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ORIGINAL PAPER

Occurrence of the rare plant *Sternbergia colchiciflora* in an urban environment

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Abstract
In this paper, we report a remarkable population of the rare plant *Sternbergia colchiciflora* found along a busy road section in the downtown of county seat Veszprém (W-Hungary). The population contains at least 7000 individuals and spreads across fifteen grassy traffic islands. Regarding the position of individuals, their relative distance from the road/sidewalk within the traffic islands differed significantly from a hypothetical uniform distribution, with higher number of individuals situated close to the island edges than expected by chance. Besides this rare bulbous plant, several other dry grassland specialist plant species were also found in these habitat patches, e.g., *Astragalus austriacus, Festuca rupicola, Filipendula vulgaris, Muscari neglectum, Petrorhagia saxifraga, Potentilla arenaria, Ranunculus illyricus, Salvia nemorosa, Sanguisorba minor, Teucrium chamaedrys, Thesium linophyllon, Verbascum phoeniceum* and *Vinca herbacea*. The origin of these dry grassland plants in this highly disturbed urban environment is uncertain; possibly, they were introduced ca. 15 years ago in the course of earthworks during the construction of the road. Recent management (frequent and motorized lawn mowing) seems to favor the *Sternbergia colchiciflora*, while the habitat is currently not directly threatened. Unfortunately, the potential for local conservation appears to be highly limited.

Keywords Amaryllidaceae · CITES · Protected species · Red list species · Traffic islands · Urban flora

Introduction

The *Sternbergia colchiciflora* W. & K. (Amaryllidaceae) is a hysteranthous and myrmecochorous bulbous geophyte (Dafni et al. 1981). Its distribution covers North-Africa, Southern Central and Eastern Europe, Anatolia and the Caucasus (CITES 2017). In several countries it is considered rare or sporadic plant species [Slovakia: Májovský and Murín (1977), Čeřovský et al. (1999); Spain: Molero and Montserrat (1983), Lagarde (1990), Morales and Castillo 2004; Ukraine: Didukh (2009); Romania: Dihoru and Negrean (2009); Italy: Brullo et al. (2004), Peruzzi et al. (2006, 2008), Frignani et al. (2009), Croatia: Pavletić (1964), France: Debussche et al. (2006), Georgia: Lachashvili et al. (2015), Turkey: Koçyiğit and Tuna (2016)]. In Hungary it has been a protected plant species since 1982, and its IUCN status is Near Threatened (NT) (Király 2007). In Hungary the species is found sporadically in remnants of dry loess grasslands in the South-Tiszántúl region, and on dry steppe slopes along the Transdanubian Mountains (Király 2009; Bartha et al. 2015). Considerable populations of *Sternbergia colchiciflora* are living in cemeteries along its distribution range in Hungary (Molnár et al. 2018). This paper presents a remarkable population of the species in grassy traffic islands in a city of Hungary.

Materials and methods

The number of individuals of the newly discovered population in the downtown of the county seat Veszprém (W-Hungary) was estimated once a year during flowering in September 2013 and in August 2015 and 2016. The extension

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of the investigations, the detailed survey of the number of individuals and accompanying species was carried out on 12 April and between 15 and 27 August 2017. The survey of the distribution of individuals inside the traffic islands was conducted between 28 and 29 March 2018. During this survey, we recorded the distance of 671 individuals from the road and from the sidewalk along transects, which were placed on nine grassy traffic islands between the road and sidewalk (transects began next to the paved road and ended next to the sidewalk). The relative distance of individuals from the road and from the sidewalk was the ratio of its absolute distance from the road or sidewalk and the width of the traffic islands. We used one-sample Kolmogorov–Smirnov test to evaluate whether the relative distance of individuals from the road and sidewalk follows a uniform distribution (R Core Team 2018). The geocoordinates and the altitude of the locality were determined by a Garmin E-Trex Legend GPS handheld device recorded in WGS84 format. Soil samples were collected from root depth (5–15 cm) at three points at the locality. Soil analyses of seven characteristics [pH (KCL), soil plasticity, total salt, calcium carbonate, organic matter, nitrogen, phosphorous and potassium content] were carried out by the accredited laboratory of the Research Institute of Karcag of the Centre for Agricultural and Applied Economic Sciences of University of Debrecen. In this paper, plant names follow the nomenclature used in Király (2009).

Results

A population of c.a. 5000 individuals of *Sternbergia colchiciflora* on both sides of the road on traffic islands and between the road and the sidewalk was found on 8 September 2013, in Veszprém (Hold street, altitude: 254 m, Fig. 1a). According to the detailed survey of 2017, the species was found along both sides of the Hold street in 200 m length on 14 traffic islands. In this year, tens of individuals were found in the cross of the Hold and Fecske streets on two traffic islands. In 2018 we found the species on four new traffic islands and also on two traffic islands 350 m distance in straight line from the previously found subpopulations in the cross of Haszkovó and Akácfa streets. Altogether 7000 individuals were found on 16 traffic islands with the area of 1250 m^2. Area of the different traffic islands varied between 6 and 255 m^2 (Table 1). Soil of the habitat can be characterized by a slightly basic pH, with clay, a moderate chalk and high nutrient content (Table 2). The 0.1% salt content of the soil can be attributed to the winter de-icing salt (see also Fekete et al. 2018). Both the increase in the number of colonized traffic islands and the increase in the number of individuals on these traffic islands suggest the spatial spread of the population.

Individuals of *Sternbergia colchiciflora* show a typical distribution on the traffic islands. The closest individuals were at 2 cm distance from the road edge and 0 cm from the

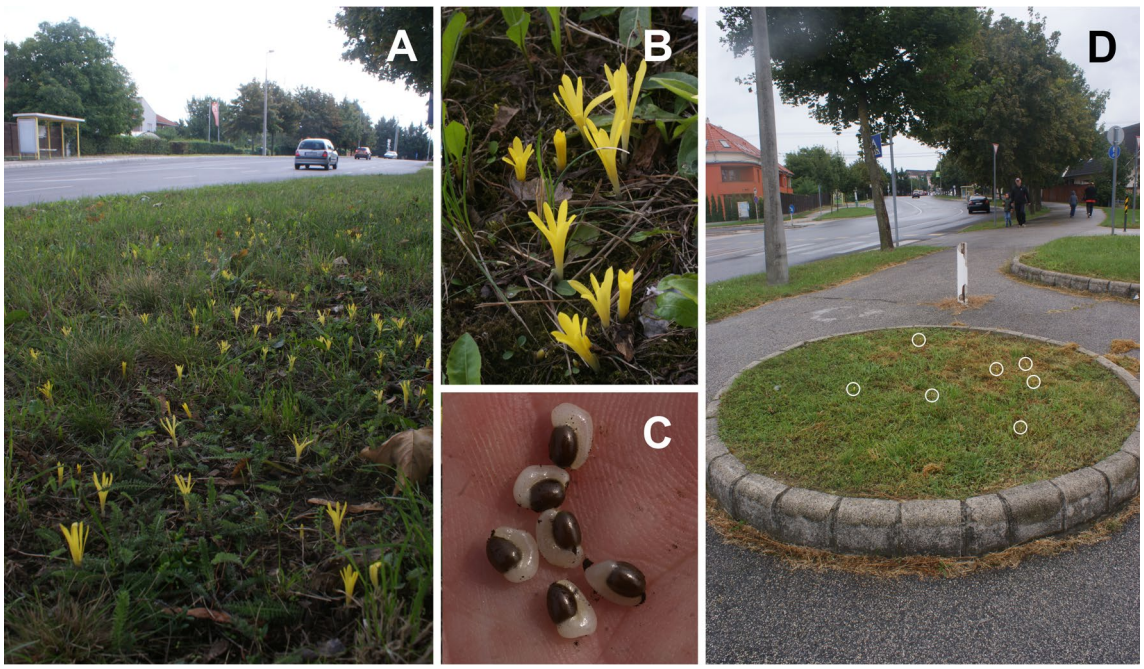

Fig. 1 **a** Occurrence of *Sternbergia colchiciflora* in downtown of Veszprém; **b** individuals in buds, with freshly opened flowers and in full bloom (23. 08. 2015); **c** myrmecochorous seeds with elaiosomes; **d** flowering individuals on a traffic island (11. 08. 2016). Photographs of A. V. Molnár

Table 1 Characteristics of grassy roadside and midfield islets (i.e., traffic islands) in downtown of Veszprém, hosting *Sternbergia colchiciflora* and/or other dry grassland species

No.	Geocoordinates	Area (m^2)	Year of first observation	Number of individuals observed		
				2016	2017	2018
1.	47.09985° N 17.92452° E	15	2017	0	10	27
2.	47.09985° N 17.92458° E	27	2017	0	13	56
3.	47.09972° N 17.92453° E	6	2016	12	100	150
4.	47.09969° N 17.92452° E	30	2017	0	5	50
5.	47.09938° N 17.92484° E	120	2013	~1800	~2000	~2000
6.	47.09957° N 17.92454° E	85	2017	0	15	45
7.	47.09912° N 17.92512° E	6	2017	0	10	45
8.	47.09890° N 17.92543° E	170	2013	~1000	~1000	~1000
9.	47.09065° N 17.92570° E	120	2013	50	100	392
10.	47.09853° N 17.92616° E	10	2017	0	5	47
11.	47.09874° N 17.92592° E	126	2013	~800	~1000	1580
12.	47.09906° N 17.92554° E	80	2017	NA	300	292
13.	47.09943° N 17.92508° E	60	2017	NA	280	246
14.	47.09981° N 17.92498° E	255	2017	NA	500	604
15.	47.10148° N 17.92484° E	66	2017	NA	10	42
16.	47.10027° N 17.92501° E	31	2018	0	0	8
17.	47.10180° N 17.92463° E	80	2017	NA	1	14
18.	47.10191° N 17.92452° E	54	–	NA	NA	–
19.	47.10189° N 17.92467° E	160	–	NA	NA	–
20.	47.10077° N 17.92513° E	80	–	NA	NA	–
21.	47.10311° N 17.92083° E	4	2018	NA	NA	19
22.	47.10323° N 17.92060° E	22	2018	NA	NA	98
23.	47.09910° N 17.92455° E	20	2018	0	0	5
24.	47.09824° N 17.92493° E	4	2018	0	0	40
25.	47.09938° N 17.92477° E	6	2018	0	0	6
26.	47.09944° N 17.92471° E	1	2018	0	0	2
27.	47.09902° N 17.92569° E	6	2018	0	0	12

Table 2 Soil characteristics of the site with *Sternbergia colchiciflora* in Veszprém

pH (KCl)	Plasticity according to Arany	Salt (m/m)%	$CaCO_3$ (m/m)%	Organic matter %	$NO_2 + NO_3 - N$ mg/kg	AL–P_2O_5 mg/kg	AL–K_2O mg/kg
7.2	51	0.1	7.43	5.2	135.7	354	795

Samples were analyzed at the DE AKIT Karcag Research Institute for eight soil parameters including pH (KCL), values of the compactness (KA) [based on the yarn test of Arany, in which the amount of water in cm^3 added to a 100-g soil sample to obtain a yarn (MSZ-08-0205 1978) is determined], overall salinity, lime content, organic material content, overall nitrogen content, overall calcium content and overall potassium content

sidewalk edge. Individuals were closer to the sidewalk on average than to the road edge (Fig. 2), and their mean ± SD distance from road edge was 3.0 ± 2.4 m, while from the sidewalk edge 2.3 ± 1.9 m. The least number of individuals was found in the middle of the traffic islands, while in the directions of the two edges of the traffic islands the number of individuals increased, but in the immediate vicinity of road, their frequency decreased (Fig. 2). The relative distance of the individuals from the road edge and from the sidewalk differed significantly from a hypothetical uniform distribution, with higher number of individuals situated closer to the road than expected by chance (One-sample Kolmogorov–Smirnov test $p < 0.001$).

During the detailed botanical survey of the locality in 2017, two other protected species were also found, such as *Ranunculus illyricus* L. (c.a. 3500 individuals on 15 traffic islands) and *Vinca herbacea* Waldst. & Kit. (c.a. 350 individuals on nine traffic islands). All three protected species (*Ranunculus illyricus*, *Sternbergia colchiciflora* and *Vinca herbacea*) were co-occurring on seven traffic islands.

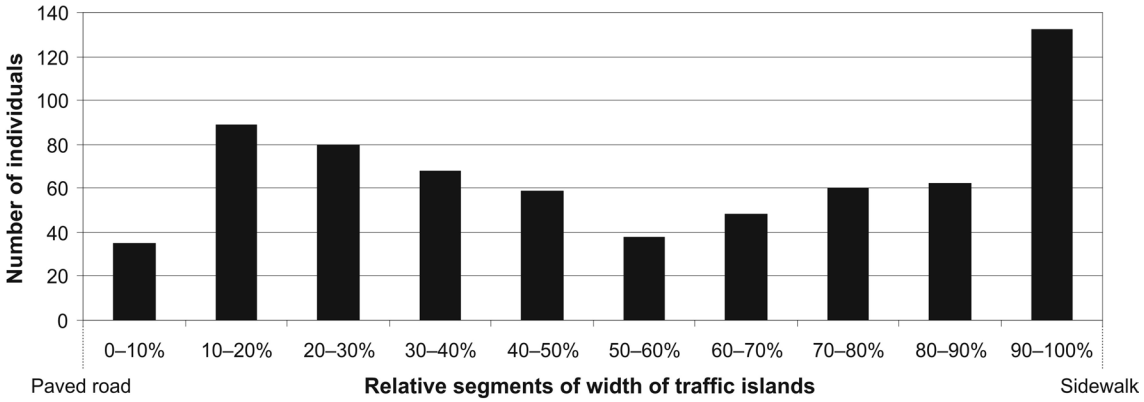

Fig. 2 Distribution of *Sternbergia colchiciflora* individuals along transverse directional transects of traffic islands

In addition, we observed the co-occurrence of *Sternbergia colchiciflora* and *Ranunculus illyricus* on six more traffic islands. On the surveyed islands, we have found other characteristic species of semi-natural dry grasslands, such as *Astragalus austriacus* Jacq. (3 islands), *Festuca rupicola* Heuff. (14 islands), *Filipendula vulgaris* Moench (6 islands), *Muscari neglectum* Guss. ex Ten. (5 islands), *Petrorhagia saxifraga* Link (6 islands), *Potentilla arenaria* Borkh. (6 islands), *Salvia nemorosa* L. (2 islands), *Sanguisorba minor* Scop. (2 islands), *Teucrium chamaedrys* L. (6 islands), *Thesium linophyllon* L. (4 islands) and *Verbascum phoeniceum* L. (1 island). On five traffic islands, there were planted individuals of *Acer platanoides* L. 4.5–5 m distance from each other with 19–31 cm trunk diameter (approximately 12–20 years old), giving shade to the habitat. In most traffic islands we found many disturbance- and trampling-tolerant species, such as *Ballota nigra* L., *Berteroa incana* (L.) DC., *Cichorium intybus* L., *Convolvulus arvensis* L., *Dactylis glomerata* L., *Digitaria sanguinalis* (L.) Scop., *Echium vulgare* L., *Erigeron annuus* (L.) Pers., *Erodium cicutarium* (L.) L'Hér., *Falcaria vulgaris* Bernh., *Linaria vulgaris* Mill., *Lolium perenne* L., *Lotus corniculatus* L., *Malva neglecta* Wallr., *Medicago lupulina* L. *Plantago lanceolata* L., *Polygonum aviculare* L., *Portulaca oleracea* L., *Reseda lutea* L., *Potentilla argentea* L., *Silene alba* (Mill.) E.H.L. Krause, *Taraxacum officinale* agg., *Trifolium pratense* L., *Trifolium repens* L. and *Verbena officinalis* L.

Discussion

The origin of the *Sternbergia colchiciflora* population in Veszprém is not known. The inner road ring in Veszprém (to where the Hold Street belongs) was created 10–15 years ago with lots of earthwork at the area. Thus, it seems that the species was introduced with the soil used during the constructions at that time. The most important anthropogenic effect on the population is mowing, but when this activity is the most intensive, *Sternbergia colchiciflora* is inactive (see also at Molnár et al. 2018b). Our experiences in August 2016 showed that mowing during the flowering period did not threaten the individuals, due to stubble height, which is higher than the plants (2–5 cm). Occurrence of the species in the frequently mowed grassy areas of other cities (e.g., Budapest, Gellért Hill) is also known (Molnár et al. 2017, 2018b).

Passers-by do not notice the *Sternbergia colchiciflora* individuals during flowering. However, there were less flowering individuals in 2016 than in previous years; there were individuals present on traffic islands where they were previously absent (Fig. 1d). The observation of the species is difficult by the fact that *S. colchiciflora* often produces self-pollinating, underground flowers (Soó 1973). According to Peruzzi et al. (2006), the rate of cleistogamy may exceed 70%. During autumn, only above-ground flowering (non-cleistogamous) individuals are detectable. Since the seeds with elaiosome (Fig. 1c) of the species are dispersed by different ant species (see also at Molnár et al. 2018a), it is possible that its local spread is due to the activity of ants; however, it is also possible that we did not notice them before. The role of mowing machines in seed dispersal has also been revealed (Strykstra et al. 1997; Vitalos and Karrer 2009).

According to the information provided by the Municipality of Veszprém, the site is located on the public plot of Veszprém, Hold utca 3219/1. The area is owned by the Municipality of Veszprém. According to the ownership sheet of the area, the cultivation branch is "taken off road"; according to the utility map, there is an electric ground cable under the plants. Roadway and roadside were built 15 years ago, and the bicycle path was built 10 years ago. Since then, the roadway and the roadside have remained unchanged. It seems likely that the soil which contained the individuals and/or seeds of other species typical to semi-natural

grasslands has come to the area during the construction of the inner roadway or the bicycle path. The local protection of the species was initiated in August 2015 by the Local Group of Veszprém County No. 18 of Birdlife Hungary. The Municipality of Veszprém did not initiate the procedure for the declaration of protection, because the protected natural value, the habitat and individuals of the natural monument cannot be sustained safely in the given area in the long term. Future road and utility reconstruction, technical improvements and increased traffic load on the internal road ring can significantly reduce the chances of survival.

Conclusion for future biology

The flora of the Eastern European cities is especially diverse compared to the adjacent areas, and this phenomenon is not only due to the diversity of introduced species, but also due to the diversity of the native flora (Kühn et al. 2004). Cities could provide habitats for plant species with local or regional importance (Kantsa et al. 2013), similarly to *Sternbergia colchiciflora* in Veszprém. The spread of the species detected during recent years may be due to the use of motorized lawn mowers.

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Authors' contributions Field data were collected by AVM, SS and HAM. RF analyzed the data and AVM contributed to their interpretation. The article was drafted by AVM and revised by RF. All authors gave final approval for publication and agree to be held accountable for this work.

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Data accessibility The data sets supporting this article have been published in Tables 1 and 2.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

References

Bartha D, Király G, Schmidt D, Tiborcz V, Barina Z, Csiky J, Jakab G, Lesku B, Schmotzer A, Vidéki R, Vojtkó A, Zólyomi Sz (eds) (2015) Distribution atlas of vascular plants of Hungary. Nyugat-magyarországi Egyetem Kiadó, Sopron

Brullo S, Salmeri C, Venora G (2004) Considerazioni tassonomiche e cariologiche sulle popolazioni siciliane di Sternbergia colchiciflora Waldst & Kit. (Amaryllidaceae). Informatore Botanico Italiano 36:464–469

Čeřovský J, Feráková V, Holub J, Maglocký Š, Procházka F (1999) Červená kniha ohrozených a vzácnych druhov rastlín a živočíchov SR a ČR: Vyššie rastliny, vol 5. Príroda a. s., Bratislava

CITES (2017) Appendices I, II and III. https://cites.org/eng/app/appendices.php#hash4. Accessed 18 Feb 2020

Dafni A, Shmida A, Avishai M (1981) Leafless autumnal-flowering geophytes in the Mediterranean region—phytogeographical, ecological and evolutionary aspects. Plant Syst Evol 137:181–193. https://doi.org/10.1007/BF00989872

Debussche M, Michaud H, Molina J, Debussche G (2006) *Sternbergia colchiciflora* Waldst. & Kit. (Amaryllidaceae) en France. Bull Soc Bot Centre Ouest ns 36:47–60

Didukh YP (ed) (2009) Red data book of Ukraine. Globalkonsulting, Kiev

Dihoru G, Negrean G (2009) Cartea roşie a plantelor vasculaire din România. Editura Academiei Române, Bucureşti

Fekete R, Mesterházy A, Valkó O, Molnár AV (2018) A hitchhiker from the beach: the spread of the maritime halophyte *Cochlearia danica* along salted continental roads. Preslia 90:23–37

Frignani F, Geri F, Gestri G, Peruzzi L (2009) Distribution of the genus *Sternbergia* Waldst. & Kit. (Amaryllidaceae) in Tuscany (central Italy). Atti Soc Tosc Sci Nat Mem Serie B 116:67–71

Kantsa A, Tscheulin T, Junker RR, Petanidou T, Kokkini S (2013) Urban biodiversity hotspots wait to get discovered: the example of the city of Ioannina, NW Greece. Landsc Urban Plan 120:129–137

Király G (ed) (2007) Red list of the vascular flora of Hungary. Private edition of the authors, Sopron

Király G (ed) (2009) Új magyar Füvészkönyv. Magyarország hajtásos növényei. Határozókulcsok. Aggteleki Nemzeti Park Igazgatóság, Jósvafő

Koçyiğit M, Tuna M (2016) Taxonomic remarks on the genus Sternbergia L. (Amaryllidaceae) in Turkey based on leaf anatomy, karyosystematic analysis and nuclear DNA content. Phytotaxa 265:238–250

Kühn I, Brandl R, Klotz S (2004) The flora of German cities is naturally species rich. Evol Ecol Res 6:749–764

Lachashvili N, Eradze N, Khachidze M, Khetsuriani L (2015) New data on some rare species of flora of Georgia. Bull Georg Natl Acad Sci 9:134–138

Lagarde F (1990) La Sierra de Cazorla (Espagne), une nouvelle station pour *Sternbergia colchiciflora* Waldst et Kit. (Amaryllidacees). Sierra de Cazorla (Spain), a new place for *Sternbergia colchiciflora* Waldst et Kit. (Amaryllidaceae). Bull Mens Soc Linn Lyon 59:297–298

Májovský J, Murín A (1977) *Sternbergia colchiciflora* W. et K. na Slovensku. Biologia 3:499–503

Molero J, Montserrat JM (1983) *Sternbergia colchiciflora* Waldst. & Kit. en el valle del Ebro. Anales del Jardín Botánico de Madrid 39:544

Molnár AV, Löki V, Máté A, Molnár A, Takács A, Nagy T, Lovas-Kiss Á, Lukács BA, Sramkó G, Tökölyi J (2017) The occurrence of *Spiraea crenata* and other rare steppe plants in Pannonian graveyards. Biologia 72:500–509

Molnár AV, Mészáros A, Csathó AI, Balogh G, Csősz S (2018a) Ant species dispersing the seeds of the myrmecochorous *Sternbergia colchiciflora* (Amaryllidaceae). North West J Zool e177101. http://biozoojournals.ro/nwjz/content/v14n2/nwjz_e177101_Molnar.pdf

Molnár AV, Mészáros A, Csathó AI, Balogh G, Takács A, Löki V, Lovas-Kiss A, Tökölyi J, Bauer N (2018b) Distribution and seed production of the rare, dry grassland specialist *Sternbergia colchiciflora* (Amaryllidaceae) in Pannonian cemeteries. Tuexenia 38:371–384

Morales R, Castillo J (2004) El género *Sternbergia* (Amaryllidaceae) en la Península Ibérica. An del Jard Botánico de Madrid 61(2):119–128

Pavletić Z (1964) Ein neuer Fundort von *Sternbergia colchiciflora* WK var. *dalmatica* Rchb. Acta Bot Croat 23:148–150

Peruzzi L, Gargano D, Bernardo L, Tison J-M (2006) Osservazioni distributive e cariologiche su *Sternbergia colchiciflora* Waldst. et Kit. (*Amaryllidaceae*) nel Parco Nazionale del Pollino. Informatore Botanico Italiano 38:537–539

Peruzzi L, Di Benedetto C, Aquaro G, Caparelli KF (2008) The genus *Sternbergia* Waldst. & Kit. (Amaryllidaceae) in Italy. Contribution to the cytotaxonomical and morpho-anatomical knowledge. Caryologia 61:107–113

Soó R (1973) A magyar flóra és vegetáció rendszertani-növényföldrajzi kézikönyve, vol 5. (Synopsis systematico-geobotanica florae vegetationisque Hungariae, Tom. 5). Akadémiai Kiadó, Budapest, pp 101–102

Strykstra RJ, Verweij GL, Bakker JP (1997) Seed dispersal by mowing machinery in a Dutch brook valley system. Acta Bot Neerl 46:387–401. https://doi.org/10.1111/plb.1997.46.4.387?af=R

Vitalos M, Karrer G (2009) Dispersal of *Ambrosia artemisiifolia* seeds along roads: the contribution of traffic and mowing machines. NeoBiota 8:53–60