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Krzysztof Spalik, Faculty of Biology, University of Warsaw, Poland

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JK, HW: collected the material and analyzed the data, image documentary; JK: idea of the study, species determination, writing the first draft of the manuscript; HW: revision and the first version of the manuscript; MW: mapping the distribution

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No competing interests have been declared.

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ORIGINAL RESEARCH PAPER

Distribution of *Carex pallidula* (Cyperaceae) in Europe

Jacob Koopman¹, Helena Więclaw^{2*}, Marcin Wilhelm²¹ Kochanowskiego 27, 73-200 Choszczno, Poland² Department of Plant Taxonomy and Phytogeography, Faculty of Biology, University of Szczecin, Wąska 13, 71-415 Szczecin, Poland* Corresponding author. Email: wieclawh@univ.szczecin.pl**Abstract**

Carex pallidula is a European species which is often overlooked because it is similar in appearance to *C. digitata*. So far, this species has been recorded from ten European countries. During herbarium studies in 2014 and 2015, the occurrence of *C. pallidula* was confirmed for another six European countries (Albania, Austria, Greece, Romania, Serbia, and Switzerland), providing a new insight into its distribution. A list of new localities of *C. pallidula* and a distribution map for Europe are provided. A key for determining some taxa within the section *Clandestinae* is presented. Finnish material of the supposed hybrid of *C. digitata* and *C. pallidula* is considered to be young specimens of *C. digitata*.

Keywords*Carex digitata*; *Clandestinae*; *Digitatae*; new localities**Introduction**

Fristedt [1] distinguished in his thesis one variety of *Carex digitata* L., and named it var. *pallens* Fristedt. However, Kükenthal [2] treated it only as a form of *C. digitata*, f. *pallens* (Fristedt) Kük. Domin [3] distinguished another form, f. *eurycarpa* Domin, which appeared to be identical to f. *pallens* [4]. Mäkinen [5] compared the morphological characters and phenology of *C. digitata* var. *pallens*, *C. digitata* s. s., and *C. rhizina* Blytt ex Lindblom [syn. *C. pediformis* subsp. *rhizodes* (Blytt) H. Lindb.]. He pointed out that *C. digitata* var. *pallens* is morphologically intermediate between *C. digitata* and *C. rhizina*. This opinion was supported by Chater [6]. Harmaja [7] made a thorough study of the material and raised the taxon to species level, *C. pallens* (Fristedt) Harmaja. Unfortunately, Harmaja had overlooked an earlier homonym described by Wang [8]. Therefore, Harmaja [9] corrected the name to *C. pallidula*, which is now the accepted name [10].

Carex pallidula Harmaja is similar to *C. digitata* and the differences are rather subtle [4,7]. In general appearance, *C. pallidula* is more upright and taller than *C. digitata* and the inflorescences are usually longer than the leaves, in contrast to *C. digitata*. Besides, specimens of *C. pallidula* are a bit paler in color because the female glumes are pale brown, rather than reddish-brown as in *C. digitata*. Similarly, the lowest bract sheath is usually paler and more greenish than that of *C. digitata*, which is always reddish-purple. However, the most reliable features are the size and form of the utricles (e.g., [7,11,12]). Holub [11] gives drawings of the utricles of both species, in which the differences are obvious (see also the photograph in Harmaja [7]). According to Holub [11], *Carex pallidula* has smaller utricles, 2.9–3.6 mm long, which are more shining and have a very short, blunt beak, while *C. digitata*'s utricles are longer, 3.4–4.2 mm, more hairy and with a longer, tapering beak. Harmaja [7] gives slightly bigger sizes of the utricles: 3.3–3.7 mm long for *C. pallidula* and 3.8–4.2 mm long for *C. digitata*.

Carex pallidula and allied species have been grouped into section *Clandestinae* G. Don [syn. *Digitatae* (Fries) Christ] [6,12,13]. Nine taxa in this section occur in Europe: *C. digitata*, *C. glacialis* Mack., *C. humilis* Leyss., *C. ornithopoda* Willd. subsp. *ornithopoda*, *C. ornithopoda* subsp. *ornithopodioides* (Hausmann) Nyman, *C. pallidula*, *C. pediformis* C. A. Mey var. *pediformis*, *C. pediformis* var. *macroura* (Meinsh.) Kük., and *C. rhizina* [6,12–14]. Although the taxa within the section *Clandestinae* are rather similar in appearance, they have been demonstrated to be an artificial group. The section is polyphyletic despite the fact that all the species look alike (P. Jiménez-Mejías, personal communication, 2016). There are only a few hybrids known within this section. The one which is relatively most common is *C. ×dufftii* Hausskn. (*C. digitata* × *C. ornithopoda*), known from North(-East) and Central Europe [14]. The hybrid *C. digitata* × *C. rhizina* has been recorded for Norway [15], whereas *C. digitata* × *C. pallidula* has been reported from Finland [7].

Carex pallidula is a temperate-European species with a disjunctive range [16]. It occurs in Northern Europe [4,5,7,17] and in some central and southeastern parts of Europe, from the highlands in the south of Poland to the northern part of the Balkan Peninsula [4,7,11,18,19]. Jiménez-Mejías and Luceño [20] reported a similar distribution pattern for this species, but the map shows the Caucasus by mistake. They erroneously merged *C. pallidula* with *C. pamirica* var. *dichroa* (Malyshev) T. V. Egorova [20]. According to Koopman [14], *Carex pallidula* is currently known from the following nine countries worldwide: Norway, Sweden, Finland, Russia, Poland, the Czech Republic, Slovakia, Slovenia, and Montenegro. Additionally, it is also known from Bulgaria [21].

Material and methods

The available material of *C. digitata*, *C. ornithopoda* subsp. *ornithopoda*, *C. ornithopoda* subsp. *ornithopodioides*, *C. rhizina*, and *C. pallidula* in the herbaria of Berlin (B), Vienna (W) and Wrocław (WRSL) was studied in 2014 and 2015, as these species are sometimes confused with one another. Besides, material of the first author's private herbarium and of *C. pallidula* collected during fieldwork in the Czech Republic in 2014, deposited in the Herbarium of Szczecin University (SZUB), was taken into account. We have also examined the material of *C. digitata* × *C. pallidula* on loan from the Herbarium of the Finnish Museum of Natural History (H; Appendix S1 and Appendix S2). Abbreviations of herbaria follow Index Herbariorum [22].

Results

Carex pallidula was detected in the following six European countries: Albania, Austria, Greece, Romania, Serbia, and Switzerland, where its occurrence was unknown until now. All the material was originally labeled as *C. digitata* (Appendix S1). *Carex pallidula* was identified only in the herbarium material from Berlin (B) and Vienna (W). A search through the material in Wrocław (WRSL) did not reveal any sheets with *C. pallidula*, although this species is mentioned for central-southern Poland [18,19].

The oldest collections of *C. pallidula*, newly reported in this paper, are from NE Greece (near Nomós Dráma, Rodopi), SE Serbia (Piroć), SW Romania (near Herkulesbad), and E Switzerland (Molinis, E of Chur, Graubünden). In each of these countries, only one locality for this species was found. Two recent collections, from 2007 and 2010, have been made in northern Albania. Eleven new localities of *C. pallidula* were recorded from Austria and these are scattered throughout the country: three in Lower Austria and Vienna (E Austria), four in Upper Austria and Salzburg (N Austria), two in Vorarlberg (W Austria), one in Carinthia, and one in Styria (S Austria; Appendix S1, Fig. 1).

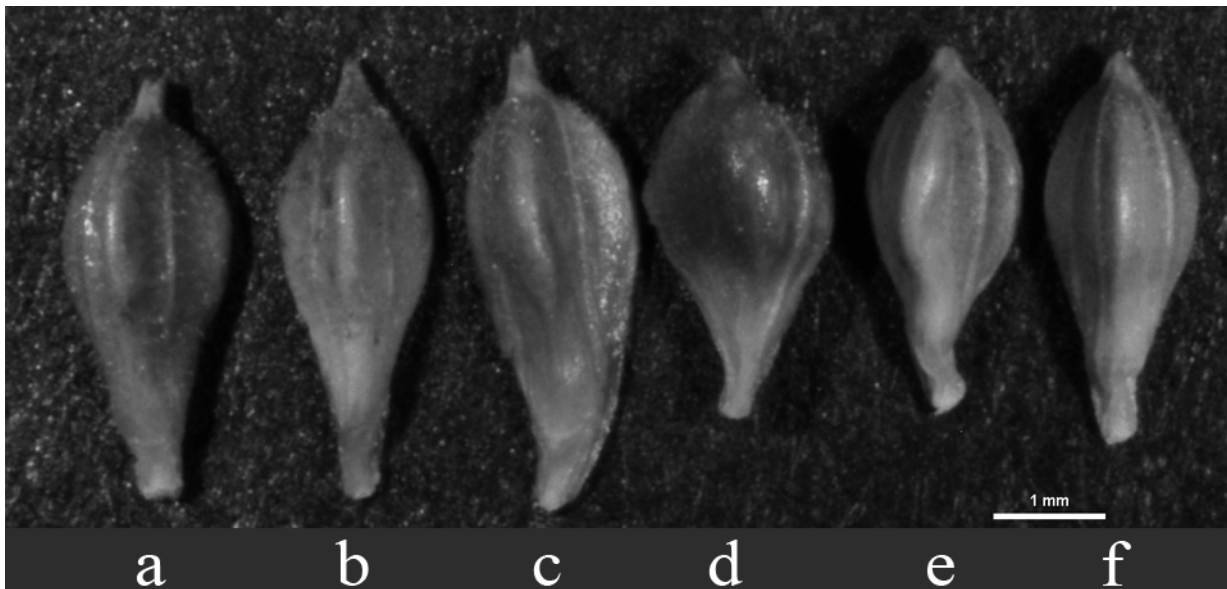


Fig. 1 Utricles of *Carex digitata* (a–c) and *Carex pallidula* (d–f).

The hybrid *C. digitata* × *C. pallidula* has hitherto been recorded from a few locations in Finland. Harmaja [7] was the first who identified this hybrid. Although Harmaja wrote “HH” on p. 151 indicating that his material was deposited in H, the staff from the Herbarium of the Finnish Museum of Natural History could not find any specimens of *Carex* deposited by Harmaja in their collections. However, we were able to study some other material of this supposed hybrid from H comprising eleven gatherings (Appendix S2). After the name of four collections the finders added a question mark and one more with “cf.”, obviously not being sure of their determination, which is understandable, taking into account the striking similarity of the putative parents. The other collections from H have more or less normally developed utricles and nuts, which are identical in shape and size to *C. digitata*. Besides, the anthers were normally developed in all the collections which were examined. All examined collections of the presumed hybrid, in our opinion, represent the same taxon and comprise young material of *C. digitata*, rather than the supposed hybrid.

Discussion

A valid description of *Carex pallidula* has been published in 2005, and in the scarce literature it has been reported until now from ten countries worldwide, all in Europe [14]. It is strikingly similar to the well-known *C. digitata*. The characters mentioned in literature are not always as clear-cut as supposed; however, the most reliable features are the size and shape of the utricles [4,7,11] (Fig. 1). *Carex digitata* and *C. pallidula* are very similar in appearance, which may suggest a close affinity, but the hybrid of both species has not been yet detected with certainty. The supposed hybrid material seen from Finland is here regarded as young material of *C. digitata*. *Carex pallidula* is often confused with *C. digitata*, therefore, the hybrid of these two species may exist but may not be recognized. Tyler’s studies [23] show that gene flow between *C. pallidula* and *C. digitata* appears to be very limited. Also Harmaja [4,7] pointed out that hybrids between this species are not common.

Carex pallidula is often regarded as a more northern species, probably because it was first found in Scandinavia [7,9]. Fig. 2 makes clear that it has a much wider range in Europe, from Scandinavia to the Balkan Peninsula. Obviously it is often overlooked and/or misidentified for *C. digitata*, as Holub [11] already made clear with his search through Czech and Slovakian herbaria. In the Czech Republic, *C. pallidula* does not seem to be very rare. During the fieldwork by the first two authors in 2014, this species proves to be rather common in Bohemia (CZ).

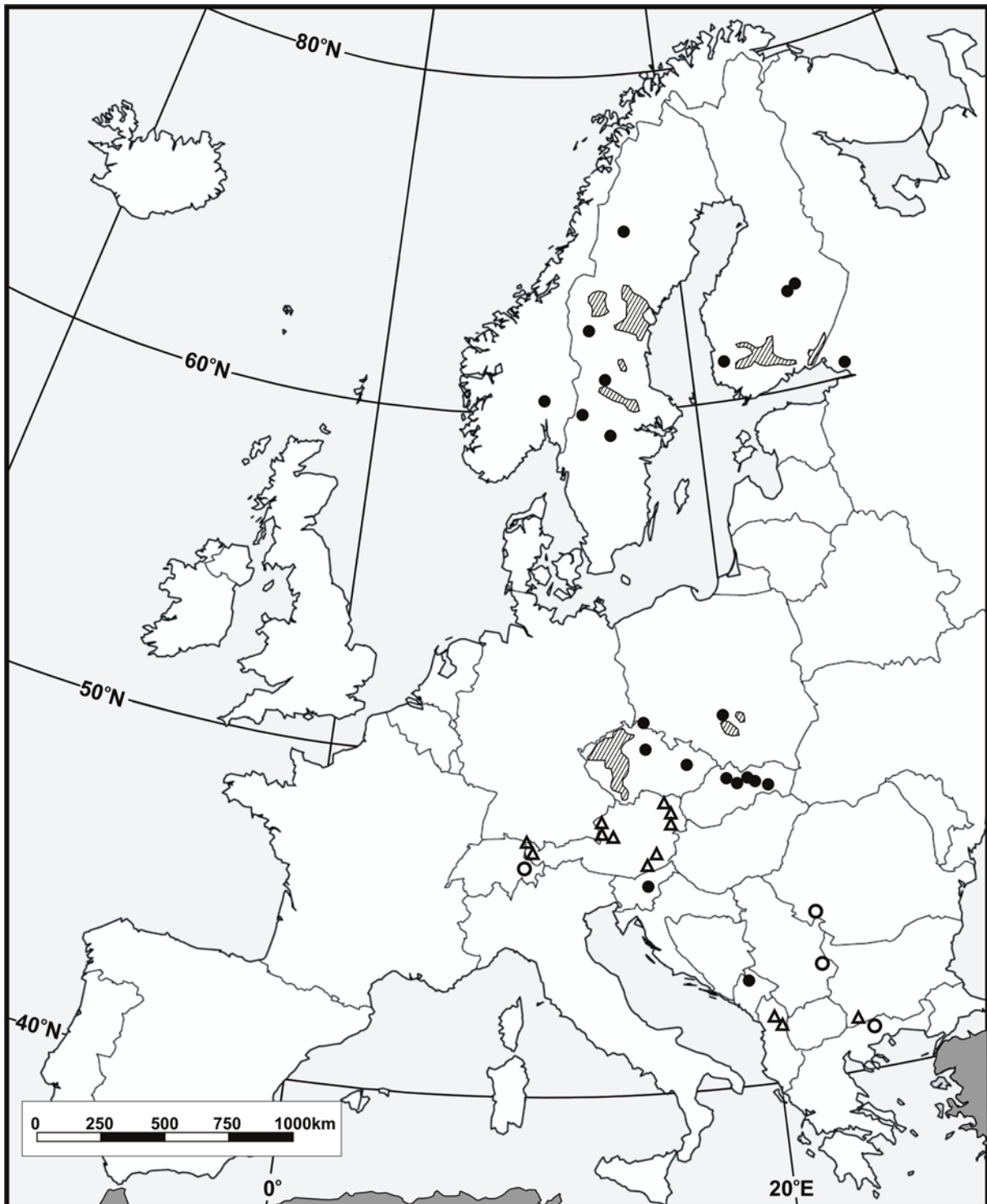


Fig. 2 Distribution of *Carex pallidula* Harmaja in Europe, according to herbarium vouchers and literature. The outlined areas indicate dense populations. Black circles – single, isolated locations known from the literature. Triangles – new locations based on herbarium material. White circles – single locations (where only one old collection for each country was found in the studied herbarium material).

In fact the precise geographical distribution of *C. pallidula* has not been delineated yet [10]. Based on literature, the locations in Scandinavia [4,9,10], Russia [17], Poland [18,19], the Czech Republic, Slovakia [11], Slovenia, and Montenegro [10] have been identified. However, the new data presented here indicate that in Central and Southern Europe, the species is more common than suggested by previous research (e.g., [9–11,18,19]). The eleven findings in Austria show that the species seems to be less rare in this country. However, the fact we could find only one, old, collection for four other new countries, Greece, Romania, Serbia, and Switzerland, reflects only the historical distribution of the species. The occurrence of *C. pallidula* in these countries is still questionable. *Carex pallidula* was also mentioned by Valev and Kitanov [21] in Flora Bulgaria, but it was missing in Koopman [14]. The first author of this article collected material of this species in 2013 in SW Bulgaria, on Gocev Vrah, Slavyanka (Appendix S1).

We checked all the German material in Berlin, but *C. pallidula* did not show up for this country. It also seems to be absent in Hungary (A. Mesterházy, personal communication, 2015). However, as it occurs in the neighboring countries (Austria, the Czech Republic, Poland, and Switzerland), the presence of this species in Germany and Hungary should be expected. To get a more complete picture of the distribution of *C. pallidula* in Europe other searches in Central and Eastern European herbaria and/or intensive fieldwork are needed and these may reveal *C. pallidula* for these two countries. Its occurrence in nearby Asia, e.g., on the Caucasus, should not be ruled out [20].

Key for determining the taxa of the section *Clandestinae* in Europe (excluding *C. glacialis*, *C. humilis*, and *C. pediformis*)

Plants more or less densely caespitose, without creeping rhizomes, or laxly caespitose with short, creeping rhizomes (*C. rhizina*). Male spike solitary, linear. Female spikes linear to oblong or fusiform, lax. Utricles puberulent or glabrous with a short, conical beak not more than 0.5 mm long. Stigmas 3.

- 1 Leaves of flowering shoots consisting of sheaths without blades or the uppermost with short setaceous blade. Female glumes with obtuse apex and wide purple-membranous margins.....2
 - Leaves of flowering shoots with sheaths and blades. Female glumes with acute apex and white-membranous margins. Utricles 3.5–4 mm long; beak 0.2–0.3 mm long. Plants 15–35 cm high, forming loose tuft, with creeping rhizomes *Carex rhizina*
- 2 Inflorescence 1–2.5 cm long. Utricles 2–3 mm long. Female glumes 1/2–2/3 as long as utricles..... 3
 - Inflorescence 3–4(–5) cm long. Utricles 2.9–4.5 mm long. Female glumes equaling utricles..... 4
- 3 Stems up to 25 cm, erect or decumbent. Utricles 2.5–3 mm, puberulent *Carex ornithopoda* subsp. *ornithopoda*
 - Stems 5–10 cm, strongly curved and decumbent. Utricles 2–2.5 mm, glabrous *Carex ornithopoda* subsp. *ornithopodioides*
- 4 Utricles 2.9–3.7 mm long. Beak as long as broad, broadly conical. Female glumes pale brown. Sheath of lowest bract pale green..... *Carex pallidula*
 - Utricles 3.4–4.5 mm long. Beak clearly longer than broad, narrowly conical. Female glumes reddish-brown. Sheath of lowest bract red-brown..... *Carex digitata*

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C. digitata material in BP. We thank the curators from the herbaria of Berlin (B), Vienna (W), and Wrocław (WRSŁ) for access to their collections. We are grateful to Liz Charter for checking and improving the English. We thank three reviewers for their valuable comments on the first manuscript.

Supplementary material

The following supplementary material for this article is available at <http://pbsociety.org.pl/journals/index.php/asbp/rt/suppFiles/asbp.3512/0>:

Appendix S1 List of newly reported localities of *Carex pallidula* in Europe.

Appendix S2 List of localities of supposed *Carex digitata* × *C. pallidula*.

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