

The accelerated spread of a neophyte introduced to Europe long ago – First occurrence of *Sporobolus indicus* (Poaceae) in Hungary

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Abstract – The first occurrence of *Sporobolus indicus* in Hungary is reported. The neotropical *S. indicus* is one of the oldest introduced neophytes to Europe. From the middle of the 19th century until the last decade of the 20th century, apart from a few occasional occurrences, it expanded only in the Mediterranean area. However, the number of observations has dramatically increased in the past two decades, even outside the Mediterranean region. Its recent rapid spread is evident along roads, on lawns and in tourist places subject to trampling (e.g., campsites). Tourism certainly contributes to the very successful recent diffusion of the species. Still, global warming, including the increasingly mild winters in continental Europe, can certainly enhance the establishment and further dispersal of this cold sensitive species.

Keywords: alien species, anthropochory, global warming, plant invasion, Poaceae

Introduction

The genus *Sporobolus* (Clayton et al. 2006, Peterson et al. 2014, Govaerts et al. 2021), is very rich in species (~ 200 species / 160–222 species, depending on genus delimitation), the majority of them being of tropical or subtropical origin. In the temperate zone of North America, it numbers approximately 30 indigenous species, while in Europe only *S. pungens* (Schreb.) Kunth, occurring in the Mediterranean, is considered native, excluding the species of *Crypsis* and *Spartina* that, according to some authors (e.g., Peterson et al. 2014), should also be classified in the genus *Sporobolus*. Most *Sporobolus* species found in Europe are thus alien taxa. They include both ephemerals and dangerous habitat-modifying invasive species (Hansen 1980, Verloove 2006, Celesti-Grapow et al. 2010). It is mainly the species of temperate America that spread successfully (*Sporobolus cryptandrus* (Torr.) A. Gray, *S. neglectus* Nash, *S. vaginiflorus* (Gray) Alph. Wood.) with the exception of *S. indicus* (L.) R.Br. with a tropical or subtropical origin. It was described based on specimens collected in tropical Eastern Australia (Brown 1810), but presumably it is a neotropical species (Clayton et al. 2006, POWO 2021). According to Thellung (1912), it was introduced to Europe from South America (Argentina or Brazil), more than a century and a half ago.

Currently, the occurrence of *S. vaginiflorus* (Király and Hohla 2015), *S. neglectus* (Király 2016), and *S. cryptandrus* (Polgár 1933, Török and Aradi 2017, Török et al. 2021) are known from Hungary. Out of these, *S. cryptandrus* has become a dangerous invasive species within a short time (Török et al. 2021). Although *S. indicus* is the oldest introduced *Sporobolus* species in Europe, the proliferating number of new observations (Niketić 1998, Glasnović and Jogan 2009, Celesti-Grapow et al. 2010, Lauber et al. 2018, Perić et al. 2013, Eichberger et al. 2015, Pachschröll et al. 2016, Amarell and Himpel 2020) testifies its accelerating spread.

Sporobolus indicus arrived to Europe as a vagrant with various commodities (e.g. crops), but primarily with shipments of wool (Thellung 1912, p. 654). Based on collecting data from botanists and herbalists of that time, Thellung deduced that in and near port cities in the south-west of France, in industrial areas (harbours, loading bays, wool-driers), the species was observed as early as the mid-19th century (in Bayonne and Biarritz: 1847; in Montplaisir: 1869). It emerged as a weed in the botanical garden of Montpellier in 1905 and by that time it was already naturalized in the valley of the river Orb (southern France) as well (Thellung 1912). Almost at the same time as the first observations in France, *S. indicus* was also detected by Bubani in the north-east of Spain, in the port town of Roses: Sept. 1853 (Bubani 1901). Casasayas

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(1990) erroneously thought this was the first observation of the species in Europe. Gómez-Lama et al. (2006) cited several herbarium specimens from the Iberian Peninsula. The oldest specimens in Spain were collected very close to the town of Roses, along the road and rail line connecting Montpellier and Barcelona (Figueres in 1904, Girona in 1916, Barcelona in 1910). Since then, it has been detected at several locations in the Iberian Peninsula, but its rate of spread has slowed down. It occurred in southern Spain in the past few decades (Devesa et al. 1990, Zarco 2004, Gómez-Lama et al. 2006). From Portugal, it has been known since 1944 (Pinto da Silva 1946) and it was soon further dispersed over much of the country (Almeida 1999). According to Lauber et al. (2018) and Info Flora (2021) it occurred in some places in the southern, climatologically favourable, part of Switzerland as early as in 1930, and since the late 1990s there has been a growing number of observations; nowadays it is spreading along roads and highways. In Italy, it was detected in several places in the 1930s (Fiori 1933, Montelucci 1935), but it is particularly interesting that it was discovered in Sicily only a few years ago (Galasso et al. 2015). Occasional introductions of the species were reported around wool processing plants in Germany, France, and the Czech Republic (Issler 1934, Probst 1949, Dvořák and Kühn 1966), and once after an oil exploration drilling (Rastetter 1966). In Slovenia, it was found in 2005 (Glasnović and Jogan 2009). In the Balkans, Hansen (1980) reported the species from Bulgaria. In the late 1990s it was found in Montenegro (Niketić 1998) and in Greece (Krigas et al. 1999). The species is listed in the grass-checklist of Istria, Croatia (Starmühler 2003). More recently, it has been reported from Serbia (Perić et al. 2013), Austria (Eichberger et al. 2015, Pachschwöll et al. 2016) and Germany (Amarell and Himpel 2020).

In this paper, we report the first observation of *S. indicus* in Hungary, and evaluate the prospects of its spread and the expected role of the species in European vegetation.

Materials and methods

The fieldwork was carried out in the autumn of 2021 as a part of a systematic flora survey of the Külső-Somogy region and the southern shore of Lake Balaton, Hungary. We used a MobileMapper60 satellite navigation device to record geographic coordinates. The grid number of the site is provided in accordance with the Central European Flora Mapping System (Niklfeld 1971). The herbarium acronyms mentioned in the text follow Thiers (2021).

The plant material was identified using, among others, Clayton (1965), Baaijens and Veldkamp (1991), Simon and Jacobs (1999) as well with reference to herbarium specimens found in the collections at BR and BP. The specimens collected at the new Hungarian site were deposited in the BP and BR herbaria. The nomenclature of the taxa follows the Euro+Med Plantbase (EuroMed 2006); for taxa non-native in Europe the Plants of the World Online (POWO 2021) database.

For the meaningful presentation of occurrence data and distribution of *S. indicus* in Europe, we assigned the geo-

graphic coordinates of the settlements (or larger geographic units) and the year of the observation to the published data. QGIS 2.18 software (QGIS 2022) was used to develop the cartographic representation.

Results

Sporobolus indicus was found on October 24, 2021 in the residential area of Zamárdi, characterised by detached houses with gardens (46.89088217 N, 17.979621 E, CEU-quadrat: 9173.2). About 15 specimens of *S. indicus* emerged from a mown lawn. The last mowing may have taken place in late summer. Shoot formation, flowering, and ripening must have taken place in September–October. The specimens of *S. indicus* were in the best phenophase in terms of identification, i.e. in the fruiting stage (Fig. 1). The immediate vicinity of the occurrence of the species in the recreation area of Lake Balaton, as well as in similar habitats of neighbouring settlements, were surveyed and checked systematically in the next few weeks, but no further specimens of *S. indicus* were found. Based on the 15 specimens found at only one site so far, we assume that it has been present in the lawn patch for a few years, and late autumn ripening appears to be a particularly good strategy to develop a presumably self-sustaining small population in the lawn.

The local habitat of *S. indicus* is a mown dry lawn (Fig. 2) between the sidewalk and the asphalt road, dominated by disturbance- and trampling-tolerant species of natural sandy grasslands (*Cynodon dactylon* (L.) Pers., *Bothriochloa ischaemum* (L.) Keng), with very few accompanying species



Fig. 1. *Sporobolus indicus* in fruiting stage in Zamárdi, Hungary. October 30, 2021. Photo: N. Bauer.



Fig. 2. Habitat of *Sporobolus indicus* in Zamárdi, Hungary. October 30, 2021. Photo: N. Bauer.

(*Berteroa incana* (L.) DC., *Chrysopogon gryllus* (L.) Trin., *Euphorbia seguieriana* Neck., *Petrorhagia saxifraga* (L.) Link). It is assumed that the habitat has not been overseeded, since in such semi-natural mown lawns, many species of the former sand grassland vegetation of Külsó-Somogy (see Soó 1930) can still be found. These lawns are maintained by mowing until the end of the summer holiday season, but are not treated thereafter, which is beneficial for species blooming in autumn. This is evidenced by the presence of *Spiranthes spiralis* (L.) Chevall. stocks that are found in the same type of urban habitat-islands near the occurrence of *S. indicus* (and in several settlements along the shore of Lake Balaton). Further, weed species typically introduced from large cities are also present on the streets of Zamárdi (e.g., *Cenchrus spinifex* Cav., *Eleusine indica* (L.) Gaertn., *Euphorbia maculata* L., *E. prostrata* Aiton), which is not surprising, taking into consideration the Siófok region's being one of the most popular destinations for tourists by Lake Balaton, as well as for the visitors of several pop-music festivals, resulting in about one million guest nights per year (based on the data of the Hungarian Central Statistical Office, <https://www.ksh.hu>).

Discussion

As with many adventive species in Hungary, the first observations of *Sporobolus* species can be attributed to Sándor Polgár around the railway loading area of the former Meller vegetable oil factory in Győr (Polgár 1918, 1933), but none of these records was, unfortunately, substantiated by a herbarium specimen. Some uncertainty therefore surrounds these claims and most of them also require nomenclatural updating: “*S. subinclusus* Phil.” (= *S. cryptandrus*), “*S. Argutus* (Nees) Kunth” (= *S. pyramidatus* (Lam.) Hitchc.), “*S. elongatus* (Lam.) R. Br.” (= *S. elongatus* R. Br.). The latter taxon is a member of the *S. indicus* complex (Clayton 1965, Baaijens

and Veldkamp 1991, Simon and Jacobs 1999) and very similar to *S. indicus* s.str. Until recently, these taxa had not been observed anywhere else in Hungary. *Sporobolus cryptandrus* was rediscovered in 2016 (Török and Aradi 2017, Török et al. 2021), while the discovery of *S. indicus* in 2021 is reported in this paper, but these are certainly new introductions, independent of any earlier occurrences.

While, as mentioned in the introduction, the species was initially limited to the Mediterranean region, in recent years more and more observations have been published from areas further north, outside the Mediterranean: from Serbia (Perić et al. 2013), Austria (Eichberger et al. 2015, Pachschröck et al. 2016), France (Tinguy 2016, Amblard et al. 2018), and Germany (Amarell and Himpel 2020) although in some cases it is uncertain whether genuinely naturalized populations are involved. However, even in areas where *S. indicus* used to be an ephemeral alien, it is obviously in the process of initial naturalization. In Belgium, for instance, where it has been known since 1886 as a repeatedly introduced but strictly casual wool and grain alien (Verloove 2006), it naturalized locally in recent years, especially – as in Hungary – in lawns. The same applies, even further north, to the Netherlands where it was found, among other places, in campsites, resulting from the unintentional introduction of seeds by tourists returning from southern Europe (Verloove et al. 2020), an introduction vector that is potentially similar to the one observed in Hungary.

Pre-World War I data are almost exclusively from the vicinity of ports or along roads and railways and each documented the rapid spread of the species. Unsurprisingly, *S. indicus* is one of the first neophytes to be recognized as a species spreading along roads and railways (Codina 1908, Cadevall 1911). We believe that earlier conditions for the transportation of crops may have facilitated the spread of many introduced species. Thellung (1912) mentioned one of the oldest European data (Montplaisir 1869) related to a

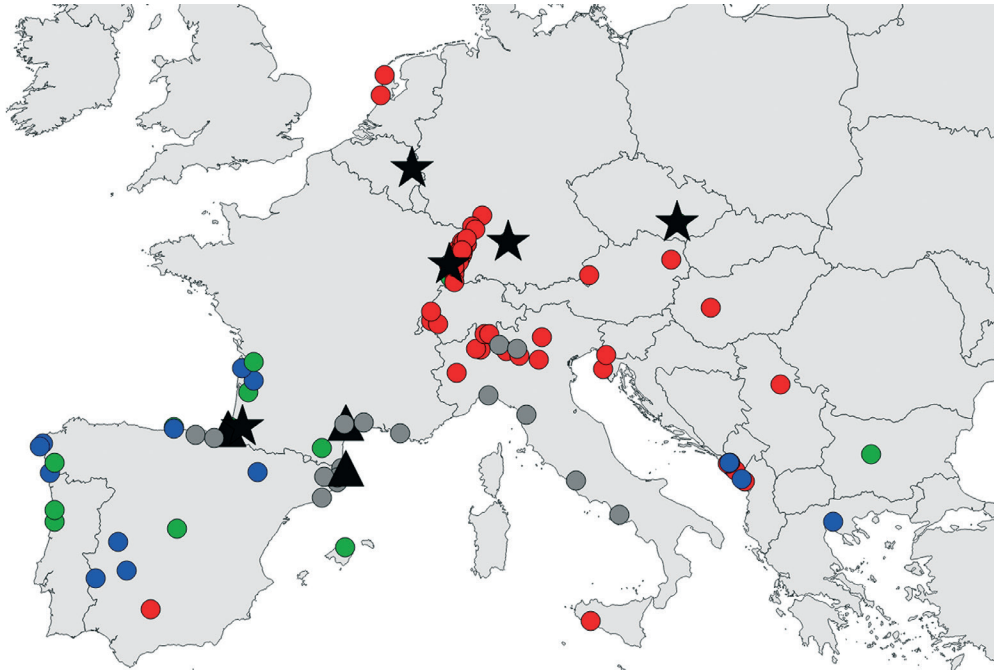


Fig. 3. Distribution of *Sporobolus indicus* in Europe based on published data. Legends are indicated on the map (black triangle: 1850–1900; grey circle: 1901–1950; green circle: 1951–1980; blue circle: 1981–2000; red circle: 2000–; black star: casual introductions to industrial areas).

wool drying plant, and it is noteworthy that it was also discovered much later at some sites of wool processing plants in Western and Central Europe (Issler 1934, Probst 1949, Dvořák and Kühn 1966), but these were casual occurrences in all cases. In the Mediterranean and Atlantic areas of Europe, it gradually spread in the 20th century, but by now it has colonised large parts of southern France, Italy, and Spain (Kerguelen 1975, Celesti-Grapow et al. 2010, Tison et al. 2014). Further north, it has reached northwestern France (Tinguy 2016, Amblard et al. 2018), Belgium, and even the Netherlands (Verloove 2006, Verloove et al. 2020), although this can only partially be explained by changing climate: its distribution area towards the north becomes fragmented, there is no gradual expansion of its entire secondary distribution area. On the contrary, in Western Europe, while plants of *S. indicus* introduced a long time ago were not able to survive and were thus mere ephemerals, this species has adapted to the local climate. In the climatologically less favourable areas (mostly with a more continental climate) it is still rare or was only detected long ago, as a casual alien (e.g., Pyšek et al. 2012).

Based on published and confirmed data, it is obvious that *S. indicus* crossed the Mediterranean and Atlantic sub-areas of Europe only in the last 2–3 decades (On-line Suppl. Tab. 1, Fig. 3). Although several older data are missing and some data may be questionable or inaccurate, the visualization of the GBIF data retrieved from herbaria and citizen science (Fig. 4) clearly shows that *S. indicus* has spread widely in France, Belgium, and in northwestern Italy (GBIF.org. 2022). The acceleration of its spread over the past few decades is observable, also in the Mediterranean region (Veldkamp 1990, Krigas et al. 1999, Lakušić et al. 2004, Galasso et al. 2015). Sporadic occurrences of the kind observed in the in-

ternal, continental areas of Europe over the past decade are also typically reported from areas with intense human pressure, mostly in cities or along roads (Eichberger et al. 2015, Meneguzzo et al. 2016, Amarell and Himpel 2020, etc.). Its accelerated spread clearly evidences anthropogenic spread associated with transportation and successively increasing vehicle traffic, as has been observed for other adventitious *Sporobolus* species. As it is a tropical and subtropical species, however, it also seems likely that increasingly mild winters and hot summers have also contributed to its successful spread, especially in urbanised areas with a more continental climate, where expected temperature increase may considerably exceed the global warming rate (Bartholy et al. 2009). Based on the experience with *S. indicus* elsewhere in Europe, it can be expected to spread further rapidly – but it will probably appear in habitats of strong anthropogenic impact, in settlements, along roads, and in trampled weed associations.

According to Casasayas (1990), *S. indicus* is a highly invasive species; its local invasion has already been observed in Austria (Englmaier and Wilhalm 2018). As it has so far appeared only in ruderal habitats of Central Europe, it does not seem to be as dangerous as *S. cryptandrus*, which has become a vegetation-transformer invasive species in the sandy areas of the Pannonian Basin within a few years (Török et al. 2021). It should also be noted that the behaviour of *S. indicus* in natural habitats has remained largely unknown. However, the massive spread of closely related species of the *S. indicus* complex (e.g., *S. africanus* Poir., *S. fertilis* (Steud.) Clayton) poses a serious ecological challenge in several areas (USA, Australia, New Zealand, and South Africa), and a number of methods have been developed to control them and curb their spread (e.g., Palmer 2004). The

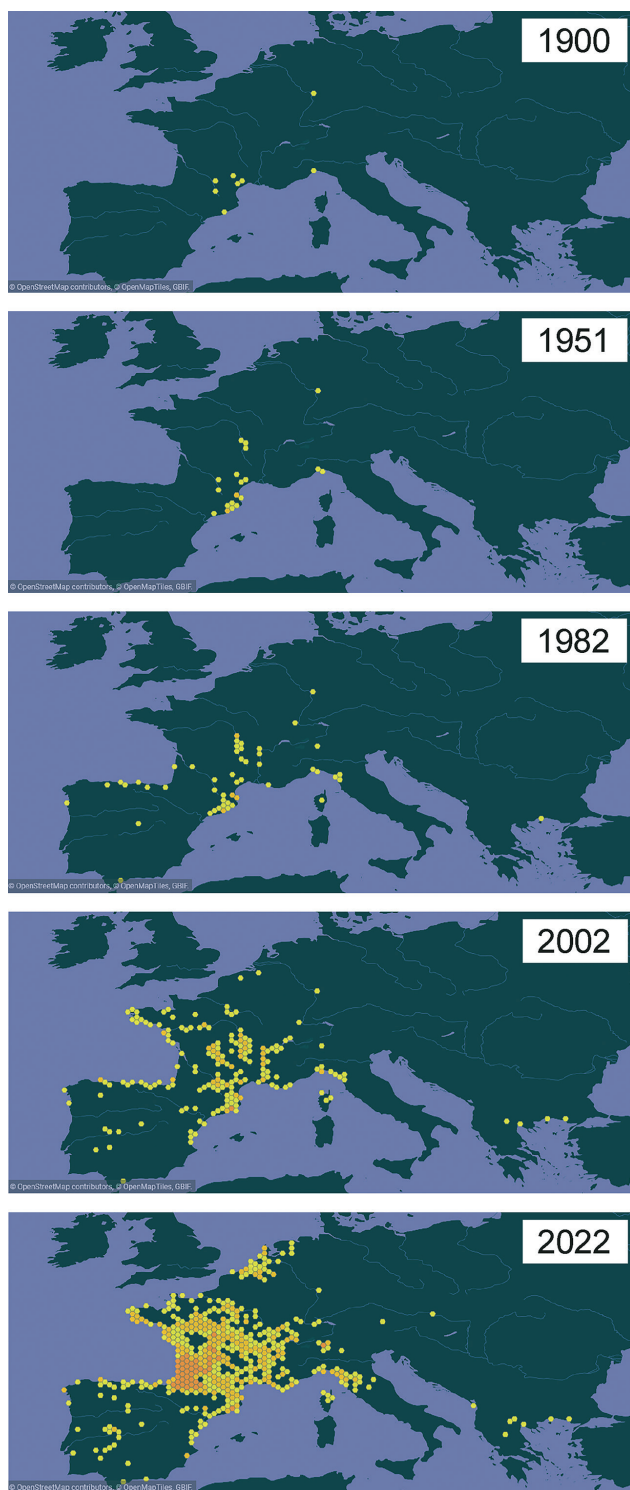


Fig. 4. Distribution and spread of *Sporobolus indicus* in Europe from 1900 to 2022 based on GBIF data (GBIF.org. 2022).

monitoring and control of the occurrence of *S. indicus* in Europe is of great importance for the conservation of grasslands close to nature.

Acknowledgments

We thank everyone who helped us, Annamária Hűvös-Récsi, Zoltán Kenyeres, András Márkus in the fieldwork and with their remarks. Angéla Matuszka, João Almeida, Gábor

Papp, and Dávid Schmidt assisted in collecting the references. The authors would like to express their gratitude to the two anonymous reviewers for their remarks.

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