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# Distribution and seed production of the rare, dry grassland specialist *Sternbergia colchiciflora* (*Amaryllidaceae*) in Pannonian cemeteries

## Verbreitung und Samenproduktion des seltenen Trockenrasenspezialisten *Sternbergia colchiciflora* (*Amaryllidaceae*) auf pannonischen Friedhöfen

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**Abstract**

Despite huge habitat losses caused by agricultural intensification, dry grasslands still represent one of the most diverse ecosystems in Europe. Their highly fragmented remnants are often preserved in man-made or human-influenced habitats (e.g., kurgans, roadside verges or cemeteries). In recent decades the significance of cemeteries as suitable habitats for preserving native and rare species has been repeatedly emphasized. However, the effect of modern management practices on long-term persistence of grassland species has remained largely unexplored. *Sternbergia colchiciflora* Waldst. & Kit. is one of the very few threatened dry grassland specialists whose occurrence in the cemeteries of the Pannonian Basin has been known for more than a century. This hysteranthous, myrmecochorous geophyte is considered rare or sporadic within its whole distribution range. In a systematic botanical survey we investigated 154 cemeteries in the Pannonian part of its distribution area. Despite modern management of cemeteries, characterised by frequent and intensive motorised lawn mowing, we found populations of *S. colchiciflora* at 27 Hungarian localities and confirmed three formerly known occurrences in Serbia. To study the effect of regular mowing on the long-term survival prospects of *S. colchiciflora* populations, we quantified the species' seed production (capsular seed number) in 9 mown and 15 unmown sites (290 and 235 specimens, respectively). The difference in seed number between the two groups was statistically insignificant (13.6±5.6 and 14.7±5.0, respectively). This result is probably due to the peculiar phenology and small stature of this species. Firstly, its annual life cycle above ground (from September to May) is out of the main mowing season. Secondly, its 3–7 cm tall flowers and fruits have a high chance of surviving the damaging effect of motorised mowing. Thirdly, it seems likely that the loss of leaf tips, i.e. a part of the assimilation surface, of this short-leaved (5–13 cm) species by mowing doesn't affect the general condition of the damaged individuals. Our study emphasizes the role of Central European cemeteries (even if mown intensively) in preservation of characteristic dry grassland plant species.

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**Keywords:** conservation, grassland management, lawn mowing, red list species, refuge

**Erweiterte deutsche Zusammenfassung am Ende des Artikels**

## 1. Introduction

Dry grasslands represent one of the most diverse ecosystems in Europe (WILSON et al. 2012, DENGLER et al. 2013); they are among the most threatened ones as well (HABEL 2013). Their long-term survival is mainly threatened by drastic changes in agricultural practices such as intensification and abandonment (GILHAUS et al. 2017, BOCH et al. 2018, VALKÓ et al. 2018), and habitat fragmentation. Highly fragmented grassland remnants or characteristic members of their regional species pools are often preserved in anthropogenically created or strongly influenced habitats such as kurgans (SUDNIK-WÓJCIKOWSKA et al. 2011, DEÁK et al. 2016a, b), roadside verges (FEKETE et al. 2017, BÓDIS et al. 2018), midfield islets (COUSINS 2006) and cemeteries. The significant role of cemeteries in preserving important habitats for various rare taxa has been underlined by numerous studies in recent years (LÖKI et al. 2015, KOWARIK et al. 2016, MOLNÁR V. et al. 2017a, b, c, d). The conservation importance of these sacred sites has its roots in their history: they avoided considerable disturbance (e.g., ploughing, fertilization) in the past. However, the effect of modern management practices (especially motorised mowing) on the persistence of grassland specialists has remained largely unexplored. *Sternbergia colchiciflora* Waldst. & Kit. is one of the very few threatened dry grassland specialists whose presence in the cemeteries of the Pannonian Basin has been known for more than a century (KOVÁCS 1915), though current records are apparently lacking.

This hysteranthous, myrmecochorous geophyte (PÉNZES 1934, DAFNI et al. 1981, MOLNÁR V. et al. 2018) is distributed from Northern Africa through Southern Europe and Asia Minor to the Caucasus and Ukraine (PASCHE & KERNDORFF 2002; Euro+Med PlantBase, http://ww2.bgbm.org/EuroPlusMed; accessed 24.9.2016). The species is listed under the Appendix II of CITES (https://cites.org/eng/app/appendices.php#hash4; accessed 27.9.2016) and considered rare or sporadic in many countries within its distribution area (PAVLETIĆ 1964, MÁJOVSKÝ & MURÍN 1977, MOLERO & MONTSERRAT 1983, FERNANDEZ ALONSO 1986, LAGARDE 1990, ČEŘOVSKÝ et al. 1999, MORALES & CASTILLO 2004, DEBUSSCHE et al. 2006, KIRÁLY 2007, DIDUKH 2009, DIHORU & NEGREAN 2009, FRIGNANI et al. 2010, LÓPEZ & RUIZ 2010, PERRINO et al. 2013, LACHASHVILI et al. 2015, MARTÍN GIL et al. 2015, BARTHA et al. 2015, KOÇYIĞIT & TUNA 2016, YOUSSEF et al. 2017).

*Sternbergia colchiciflora* often produces self-pollinating, underground flowers (SOÓ 1973), and the percentage of cleistogamy may exceed 70% (PERUZZI et al. 2006). In autumn only the above-ground flowering (chasmogamous) individuals are noticeable. The longevity of a single small, yellow flower is seven days at most (FRIGNANI et al. 2010, personal observation), within a ca. three months long potential flowering period (in Hungary from August to October), the beginning of which seems to depend on the arrival of late summer rains (JÁVORKA 1924–1925). For all these facts it is difficult to locate the plant in the field. The narrow linear leaves and oblong to subglobose fruits appear at ground level several months after blooming (in Hungary from January to March). Following a fairly short growing and ripening period, the green shoot withers (in Hungary from May to June) (Fig. 1).

Recent records from Pannonian cemeteries (CSATHÓ & BALOGH 2016, MOLNÁR V. et al. 2017a) prompted a systematic search for the species in graveyards. Since the vast majority of cemeteries nowadays are frequently and intensely mowed, the long-term survival of popu-

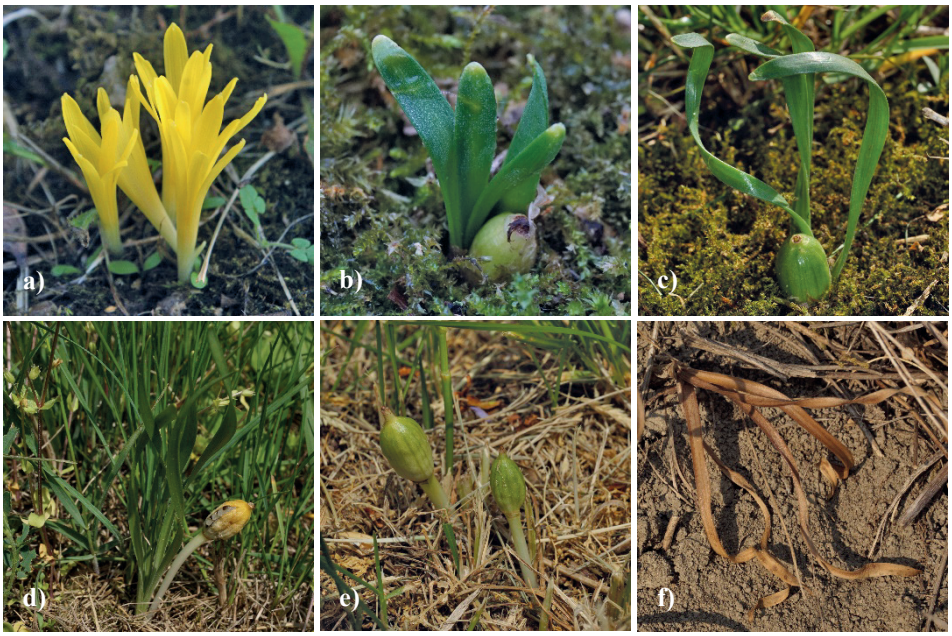



**Fig. 1.** Photographs of *Sternbergia colchiciflora*. **a)** Flowering individuals in autumn; **b)** & **c)** Spring leaves with immature fruits in early March and early April, respectively; **d)** Individual with ripe fruit in unmown habitat (early May); **e)** Leafless individuals (early May) with unripe fruits (leaflessness caused by mowing); **f)** Dried leaves in late May (unmown habitat) (Photos: A. Molnár V., 2017).

**Abb. 1.** Charakteristische Erscheinungsbilder von *Sternbergia colchiciflora*. **a)** Blühende Individuen im Herbst; **b)** & **c)** Frühlingsblätter mit unreifen Früchten Anfang März bzw. Anfang April; **d)** Exemplar mit reifer Frucht in einem ungemähten Habitat (Anfang Mai); **e)** Blattloses Exemplar mit unreifen Früchten (Blattlosigkeit durch Mähen verursacht); **f)** Getrocknete Blätter Ende Mai in einem ungemähten Habitat (Fotos: A. Molnár V., 2017).

lations apparently depends on the species' tolerance to mowing, which proved to be widely varied in other taxa (JANTUNEN et al. 2007, NAKAHAMA et al. 2016, PAUŠIČ et al. 2017). Therefore, we decided to assess the impact of mowing on survival prospects of S. colchiciflora by measuring its seed production, which is a true measure of reproductive success.

The objectives of our present paper were to (1) explore the frequency of *S. colchiciflora* in Pannonian cemeteries; (2) check the seed production of the species in differently managed (unmown vs. mown) sites.

## 2. Material and methods

### 2.1 Studied species

The morphological and phenological characteristics of S. colchiciflora are summarised according to PERUZZI et al. (2008), YOUSSEF et al. (2017) and our own observations. The species is a small, perennial hysteranthous geophyte. The bulb is subspherical (up to 15 mm in diameter), with a brown tunic. Flowers are sulphur-like, pale or bright yellow, and appear in autumn (in Hungary between August and October) almost at the ground level. Individual flowering period is very short, approximately (1–) 3 (–7) days. Perianth narrow and long (45–60 × 5–6 mm), with lanceolate, yellow segments, that make it very

easy to overlook among the dried vegetation in autumn (MATHEW 1983). The 2–5 narrow linear leaves appear several months after the flowering (in Hungary in January–March). Leaves are twisted or spiralled, deep green-glaucous with rounded apex and with a 55–130 mm long and 1–5 mm wide lamina. Fruit is a 10–13 mm long and 7–9 mm wide capsule with a 15–45 (–95) mm long pedicel.

### 2.2 Sampling

154 cemeteries were investigated between March 2017 and April 2018 in the Pannonian Ecoregion (Central Europe), within the distribution area of *S. colchiciflora*. In two cases churchyards adjacent to cemeteries were also studied (for locations see Supplement E1). The individuals of the traced populations were counted or (in large populations) their number was estimated.

### 2.3 Seed production and data analysis

Seed production was studied in the fruit ripening period (30 April – 13 May 2017). 22 populations were sampled. In total, the seeds of 290 individuals of mown and 235 individuals of unmown sites were counted in the ripe though closed fruits (Table 1). Previous mowing activity in situ was established by observing the tips of leaves of *S. colchiciflora* individuals and those of the surrounding taxa.

**Table 1.** Sampling sites for seed production of *Sternbergia colchiciflora*, and the number of specimens studied.

**Tabelle 1.** Untersuchungsorte der individuellen Samenproduktion von *Sternbergia colchiciflora* und Anzahl der untersuchten Exemplare.

| ID | Locality | Number of studied specimens in mown sites | Number of studied specimens in unmown sites |
|---|---|---|---|
| 1. | HUN: Alsóőrs: cemetery | 10 | – |
| 2. | HUN: Aszófő: cemetery | – | 10 |
| 3. | HUN: Balatonfőkajár: cemetery | – | 10 |
| 4. | HUN: Balatonkenese: Part-fő | – | 5 |
| 5. | HUN: Balatonszőlős: cemetery | – | 4 |
| 6. | HUN: Csór: cemetery | 16 | 26 |
| 7. | HUN: Csorvás: cemetery 1 | 46 | – |
| 8. | HUN: Csorvás: cemetery 2 | 25 | – |
| 9. | HUN: Csorvás: Nature protection area | – | 26 |
| 10. | HUN: Kaszaper: Sarkadipart | – | 3 |
| 11. | HUN: Paks: Vörösmalom-valley | – | 8 |
| 12. | HUN: Pécsely: Klárapuszta | – | 19 |
| 13. | HUN: Pitvaros: cemetery | – | 40 |
| 14. | HUN: Pusztaföldvár: cemetery | 25 | – |
| 15. | HUN: Tihany: Diósi-meadows | – | 18 |
| 16. | HUN: Tihany: Attila Hill | – | 6 |
| 17. | HUN: Tótkomlós: cemetery | 39 | – |
| 18. | HUN: Várpalota-Inota: cemetery | 49 | 24 |
| 19. | HUN: Veszprém: downtown | 58 | – |
| 20. | SRB: Ada: cemetery | 22 | – |
| 21. | SRB: Bečej: cemetery 1 | – | 24 |
| 22. | SRB: Bečej: cemetery 2 | – | 12 |

The effect of mowing on seed production was analyzed by using Generalised Mixed-effect Linear Models with Poisson distribution (Poisson GLMM). The number of seeds was included as a dependent variable, the presence of mowing as fixed effect and location (cemetery ID) of the plants was included as a random factor to control for the possibility that plants from the same site might be more similar to each other than expected by chance. The Poisson GLMM was implemented using the *lme4* package in the R Statistical Environment (BATES et al. 2015, R CORE TEAM 2017). We also performed within-cemetery comparisons for two cemeteries in which both mown and unmown areas were present; these data were analyzed using Generalised Linear Models with Poisson distribution (Poisson GLMs).

## 3. Results

### 3.1 *Sternbergia colchiciflora* occurrences in cemeteries

We recorded a total of 30 populations of *S. colchiciflora* in the checked 154 Hungarian and Serbian cemeteries (Table 2, Fig. 2). 9 populations consisted of less than 100 individuals, while 101–1000 individuals were found in 16, and more than 1000 individuals in 5 cemeteries. The species was mostly traced in semi-natural, mown or unmown grassland patches within the cemeteries (Fig. 3). A smaller number of individuals were observed among the graves, and only a few under *Robinia pseudoacacia* and *Syringa vulgaris* scrubs.

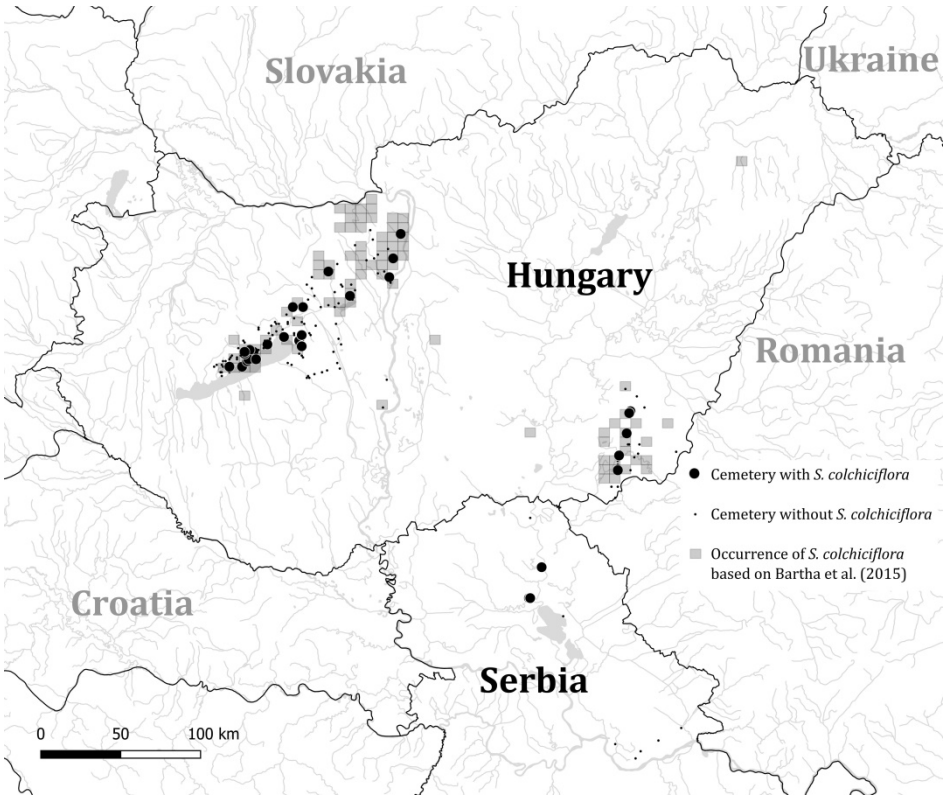



**Fig. 2.** Hungarian records of *Sternbergia colchiciflora* (based on BARTHA et al. 2015), and map of locations studied.

**Abb. 2.** Vorkommen von *Sternbergia colchiciflora* und die studierten Friedhöfe.

**Table 2.** Locations of cemeteries harbouring *Sternbergia colchiciflora* populations, listed in an alphabetical order of countries (HUN – Hungary, SRB – Serbia) and settlements.

**Tabelle 2.** Standorten der studierten Friedhöfe mit Vorkommen von *S. colchiciflora*. Ortschaften werden alphabetisch (zuerst nach Land, dann nach Ortschaft) aufgelistet. Abkürzungen: HUN – Ungarn, SRB – Serbien.

| Country: settlement | Cemetery (G) and / or churchyard (C) | Northern latitude | Eastern longitude | Estimated number of individuals of *S. colchiciflora* |
|---|---|---|---|---|
| HUN: Alsóőrs | G | 47.00° | 17.97° | 500 |
| HUN: Aszófő | G | 46.93° | 17.84° | 1,300 |
| HUN: Balatonakali | G | 46.88° | 17.77° | 250 |
| HUN: Balatonfőkajár | G | 47.02° | 18.22° | 10,000 |
| HUN: Balatonfüred | G & C | 46.96° | 17.86° | 40 |
| HUN: Balatonkenese | G | 47.04° | 18.10° | 15 |
| HUN: Balatonszőlős | G | 46.97° | 17.83° | 400 |
| HUN: Balatonudvari | G | 46.91° | 17.81° | 50 |
| HUN: Budaörs | G | 47.46° | 18.96° | 150 |
| HUN: Csákvár | G | 47.39° | 18.45° | 100 |
| HUN: Csór | G | 47.20° | 18.25° | 10,000 |
| HUN: Csorvás | G | 46.64° | 20.83° | 1,000 |
| HUN: Csorvás | G | 46.63° | 20.82° | 15,000 |
| HUN: Füle | G | 47.05° | 18.24° | 1,000 |
| HUN: Érd | G | 47.36° | 18.93° | 150 |
| HUN: Lepsény | G | 46.99° | 18.24° | 20 |
| HUN: Nadap | G | 47.26° | 18.62° | 10 |
| HUN: Örvényes | G | 46.92° | 17.82° | 100 |
| HUN: Pécsely | G | 46.95° | 17.79° | 100 |
| HUN: Pécsely | G | 46.96° | 17.79° | 1,000 |
| HUN: Pitvaros | G | 46.32° | 20.73° | 500 |
| HUN: Pusztaföldvár | G | 46.52° | 20.80° | 1,500 |
| HUN: Tihany | G | 46.92° | 17.88° | 1,000 |
| HUN: Tótkomlós | G | 46.40° | 20.74° | 800 |
| HUN: Üröm | G | 47.59° | 19.02° | 1000 |
| HUN: Várpalota-Inota | G | 47.20° | 18.17° | 1,000 |
| HUN: Zánka | G & C | 46.88° | 17.67° | 1,000 |
| SRB: Ada | G | 45.79° | 20.13° | 25 |
| SRB: Bečej | G | 45.62° | 20.03° | 400 |
| SRB: Bečej | G | 45.62° | 20.04° | 1,000 |

### 3.2 Seed production of *Sternbergia colchiciflora*

An average of 14.3 ± 5.7 (mean ± SD) seeds (range: 2–28) was found in the ripe fruits of *S. colchiciflora*. The difference between the average seed production of unmown populations (14.7 ± 5.0) and mown populations (13.6 ± 5.6) was non-significant ($\beta = 0.07$, SE = 0.05, $p = 0.13$). Similarly, the difference between the average seed number of unmown and mown individuals within the two cemeteries that contained both mown and unmown areas was statistically insignificant (Poisson GLM; cemetery of Csór: $\beta = 0.02$, SE = 0.08, $p = 0.85$; cemetery of Várpalota-Inota: $\beta = 0.93$, SE = 0.07, $p = 0.62$; Fig. 4).




**Fig. 3.** Habitats of *Sternbergia colchicflora* in Pannonian cemeteries. **a)** Tihany; **b)** Balatonszőlős; **c)** & **d)** Csorvás; **e)** Bečej; **f)** Pusztaföldvár (Photos: A. Molnár V., 2017).

**Abb. 3.** Lebensräume von *S. colchicflora* in Friedhöfen der Pannonischen Ökoregion. **a)** Tihany; **b)** Balatonszőlős; **c)** & **d)** Csorvás; **e)** Bečej; **f)** Pusztaföldvár (Fotos: A. Molnár V., 2017).

## 4. Discussion

In recent decades the significance of cemeteries as suitable habitats for preserving native and rare species has been repeatedly emphasized (e.g., COULD 1941, MCBARRON et al. 1988, LASKE 1994, BARRETT & BARRETT 2001, LÖKI et al. 2015, MOLNÁR V. et al. 2017a, b, c). Even though urban habitats are usually not able to maintain the original biodiversity, harbouring a lower number of species compared to other semi-natural habitats (DEÁK et al. 2016c), in some cases they can act as a refuge for threatened species (ALBRECHT & HAIDER 2013).

In this study we have documented the relative frequency of *S. colchiciflora* in the cemeteries of the Pannonian Ecoregion. Of the 30 traced populations two (Bečej – Óbecse) have been known for more than a century (KOVÁCS 1915). Although it is easy to detect conspicuous species during botanical surveys in cemeteries, targeted surveys are needed for detecting species with slightly rhapsodic or unpredictable appearance (MOLNÁR V. et al. 2017a).

Due to the peculiar phenology, fugaceous flowering and small stature of *S. colchiciflora*, the correct assessment of its population size is more convenient in springtime, when the characteristic twisted leaves of the species are readily noticeable. We assume that *S. colchiciflora* is also present in the cemeteries of other countries. A large-scale mapping is needed to explore the species' frequency throughout its distribution range.

Mowing in general plays a fundamental role in maintaining many grassland habitats (ERIKSSON et al. 2002, PYKÄLÄ et al. 2005, WILLIAMS et al. 2007, KELEMEN et al. 2014), though the main attributes of this practice (e.g., mechanization, cutting height, timing, frequency) can variously affect the life cycles of different species (WADI et al. 2004, HELLSTRÖM et al. 2006, WIJITPHAN et al. 2009).

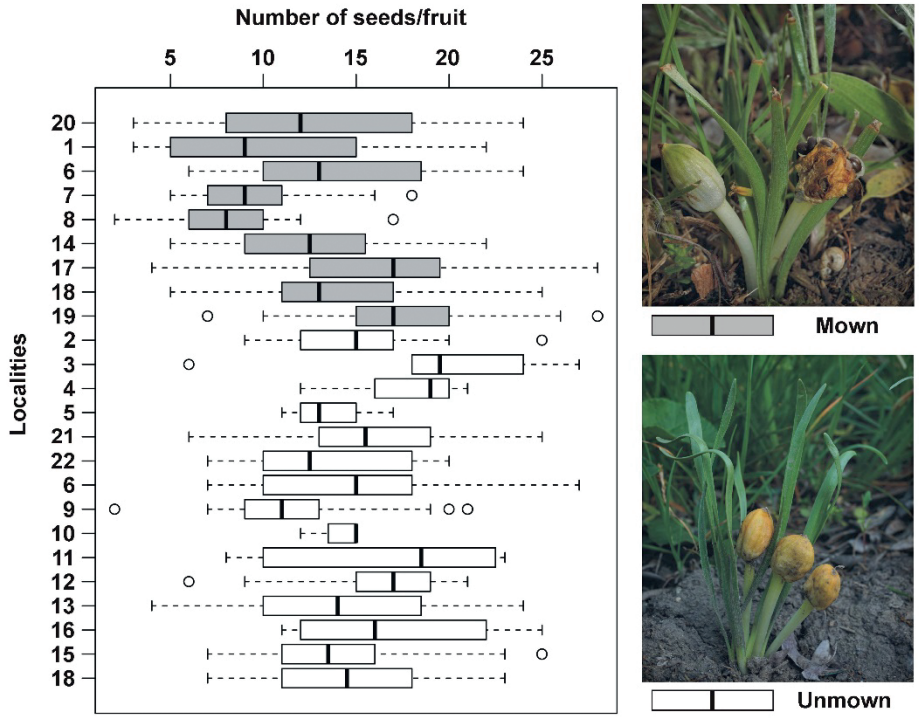



**Fig. 4.** Capsular seed numbers of *Sternbergia colchiciflora* in habitats with and without mowing. (Numbers denote localities as in Table 1) (Photos: A. Molnár V., 13. and 15. May 2017).

**Abb. 4.** Verteilung der Anzahl der Samen / Frücht von *S. colchiciflora* aus Lebensräumen mit und ohne Mähen. (Nummerierung der Lokalitäten ist wie in Tab. 1) (Fotos: A. Molnár V., 13. und 15. Mai 2017).

Despite the common practice of motorised and regular mowing in the vast majority of Hungarian cemeteries (several times between April and October), we have ascertained that *S. colchiciflora* can survive even in frequently mown sites, and its seed production is basically not affected by mowing. This can be explained by the phenological and morphological characteristics of the species.

A significant part of the annual life cycle of *S. colchiciflora* (approximately eight months of the year) is confined to underground phase (bulb). From the beginning of the mowing season (April in Hungary) the plant may be slightly damaged by mowing. This management practice, however, usually affects only the tips of leaves, because the fruits are located at the ground level until the end of April or the beginning of May, and their pedicels elongate moderately (up to 5–10 cm) at maturation only (PÉNZES 1934, Fig. 5). Similarly, in autumn the flowers reach a height (2–7 cm) that is usually below the average cutting height of motorised lawn mowers (Fig. 5). Moreover, in the flowering season a large part of the local population remains in a dormant state, inevitably avoiding the harmful effects of mowing. The statistically insignificant difference between the seed production of unmown and mown individuals show that the species is tolerant of the partial (though regular) loss of its assimilation surface (leaf tips), and mowing does not affect the condition and thus the seed production of these individuals.

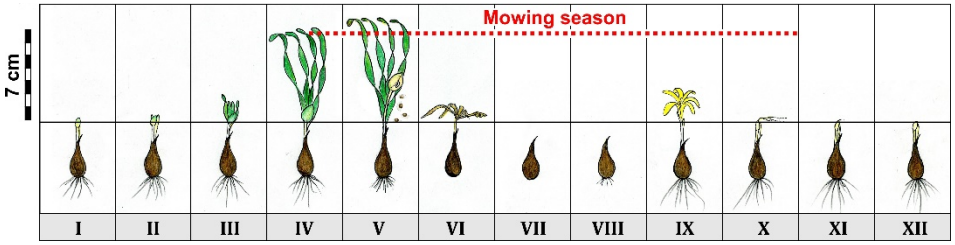



**Fig. 5.** Phenological diagram of *Sternbergia colchiciflora* and approximate duration of mowing season in Hungarian cemeteries. Roman numerals denote months.

**Abb. 5.** Phänologisches Diagramm von *S. colchiciflora* und ungefähre Dauer der Mahdsaison in ungarischen Friedhöfen. Römische Ziffern entsprechen Monaten.

## Erweiterte deutsche Zusammenfassung

**Einleitung** – Trockenrasen gehören zu den artenreichsten (WILSON et al. 2012, DENGLER et al. 2013), aber gleichzeitig auch zu den bedrohtesten (HABEL 2013) Ökosystemen Europas. Ihre Diversität ist vor allem durch die drastischen Veränderungen in der Landwirtschaft bedroht, wie die Intensivierung oder die Aufgabe der Nutzung (GILHAUS et al. 2017, BOCH et al. 2018, VALKÓ et al. 2018). Stark fragmentierte Überreste von Trockenrasen oder charakteristische Arten des regionalen Artenpools bleiben oft in anthropogen beeinflussten Sekundärhabitaten wie Grabhügel (DEÁK et al. 2016a, b), Straßenränder (FEKETE et al. 2017), Ackerinseln (COUSINS 2006), oder auf Friedhöfen erhalten. Die herausragende Stellung von Friedhöfen als wertvolle Lebensräume für verschiedene Organismen gewann in den vergangenen Jahren mehr und mehr an Bedeutung. Auch das Potential von Friedhöfen für die Erhaltung von Steppenarten wurde kürzlich hervorgehoben (MOLNÁR V. et al. 2017a). Die Auswirkungen von anthropogenen Aktivitäten (einschließlich moderner Managementpraktiken) auf die langfristige Erhaltung von Grünlandspezialisten blieb jedoch weitgehend unerforscht. *Sternbergia colchiciflora* ist ein bedrohter Trockenrasenspezialist, dessen Vorkommen auf Friedhöfen des Pannonischen Beckens seit mehr als einem Jahrhundert bekannt ist. Diese Friedhofs-Populationen von *S colchiciflora* blieben jedoch bislang weitgehend unerforscht. Neue Funde der Art auf Friedhöfen (CSATHÓ & BALOGH 2016, MOLNÁR V. et al. 2017a) gaben den Anlass zu einer systematischen Suche auf pannonischen Friedhöfen. Im Rahmen dieser Studie untersuchten wir deshalb (1) die Häufigkeit von *S. colchiciflora* auf pannonischen Friedhöfen, sowie (2) die Samenproduktion der Art an gemähten vs. ungemähten Standorten.

**Methoden** – Zwischen März 2017 und April 2018 untersuchten wir 154 Friedhöfe in der Pannonischen Ökoregion (Mitteleuropa), dem natürlichen Verbreitungsgebiet von *S. colchiciflora*. Auf jedem dieser Friedhöfe erfassten wir schutzwürdige Gefäßpflanzenarten, mit besonderem Fokus auf *S. colchiciflora*. Um den Einfluss der Mahd auf die Samenproduktion der Art zu beurteilen, zählten wir in 22 Populationen die Anzahl der Samen in den gereiften, aber noch geschlossenen Kapseln von 290 Individuen in gemähten und von 235 Individuen in ungemähten Wiesen. Wir testeten die Unterschiede in der Samenproduktion zwischen gemähten und ungemähten Wiesen mit generalisierten linearen gemischten Modellen (GLMM; R CORE TEAM 2017).

**Ergebnisse** – Wir fanden insgesamt 30 Populationen von *S. colchiciflora* auf den 154 untersuchten ungarischen und serbischen Friedhöfen. Neun Populationen bestanden aus weniger als 100 Individuen, während 16 Populationen von 101–1000 Individuen und fünf Populationen von mehr als 1000 Individuen aufgebaut waren. Die Art wuchs auf den Friedhöfen zumeist in halbnatürlichen, gemähten oder ungemähten Wiesen. Seltener fanden wir Exemplare unter Gehölzen wie *Robinia pseudoacacia* und *Syringa vulgaris* oder zwischen Gräbern. In den reifen Kapseln von *S. colchiciflora* wurden durchschnittlich 14,3 ± 5,7 (Mittelwert ± SD) Samen (2–28 Samen pro Kapsel) gebildet. Obwohl die Samen-

produktion von nicht gemähten Populationen geringfügig höher war (14,7 ± 5,0), als jene von gemähten Populationen (13,6 ± 5,6), war der Unterschied statistisch nicht signifikant (β = 0,07; SE = 0,05; $p$ = 0,13).

**Diskussion** – In den letzten Jahrzehnten gewannen Friedhöfe als wertvolle Lebensräume für verschiedene Organismen mehr und mehr an Bedeutung (MCBARRON et al. 1988, LASKE 1994, BARRETT & BARRETT 2001, LÖKI et al. 2015, MOLNÁR V. et al. 2017a, b, c). Während auffällige Arten relativ schnell bei botanischen Erhebungen gefunden werden können, sind für kleine und unscheinbare Arten gezielte Erhebungen erforderlich (MOLNÁR V. et al. 2017c; vorliegende Publikation).

Wir zeigten, dass *S. colchiciflora* innerhalb ihres natürlichen Verbreitungsgebietes regelmäßig auf Friedhöfen der pannonischen Ökoregion vorkommt. Mindestens zwei Populationen (Bečej – Óbecse) waren seit mehr als einem Jahrhundert bekannt (KOVÁCS 1915). Unsere Studie verdeutlicht auβerdem, dass die Art auch an extensiv gemähten Standorten überleben kann und die Samenproduktion der Art durch die Mahd nicht wesentlich beeinträchtigt wird. Dies lässt sich einerseits durch die sehr geringe Höhe der Pflanze und andererseits durch die phänologischen Eigenschaften mit später Blüte und früher Samenreife der Art erklären (Abb. 5). Die längste Zeit des Jahres überdauert die Art im Boden (ca. 8 Monate) und selbst bei einer frühen Mahd im Frühjahr geht nur ein kleiner Teil der Assimilationsfläche, jedoch nicht die Fruchtstände verloren (Abb. 5). Obwohl im Herbst die kleinen gelben Blüten von *S. colchiciflora* wie Laternen aus den grünen Wiesen leuchten, ist die Pflanze leicht im Frühjahr anhand ihrer auffällig verdrehten Blätter zu erkennen. Da ein Großteil der Individuen einer Population nicht blüht und die Blüten sehr schnell wieder verschwinden (in 3–4 Tagen) ohne eine Spur über dem Boden zu hinterlassen, ist die Kartierung im Frühjahr sogar sinnvoller. Sehr wahrscheinlich kommt diese bedrohte Art auch auf Friedhöfen anderer Länder, sowie weiteren anthropogen beeinflussten Lebensräumen vor. Die systematische Suche sollte deshalb weitergeführt werden, um mehr über die Gesamtverbreitung der Art zu erfahren.

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## Supplements

**Additional supporting information may be found in the online version of this article.**

**Zusätzliche unterstützende Information ist in der Online-Version dieses Artikels zu finden.**

**Supplement E1.** All surveyed graveyards with geocoordinates.

**Anhang E1.** Alle untersuchten Friedhöfe mit Geokoordinaten.

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**Supplement E1.** All surveyed graveyards with geocoordinates.

**Anhang E1.** Alle untersuchten Friedhöfe mit Geokoordinaten.

| Country: settlement | Graveyard (G) and/or churchyard (C) | Geocoordinates | | Number of individuals of *S. colchiciflora* |
|---|---|---|---|---|
| HUN: Aba | G | 47.03° | 18.53° | 0 |
| HUN: Alsóőrs | G | 47.00° | 17.97° | 500 |
| HUN: Ambrózfalva | G | 46.35° | 20.73° | 0 |
| HUN: Aszófő | G | 46.93° | 17.84° | 1300 |
| HUN: Balatonakali | G | 46.88° | 17.77° | 250 |
| HUN: Balatonalmádi | G | 47.03° | 17.99° | 0 |
| HUN: Balatonalmádi-Vörösberény | C | 47.05° | 18.01° | 0 |
| HUN: Balatonalmádi-Vörösberény | G | 47.05° | 18.01° | 0 |
| HUN: Balatonbozsok | G | 46.95° | 18.22° | 0 |
| HUN: Balatoncsicsó | G | 46.92° | 17.67° | 0 |
| HUN: Balatonfőkajár | G | 47.02° | 18.22° | 10000 |
| HUN: Balatonfüred | G | 46.96° | 17.87° | 0 |
| HUN: Balatonfüred | G | 46.96° | 17.86° | 0 |
| HUN: Balatonfüred (Papsoka) | G & C | 46.96° | 17.86° | 40 |
| HUN: Balatonfüred-Balatonarács | G | 46.97° | 17.90° | 0 |
| HUN: Balatonfüzfő | G | 47.07° | 18.04° | 0 |
| HUN: Balatonhenye | G | 46.91° | 17.62° | 0 |
| HUN: Balatonkenese | G | 47.04° | 18.10° | 15 |
| HUN: Balatonkenese | G | 47.03° | 18.12° | 0 |
| HUN: Balatonszabadi | G | 46.9° | 18.13° | 0 |
| HUN: Balatonszabadi-Siómaros | G | 46.89° | 18.16° | 0 |
| HUN: Balatonszepezd | G | 46.85° | 17.67° | 0 |
| HUN: Balatonszőlős | G | 46.97° | 17.83° | 400 |
| HUN: Balatonudvari | G | 46.91° | 17.81° | 50 |
| HUN: Barnag | G | 46.98° | 17.74° | 0 |
| HUN: Belsőbáránd | G | 47.11° | 18.51° | 0 |
| HUN: Berhida | G | 47.11° | 18.13° | 0 |
| HUN: Berhida | G | 47.12° | 18.13° | 0 |
| HUN: Biatorbágy | G | 47.48° | 18.84° | 0 |
| HUN: Biatorbágy | G | 47.46° | 18.81° | 0 |
| HUN: Budajenő | G | 47.56° | 18.80° | 0 |
| HUN: Budakeszi | G | 47.51° | 18.92° | 0 |
| HUN: Budaörs | G | 47.46° | 18.96° | 150 |
| HUN: Budaörs | G | 47.47° | 18.96° | 0 |
| HUN: Csajág | G | 47.05° | 18.18° | 0 |
| HUN: Csákberény | G | 47.36° | 18.32° | 0 |
| HUN: Csákvár | G | 47.39° | 18.45° | 100 |
| HUN: Csanádpalota | G | 46.23° | 20.73° | 0 |
| HUN: Csór | G | 47.2° | 18.25° | 10000 |
| HUN: Csorvás | G | 46.64° | 20.83° | 1000 |
| HUN: Csorvás | G | 46.63° | 20.82° | 33000 |
| HUN: Dég | G | 46.86° | 18.44° | 0 |
| HUN: Dunaföldvár | G | 46.81° | 18.91° | 0 |
| HUN: Dunakömlőd | G | 46.66° | 18.88° | 0 |
| HUN: Enying | G | 46.94° | 18.24° | 0 |
| HUN: Enying | G | 46.93° | 18.25° | 0 |
| HUN: Etyek | G | 47.45° | 18.75° | 0 |
| HUN: Érd | G | 47.36° | 18.93° | 150 |
| HUN: Érd | G | 47.39° | 18.89° | 0 |
| HUN: Felsődörgicse | G | 46.92° | 17.73° | 0 |

| Country: settlement | Graveyard (G) and/or churchyard (C) | Geocoordinates | | Number of individuals of *S. colchiciflora* |
|---|---|---|---|---|
| HUN: Felsőőrs | G | 47.02° | 17.95° | 0 |
| HUN: Füle | G | 47.05° | 18.24° | 1000 |
| HUN: Iszkaszentgyörgy | G | 47.24° | 18.29° | 0 |
| HUN: Jenő | G | 47.11° | 18.26° | 0 |
| HUN: Káloz | G | 46.96° | 18.49° | 0 |
| HUN: Kaszaper | G | 46.46° | 20.81° | 0 |
| HUN: Kaszaper | G | 46.46° | 20.82° | 0 |
| HUN: Kétsoprony | G | 46.72° | 20.88° | 0 |
| HUN: Kevermes | G | 46.42° | 21.19° | 0 |
| HUN: Királyszentistván | G | 47.11° | 18.04° | 0 |
| HUN: Kisdörgicse | G | 46.93° | 17.73° | 0 |
| HUN: Kondoros | G | 46.76° | 20.79° | 0 |
| HUN: Kőszárhegy | G | 47.10° | 18.35° | 0 |
| HUN: Kővágóörs | G | 46.85° | 17.6° | 0 |
| HUN: Kővágóörs | G | 46.85° | 17.61° | 0 |
| HUN: Kövegy | G | 46.23° | 20.68° | 0 |
| HUN: Köveskál | G | 46.88° | 17.62° | 0 |
| HUN: Köveskál | G | 46.89° | 17.61° | 0 |
| HUN: Középbogárd | G | 46.85° | 18.40° | 0 |
| HUN: Középbogárd | G | 46.85° | 18.40° | 0 |
| HUN: Küngös | G | 47.06° | 18.18° | 0 |
| HUN: Mány | G | 47.53° | 18.66° | 0 |
| HUN: Lajoskomárom | G | 46.84° | 18.34° | 0 |
| HUN: Lepsény | G | 46.99° | 18.24° | 20 |
| HUN: Lepsény | G | 47.00° | 18.24° | 0 |
| HUN: Litér | G | 47.10° | 18.00° | 0 |
| HUN: Lovas | G | 47.00° | 17.96° | 0 |
| HUN: Lovasberény | G | 47.32° | 18.55° | 0 |
| HUN: Lovasberény | G | 47.31° | 18.56° | 0 |
| HUN: Magyaralmás | G | 47.30° | 18.32° | 0 |
| HUN: Magyarbánhegyes | G | 46.46° | 20.90° | 0 |
| HUN: Mezőhegyes | G | 46.32° | 20.83° | 0 |
| HUN: Mezőkomárom | G | 46.82° | 18.30° | 0 |
| HUN: Mezőkomárom | G | 46.83° | 18.29° | 0 |
| HUN: Mezőkovácsháza-Református-kovácsháza | G | 46.41° | 20.89° | 0 |
| HUN: Mindszentkálla | G | 46.88° | 17.55° | 0 |
| HUN: Monoszló | G | 46.91° | 17.64° | 0 |
| HUN: Nadap | G | 47.26° | 18.62° | 10 |
| HUN: Nádasdladány | G | 47.12° | 18.24° | 0 |
| HUN: Nagyér | G | 46.37° | 20.73° | 0 |
| HUN: Nagylak | G | 46.17° | 20.71° | 0 |
| HUN: Óbudavár | G | 46.94° | 17.69° | 0 |
| HUN: Örvényes | G | 46.92° | 17.82° | 100 |
| HUN: Ősi | G | 47.14° | 18.18° | 0 |
| HUN: Pákozd | G | 47.22° | 18.53° | 0 |
| HUN: Paloznak | G | 46.98° | 17.94° | 0 |
| HUN: Papkeszi | G | 47.08° | 18.09° | 0 |
| HUN: Pátka | G | 47.28° | 18.50° | 0 |
| HUN: Pázmánd | G | 47.29° | 18.66° | 0 |
| HUN: Pécsely | G | 46.95° | 17.79° | 100 |
| HUN: Pécsely | G | 46.96° | 17.79° | 1000 |
| HUN: Pécsely | G | 46.95° | 17.79° | 0 |
| HUN: Pétfürdő | G | 47.16° | 18.12° | 0 |
| HUN: Pitvaros | G | 46.32° | 20.73° | 400 |

| Country: settlement | Graveyard (G) and/or churchyard (C) | Geocoordinates | | Number of individuals of *S. colchiciflora* |
|---|---|---|---|---|
| HUN: Polgárdi | G | 47.06° | 18.30° | 0 |
| HUN: Polgárdi | G | 47.05° | 18.31° | 0 |
| HUN: Pusztaföldvár | G | 46.52° | 20.80° | 1200 |
| HUN: Révfülöp | G | 46.83° | 17.61° | 0 |
| HUN: Sárbogárd-Nagyhörcsök | G | 46.9° | 18.52° | 0 |
| HUN: Sárbogárd-Sárhatvan | G | 46.87° | 18.54° | 0 |
| HUN: Sárkeresztes | G | 47.26° | 18.34° | 0 |
| HUN: Sárkeresztúr | G | 47.00° | 18.55° | 0 |
| HUN: Sóly | G | 47.12° | 18.03° | 0 |
| HUN: Söréd | G | 47.32° | 18.28° | 0 |
| HUN: Sukoró | G | 47.25° | 18.60° | 0 |
| HUN: Szabadhídvég | G | 46.82° | 18.28° | 0 |
| HUN: Százhalombatta | G | 47.33° | 18.94° | 0 |
| HUN: Székesfehérvár | G | 47.20° | 18.39° | 0 |
| HUN: Székesfehérvár, Béla úti temető | G | 47.21° | 18.45° | 0 |
| HUN: Székesfehérvár, Kisfalud | G | 47.20° | 18.50° | 0 |
| HUN: Szentbékkálla | G | 46.89° | 17.57° | 0 |
| HUN: Szentjakabfa | G | 46.93° | 17.68° | 0 |
| HUN: Szentkirályszabadja | G | 47.06° | 17.98° | 0 |
| HUN: Tagyon | G | 46.90° | 17.68° | 0 |
| HUN: Tárnok | G | 47.38° | 18.84° | 0 |
| HUN: Telekgerendás | G | 46.66° | 20.94° | 0 |
| HUN: Tihany | G | 46.92° | 17.88° | 1000 |
| HUN: Tinnye | G | 47.61° | 18.78° | 0 |
| HUN: Tótkomlós | G | 46.4° | 20.74° | 800 |
| HUN: Tótkomlós | G | 46.42° | 20.75° | 0 |
| HUN: Tótvázsony | G | 47.01° | 17.79° | 0 |
| HUN: Tótvázsony | G | 47.02° | 17.78° | 0 |
| HUN: Üröm | G | 47.59° | 19.02° | 1000 |
| HUN: Várpalota | G | 47.20° | 18.15° | 0 |
| HUN: Várpalota-Inota | G | 47.20° | 18.17° | 1000 |
| HUN: Vászoly | G | 46.94° | 17.76° | 0 |
| HUN: Végegyháza | G | 46.39° | 20.86° | 0 |
| HUN: Velence | G | 47.24° | 18.64° | 0 |
| HUN: Vereb | G | 47.32° | 18.63° | 0 |
| HUN: Vértesboglár | G | 47.43° | 18.52° | 0 |
| HUN: Veszprém | G | 47.09° | 17.90° | 0 |
| HUN: Veszprém | G | 47.08° | 17.90° | 0 |
| HUN: Vilonya | G | 47.11° | 18.06° | 0 |
| HUN: Zánka | G & C | 46.88° | 17.67° | 1000 |
| SRB: Ada | G | 45.79° | 20.13° | 25 |
| SRB: Bečej | G | 45.62° | 20.03° | 400 |
| SRB: Bečej | G | 45.62° | 20.04° | 1000 |
| SRB: Deliblato | G | 44.83° | 21.05° | 0 |
| SRB: Grebenac | G | 44.90° | 21.23° | 0 |
| SRB: Kanjiža | G | 46.06° | 20.04° | 0 |
| SRB: Melenci | G | 45.52° | 20.30° | 0 |
| SRB: Pločica | G | 44.73° | 20.87° | 0 |
| SRB: Skorenovac | G | 44.77° | 20.91° | 0 |
| SRB: Starčevo | G | 44.81° | 20.71° | 0 |

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Artikel/Article: Distribution and seed production of the rare, dry grassland specialist Sternbergia colchiciflora (Amaryllidaceae) in Pannonian cemeteries 371-384