

Overview on alien *Carex* species of section *Cyperoideae* (including *Ovales*) in Europe and the discovery of *Carex scoparia* in Austria

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Abstract

Based on an extensive survey of literature, a compilation of the alien *Carex* species of section *Cyperoideae* (including section *Ovales*) in Europe is presented. In total, nine species (*C. bebbii*, *C. brevior*, *C. crawfordii*, *C. cristatella*, *C. muskingumensis*, *C. pachystachya*, *C. praticola*, *C. scoparia*, and *C. tribuloides*) have been recorded as aliens so far. In addition the nomenclature of *C. bebbii* (OLNEY ex BAILEY) FERNALD is discussed. The invasion history and ecology of the North American *Carex scoparia* is presented in detail. It was first recorded in Europe in 1982 in Slovakia, and has recently been found in Belgium and the Netherlands. In Austria it was found by the second author for the first time in 2009 in Upper Austria. Since then, the population size has substantially increased and the species has become locally established in a disturbed wetland, dominated by species of wet tall herb and reed vegetation. To document the further spread of alien *Carex* species in Europe, their inclusion into standard floras is highly recommended.

Key words: alien species, neophytes, *Carex scoparia* (broom sedge), *C. bebbii*, *C. brevior*, *C. crawfordii*, *C. cristatella*, *C. muskingumensis*, *C. pachystachya*, *C. praticola*, *C. tribuloides*, *C. section Cyperoideae*, *C. section Ovales*, Cyperaceae, Flora of Austria.

Zusammenfassung

Eine Zusammenstellung der fremdländischen *Carex*-Arten aus der Sektion *Cyperoideae* (inklusive Sektion *Ovales*) in Europa wird, basierend auf einer umfassenden Literaturschau, präsentiert. Bislang wurden insgesamt 9 *Carex*-Arten aus dieser Sektion als Neophyten (*C. bebbii*, *C. brevior*, *C. crawfordii*, *C. cristatella*, *C. muskingumensis*, *C. pachystachya*, *C. praticola*, *C. scoparia* und *C. tribuloides*) in Europa nachgewiesen. Die Nomenklatur von *C. bebbii* (OLNEY ex BAILEY) FERNALD wird eingehend besprochen. Die Verschleppung und Ökologie der nordamerikanischen *C. scoparia* in Europa wird diskutiert. Dieser Neophyt wurde erstmals 1982 in der Slowakei nachgewiesen, und ist vor kurzem auch aus Belgien und den Niederlanden gemeldet worden. In Österreich wurde diese Art erstmals 2009 vom zweiten Autor in Oberösterreich gefunden. Seither hat die Populationsgröße deutlich zugenommen, und die Art hat sich in einem gestörten Feuchtgebiet in von Hochstauden und Röhrichtarten dominierter Vegetation lokal etabliert. Um die weitere Ausbreitung neophytischer *Carex*-Arten in Europa zu beobachten, empfehlen wir sehr ihre Aufnahme in Florenwerke.

Introduction

Recent molecular studies revealed that members of *Carex* section *Cyperoideae* G.DON are embedded in the large section *Ovales* KUNTH (HIPPI et al. 2006, HIPPI 2008b, Andrew L. Hipp via email 15.1.2015). A fusion of both sections is thus necessary and the older name *Cyperoideae* has to be adopted. This name derives from *Carex cyperoides* and con-

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fusingly bears, by coincidence, the same ending as generally used to define subfamilies. It is, however, in concordance with the rules of the International Code of Nomenclature for Algae, Fungi, and Plants (MCNEILL et al. 2012).

According to "Flora of North America" (MASTROGIUSEPPE et al. 2002), the complex and difficult section *Ovales* KUNTH is the largest section of *Carex* in North America. In the USA and in Canada 72 of the ca. 85 known species occur. The few remaining species are distributed in Mexico, the West Indies, Bermuda, Central and South America, and in Eurasia. The former section *Ovales* is represented in Europe only by two native species: the widespread *Carex leporina* L. (syn. *C. ovalis* GOOD.) and *C. macloviana* D'URV. in Northern Europe (CHATER 1980, KOOPMAN 2011). Section *Cyperoideae* consisted, as traditionally circumscribed, only of two species of which one is native in Europe, namely *Carex bohemica* SCHREB. (syn. *C. cyperoides* L.).

Most of the species in section *Cyperoideae* (including section *Ovales*) are closely related and thus morphologically similar. Differences are minute and consist often only of modifications in size and proportions of the utricles (perigynia)! The identification keys for the North American species (MASTROGIUSEPPE et al. 2002) are the most comprehensive ones and should, therefore, be used. They are also available online (<http://flora-northamerica.org/>). The two European species *C. leporina* and *C. macloviana* are also included! These keys are indispensable because additional American species belonging to this section are expected to be introduced into Europe in the future!

In the present study, we list (based on an extensive survey of literature) the currently known alien *Carex* species of section *Cyperoideae* sensu lato in Europe. Further, we discuss the ecology and spread history of *C. scoparia* in Europe and present the first record of this species in Austria. We characterize the Austrian population phytosociologically with two relevés according to BRAUN-BLANQUET (1964) and compare these with further relevés from Slovakia (ŘEPKA et al. 1997) (Table 1).

Species of the *Carex* section *Cyperoideae* (including *Ovales*) reported as aliens in Europe

So far, nine species belonging to this section have been reported as aliens in Europe. As these taxa belong to a very complex and taxonomically difficult group, some of the corresponding vouchers may need to be checked by American specialists.

***Carex bebbii* (OLNEY ex BAILEY) FERNALD:** This species was first collected in Central Europe in 1991 in Nordtirol (northern part of Tyrol) in Austria (WALLNÖFER 1993: with a color photo!). The identification of the corresponding specimens was confirmed by R.F.C. Naczi (NY) in 2005. The report for Vienna (FISCHER et al. 2008) is, on the contrary, erroneous. The first author has seen only a fragment of the original material as well as badly prepared specimens from plants cultivated by K. Oswald. Unfortunately, these specimens could not be identified. In Sweden *C. bebbii* was collected from 1980 onwards and is known already from 11 provinces (KARLSSON 2012, see also LIDBERG & LINDSTRÖM 2010, STENBERG 2010: with a color photo!). Its fruits are probably an impurity in grass "seed"-mixtures imported from North America to grass slopes and embankments of motorways (superhighways) and roadsides in Sweden (KARLSSON 2012). There

it is regarded now as "resident but new" instead of being classified just as a casual by KARLSSON & AGESTAM (2014). In the past it was often misidentified as *C. tribuloides* by Swedish botanists. KOOPMAN (2011 and 2015) reported *C. bebbii* also from the Netherlands. The corresponding collection (a duplicate is also in W) was only provisionally identified as such by the first author and needs, therefore, further study and confirmation by a specialist.

Note on taxonomy: The authors of this taxon are given erroneously as "(L.H.BAILEY) OLNEY ex FERNALD" in the treatment for Flora of North America (MASTROGIUSEPPE et al. 2002), in TPL (2015), and in IPNI (2015). The name "*Carex bebbii* OLNEY" was used for a series of exsiccata and is according to FERNALD (1902) and MCNEILL et al. (2012: Recommendation 50B.1, Ex.1), a nomen nudum. It was BAILEY (1889) who validated Olney's name at the rank of a variety: *Carex tribuloides* WAHLENB. var. *bebbii* OLNEY ex BAILEY. This variety was later raised to the rank of a species by FERNALD (1902). The correct authorship is thus "(OLNEY ex BAILEY) FERNALD". The word "ex" follows the source, namely the name of the person who coined the name of the taxon. It was BAILEY who took up the name first. An invalid name (such as "*Carex bebbii* OLNEY") does not have a rank in botanical taxonomy. These facts have already been pointed out by WALLNÖFER (1993).

***Carex brevior* (DEWEY) MACK. ex LUNELL:** collected in 1954 in Västergötland in Sweden (BLOM 1961, BERTILSSON et al. 2002, KARLSSON 2003) and classified as a casual by KARLSSON & AGESTAM (2014).

***Carex crawfordii* FERNALD:** reported from the Netherlands (KERN & REICHEL 1932, 1954, HELD & KORTSELIUS 1964; KOOPMAN 2011, 2015), Belgium (DUVIGNEAUD & SCHUMACKER 1977, LAMBINON & VERLOOVE 2012), the federal state of Rheinland-Pfalz in Germany (GALUNDER & PATZKE 1988a, 1988b, compare also <http://www.deutschlandflora.de/>), as a grass-seed alien from four provinces in Sweden (NILSSON 2008, KARLSSON 2012, LÖFGREN 2013), from the United Kingdom (CLEMENT & FOSTER 1994, SELL & MURRELL 1996, JERMY et al. 2007), and from France (Tela Botanica 2015, TISON & FOUCAULT 2014).

***Carex cristatella* BRITTON & A.BR.:** A specimen of this species was collected in 1854 in Linz in Austria (WALLNÖFER 2006). Recently, it has also been found at one site in Germany (BUTTLER 2002, see also HEMM 2008).

***Carex muskingumensis* SCHWEIN.:** This species is often cultivated and was found as an escapee apparently for the first time in 1947 in the Czech Republic (JEDLIČKA 1949, GRÜLL 1952, see also PYŠEK et al. 2012). According to ŘEPKA & GRULICH (2014), it was cultivated there at first on the exhibition (fair) grounds in Brno and appeared afterwards on a dumping-ground in Brno-Pisárky where it persisted several years. In 2010 it was found in Bohemia along the Vltava river (Moldau) between the villages "Řež" and "Libčice nad Vltavou" (in the north of Prague), and in 2012 in a floodplain forest near "Vranovice" in southern Moravia. It was reported also from Germany (KRAMER 1992, compare also <http://www.deutschlandflora.de/>), the Netherlands (KOOPMAN 2011, 2015), Belgium (LAMBINON & VERLOOVE 2012), and temporarily as a casual from Sweden (KARLSSON 2012, KARLSSON & AGESTAM 2014). In Austria it was detected along a rivulet downstream from a market-garden near the western border of Vienna (A. Mrkvicka

via email). A specimen is present in the herbarium of the Naturhistorisches Museum Wien (W) and bears the following information: Mauerbach-Retentionsbecken, 7763/3, 9 August 2002, A. Mrkvicka 3863 (a color photo of a living plant is shown on page 663 in KOOPMAN 2011).

***Carex pachystachya* CHAM. ex STEUD.** [= *C. macloviana* subsp. *pachystachya* (CHAM. ex STEUD.) HULTÉN]: reported as a grass-seed alien from four provinces in Sweden by ÅSTRÖM (2003), LARSSON (2010), LIDBERG & LINDSTRÖM (2010), and KARLSSON (2012), and classified as a casual by KARLSSON & AGESTAM (2014).

***Carex praticola* RYDB.**: reported as a grass-seed alien from Sweden by ARONSSON (1992), WANNTORP (1994), KARLSSON (1998, 2012), RYDBERG & WANNTORP (2001), JONSELL (2010), STENBERG (2010), LIDBERG & LINDSTRÖM (2010), MOSSBERG & STENBERG (2010), and indicated only as a casual by KARLSSON & AGESTAM (2014). According to KARLSSON (2012), it was erroneously indicated by some of the aforementioned authors as "*C. straminea*", a species which has not been found in Scandinavia so far. *C. praticola* is also indicated for Norway by GBIF (2015), and Discoverlife (2015).

***Carex scoparia* SCHKUHR ex WILLD.**: see below.

***Carex tribuloides* WAHLENB.**: According to KARLSSON (2012), it was found in Sweden only from 1938 to 1947. Nearly all of the more recent reports (ERICSSON 1984, 1999, WANNTORP 1994, RYDBERG & WANNTORP 2001, EDQVIST & KARLSSON 2007, MOSSBERG & STENBERG 2010) are based on misidentifications of *C. bebbii*. *Carex tribuloides* is classified as a casual by KARLSSON & AGESTAM (2014).

The accidental introduction of *Carex scoparia* to Europe

Carex scoparia was collected here for the first time in 1982 and later on the 3rd August 1992 [date according to a handwritten correction in the reprint, which was sent to the first author] in two nearby localities in eastern Slovakia (ŘEPKA et al. 1997). Duplicates of the second collection were sent to the first author and are now deposited in B and W (acronyms of herbaria according to THIERS 2015). *C. scoparia* was included in the Slovakian checklist of alien plant species (MEDVEČKÁ et al. 2012). – From 2012 onwards, it has been observed in one locality in the Netherlands (see MAPB 2015, and <http://waarneming.nl/soort/view/317242>). This record was published recently by KOOPMAN (2015). In 2013, a few plants were discovered "on the verge of an artificial water body" in Hechtel in Belgium (MAPB 2015). – It was also accidentally introduced into New Zealand and Australia (GCW 2015, NZPCN 2015, JOHNSON 1998, HEALY & EDGAR 1980).

Infraspecific taxa of *Carex scoparia*

MASTROGIUSEPPE et al. (2002) recognized two varieties: var. *scoparia* and var. *tessellata*. The former is widespread in the USA and in southern Canada, whereas the latter is reported as an endemic of the areas near the coast in Maine (northeastern USA) and in adjacent New Brunswick (Canada). LOVIT & HAINES (2012) considered the latter to be a good species and called it *C. waponahkikensis*. According to them, it is restricted to the extreme eastern part of Maine along the coastal plain, where only ca. 12 populations are known. The putative collections from adjacent Canada turned out to be misidentifications.



Fig. 1: on top: View of the growing site of *Carex scoparia* near Rohr im Kremstal in Upper Austria; – on bottom: Detail of the growing site. The species is co-dominant with *Typha latifolia*. F. Essl, 12th July 2012.



Fig. 2: Inflorescences of *Carex scoparia* from plants transplanted from Rohr im Kremstal and cultivated in the Botanical Garden of the University of Vienna. © B. Wallnöfer, 3th June 2015.

Habitats and ecology of *Carex scoparia*

In its native range, *C. scoparia* grows in a wide range of wetland types and it shows a high tolerance to disturbance. In the Flora of North America, *C. scoparia* var. *scoparia* is reported from "wet to dry, open habitats, usually on acidic, often sandy soils at 0–2000 m altitude" (MASTROGIUSEPPE et al. 2002). In Maine, it grows "in poorly drained fields and ditches, roadsides, edges of woods and wetlands, and in disturbed areas" (ARSENAULT et al. 2013). In Virginia, it occurs in "a wide range of natural and disturbed wetlands, including bogs, fens, seeps, seepage swamps, montane depression ponds, wet meadows, ditches, alluvial clearings, beaver marshes, and other disturbed habitats", and is classified as being "often weedy" (WEAKLEY et al. 2012). HAINES (2011) reports it from "xeric to hydric open soils such as fields, roadsides, ditches, and wetland edges". In the Midwest of the USA, it grows in "wet open woods, wet prairies, wet meadows, seeps, calcareous fens, swamps" (MOHLENBROCK 2005), and in Missouri it occurs in "bottomland, prairies, upland prairies, margins of ponds and sinkhole ponds, and marshes, also in moist pastures, roadsides, and ditches, sometimes in emergent aquatics" (YATSKIEVYCH 1999). In the pacific northwest of the USA, *C. scoparia* is reported from "marshes and wet mead-

ows, generally growing in water or saturated soils" (WILSON et al. 2008). HIPP (2008a) noted: "most common in open, wet, sandy soil; occasionally in microsites that are more or less bare of other vegetation. The species ranges from shallow water (base of plant submerged) to, rarely, dry sandy uplands and from sun to partial shade. Typical habitats include marshes, sedge meadows, lakeshores, ditches, wet prairies, and occasional sphagnum bogs". – Plants cultivated in the Botanical Garden of Vienna (see below) grow very vigorously and flower over an extended period, thus, flowering and fruiting stems occur together. The nodes of stems are well spaced proximally.

The discovery and habitat of *Carex scoparia* in Austria

The site of *C. scoparia* in Austria is located in the Alpine Foothills of Upper Austria (Oberösterreich) near the village of Rohr im Kremstal. The population was discovered by the second author the 12th June 2009 in an at that time newly constructed artificial basin of ca. 600 m² size for sedimentation (Fig. 1) near a roundabout. At this time, the population size was small, only ca. 5 plants were found. The sedge, which was unknown to the second author, was collected and vouchers were deposited in his private herbarium and later shown to the first author for identification.

On the 12th July 2012 and 11th August 2013, the locality was revisited by the second author. Since 2009, the population had expanded strongly, and now consisted of several 100 plants. *C. scoparia* was growing very vigorously; the largest individuals had fertile culms of more than one meter of length and exceeded the dimensions given by ŘEPKA et al. (1997) for the Slovakian populations. Overall, the population can be assumed to be locally established. In the vicinity, suitable habitats are lacking, thus no plants of *C. scoparia* were recorded there.

At the site in Austria, *C. scoparia* colonizes an occasionally flooded wetland dominated by tall herb and reed plant species such as *Juncus effusus*, *Phalaris arundinacea* and *Typha latifolia*. These are accompanied by further species of moist habitats (*Lathyrus pratensis*, *Poa trivialis*, *Symphytum tuberosum*), and by juvenile trees (*Alnus glutinosa*, *Salix caprea*) (Tab. 1, Fig. 1). Drier microsites were not colonized. The habitat characteristics match closely the habitats reported by ŘEPKA et al. (1997) for the Slovakian populations.

In the alien range in Europe, the few records of *C. scoparia* match closely the habitats reported for North America. In Slovakia, *C. scoparia* has been recorded from a *Caricion gracilis* community of the floodplain of the Latorica river (ŘEPKA et al. 1997), which is dominated by *Carex gracilis*, *C. riparia*, and *Agrostis stolonifera* (Tab. 1, relevés 3–5). In Austria, *C. scoparia* occurs in an occasionally flooded and disturbed wetland which is dominated by species of wet tall herb and reed vegetation. Similarly, in Belgium it was recorded from the disturbed verge of an artificial water body (MAPB 2015).

Vouchers: Austria, federal state Oberösterreich (Upper Austria): wet, artificial basin for sedimentation next to the traffic circle (roundabout) ca. 0.6 km SE from the church in Rohr im Kremstal, 347 m, 48°3'46" N, 14°11'41" E, 12 June 2009, F. Essl s.n. [Herb. Essl, W], 11 August 2013, F. Essl s.n. [Herb. Essl, W]; – cultivated in the Botanical Garden of the University of Vienna, 15 July 2014, B. Wallnöfer 14912 [B, GZU, KL, LI, M, MA, NY, P, W, WU, further duplicates to be distributed], 3 June 2015, B. Wallnöfer 14943 [W, WU].

Tab. 1: Relevés with *Carex scoparia* from Austria, Rohr im Kremstal, 11.7.2012, F. Essl (numbers 1–2) and Slovakia, Latorice floodplain, 11.8.1994, ŘEPKA et al. 1997 (numbers 3–5). – Relevé 1: E-part of the sedimentation basin, 30 m², vegetation cover 100%; – relevé 2: W-part of the sedimentation basin, 30 m², cover 100%; – relevé 3: margin of a moist depression, 25 m², cover 85%; – relevé 4: margin of an oxbow, 25 m², cover 85%; – relevé 5: margin of an oxbow, 16 m², cover 75%; – KS = herb layer. The nomenclature of the species follows FISCHER et al. (2008).

Species / relevé no.	1	2	3	4	5	Species / relevé no.	1	2	3	4	5
<i>Carex scoparia</i>	3	3	1	3	2	<i>Carex acuta</i>	.	.	1	3	.
<i>Carex hirta</i>	2	2	.	.	.	<i>Carex vulpina</i>	.	.	1	+	.
<i>Typha latifolia</i>	2	1	.	.	.	<i>Poa palustris</i>	.	.	+	1	.
<i>Vicia tetrasperma</i>	1	.	.	.	.	<i>Elymus repens</i>	.	.	+	.	.
<i>Agrostis stolonifera</i>	2	.	3	2	1	<i>Lysimachia vulgaris</i>	.	.	1	1	1
<i>Phalaris arundinacea</i>	2	2	.	.	.	<i>Potentilla anserina</i>	.	.	1	1	1
<i>Symphytum officinale</i>	+	.	.	.	.	<i>Potentilla reptans</i>	.	.	+	.	+
<i>Epilobium parviflora</i>	1	1	.	.	.	<i>Inula britannica</i>	.	.	1	1	.
<i>Alnus glutinosa</i> (KS)	1	.	.	.	.	<i>Lythrum salicaria</i>	.	.	+	+	+
<i>Juncus effusus</i>	3	1	.	.	.	<i>Galium palustre</i>	.	.	+	1	1
<i>Poa trivialis</i>	1	2	.	.	.	<i>Leersia oryzoides</i>	.	.	+	+	.
<i>Equisetum arvense</i>	+	+	.	.	.	<i>Iris pseudacorus</i>	.	.	r	r	r
<i>Cirsium arvense</i>	+	+	.	.	.	<i>Ranunculus repens</i>	.	.	r	.	.
<i>Ranunculus repens</i>	r	.	.	r	+	<i>Mentha arvensis</i>	.	.	r	r	+
<i>Fraxinus excelsior</i> (KS)	r	+	.	.	.	<i>Sium latifolium</i>	.	.	r	r	.
<i>Rumex crispus</i>	+	+	.	.	.	<i>Veronica longifolia</i>	.	.	.	+	.
<i>Epilobium hirsutum</i>	+	1	.	.	.	<i>Leonurus marrubiastrum</i>	.	.	.	r	.
<i>Tussilago farfara</i>	.	+	.	.	.	<i>Lycopus exaltatus</i>	.	.	.	r	.
<i>Phleum pratense</i>	.	+	.	.	.	<i>Carex riparia</i>	.	.	.	.	2
<i>Festuca pratensis</i>	.	3	.	.	.	<i>Vicia cracca</i>	.	.	.	.	r
<i>Calystegia sepium</i>	.	1	.	.	1	<i>Alisma plantago-aquatica</i>	.	.	.	.	r
<i>Juncus articulatus</i>	.	+	.	.	.	Total species number	17	17	17	18	15

Key for the species of *Carex* section *Cyperoideae* reported from Austria

This key is adapted from "Key to *Carex* sect. *Ovales* east of the Rocky Mountains" (MASTROGIUSEPPE et al. 2002). *Carex bohémica* is added here. After the use of this key, it is strongly recommended to confirm any results with the comprehensive keys for the North American species (for further details see the introduction).

- 1 Spikes head-like clustered on top of culms; bracts 2–5, leaf-like, much longer than the inflorescence *C. bohémica*
- 1* Plant not as above 2
- 2 Pistillate scales uniformly as long as mature perigynia (utricles), concealing beaks *C. leporina* (*ovalis*)

- 2* Pistillate scales shorter than perigynia at least in middle portions of spikes; apical portion of scales narrower than beaks and not completely covering them 3
- 3 Perigynia more than 2 mm wide, 6–9 mm long; female spikes 12–28 mm long *C. muskingumensis*
- 3* Perigynia 2 mm wide or less, less than 6 (–6.8) mm long; female spikes less than 10 (–16) mm long 4
- 4 Perigynia not winged to base, with beak and distal body of perigynium spreading or recurrent at 80° angle or greater; spikes globose; leaf sheaths somewhat expanded towards apex, bearing narrow wings continuous with midvein and edges of leaf blade; vegetative shoots tall, conspicuous, with numerous leaves spaced along distal ½ of culm *C. cristatella*
- 4* Perigynia winged to base, with beak and distal body of perigynium not as above; spikes different; leaf sheaths with ± rounded edges, not distinctly expanded towards apex; vegetative shoots usually inconspicuous, with relatively few leaves clustered at apex 5
- 5 Perigynia [including beaks] (2.5–) 2.8–4 times as long as wide, body lanceolate to elliptic, distance from beak tip to top of achene 2.2–4.8 mm; spikes ellipsoid *C. scoparia*
- 5* Perigynia 1.9–2.5 times as long as wide, body ovate or elliptic, distance from beak tip to top of achene 1.2–2.2 mm; spikes ovoid to globose *C. bebbii*

Conclusions

Until recently, only relatively few *Carex* species have been recorded as alien in Europe. For instance, DAISIE (2009) reports only 11 species of this genus as alien for the European flora. However, based on a thorough analysis of literature, we could show that from the species-rich section *Cyperoideae* (including *Ovales*), of the 72 species native to the USA and Canada, currently nine species are alien in Europe. Some of these species are established in several countries, and seem to be expanding (*C. bebbii*, *C. crawfordii*, *C. scoparia*). Due to the difficult identification of these species, expert knowledge and herbaria vouchers are required for identification. In particular, the inclusion of these alien *Carex* species into European standard floras is highly recommended, as otherwise misidentifications are likely.

The first record of *C. scoparia* in Austria is the fourth alien species from the section *Cyperoideae* for this country. The rapid increase in population size, which has resulted in a local establishment within a few years, testifies its further spread potential. Therefore, the further spread of this species in Austria and beyond should be monitored.

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