

## *Galium suecicum* (Rubiaceae), a new and relict species in the flora of Poland

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In order to verify a possible occurrence of *Galium suecicum* (Rubiaceae) at the locations reported by P. Decker in 1911 under *G. pumilum* (*G. silvestre*) in the territory of western Poland, we visited all the identified stands during the years 2012 and 2013. At two of those sites, we found plants belonging to *G. pumilum* agg. that after thorough morphological and cytological studies turned out to be *G. suecicum*. These are presently the only known stands of this relict species in central Europe.

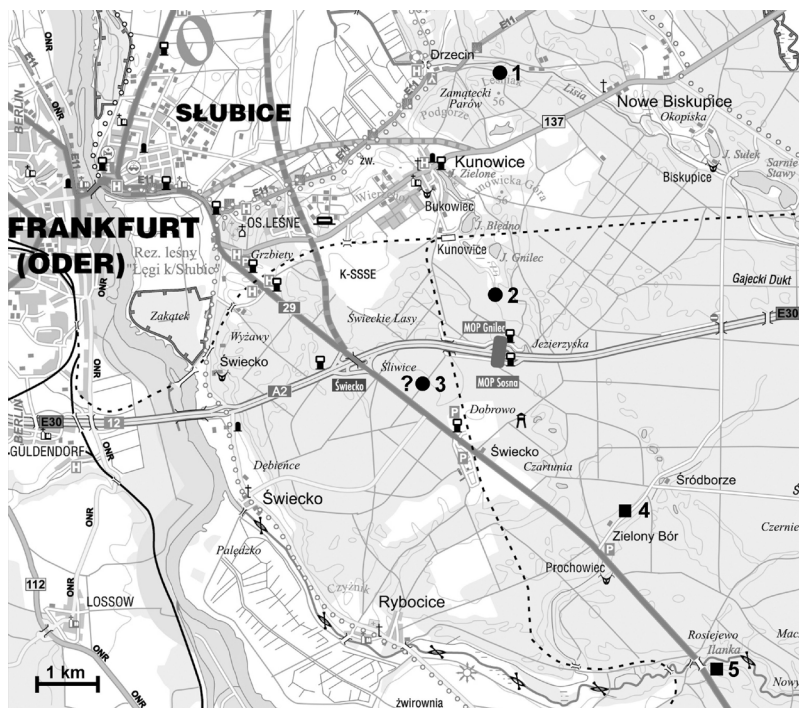
### Introduction

The *Galium pumilum* complex in Europe includes a number of species with a broad ecological spectrum, from bare rocks to open forests, and with very different distributions, from very broad, e.g. *G. pumilum s. stricto*, to narrow endemic species, such as *G. cracoviense* (Ehrendorfer 1962, Meusel & Jäger 1992, Kolář *et al.* 2013). In central Europe, the complex is represented by *G. anisophyllum* (diploid and tetraploid), *G. cracoviense* (diploid), *G. pumilum s. stricto* (octaploid), *G. sudeticum* (tetraploid) and *G. valdepilosum* (diploid and tetraploid) (Kolář *et al.* 2013).

One of the most intriguing species of the group is *G. suecicum* that was originally treated as *G. pumilum* subsp. *suecicum* and then raised to the species level (Ehrendorfer 1960). *Galium*

*suecicum* is a postglacial relict with a disjunctive distribution. It is known from Västergötland, SE Sweden (provinces of Skåne, Blekinge, Småland) and from extinct stands in north Germany (Brandenburg province; Meusel & Jäger 1992, Kolář *et al.* 2013). This species has been never reported from the territory of Poland, however it was marked to occur in the Wielkopolska region in the species distribution maps by Ehrendorfer (1962) and Meusel and Jäger (1992). Those localities were neither discussed in the literature nor supported by herbarium material. On the other hand, *G. pumilum* (*G. silvestre*) was reported by Decker (1911) east and southeast of Frankfurt am Oder, i.e. close to the Brandenburg region and that raised the possibility that *G. suecicum* could still occur at those localities.

In order to verify the possible occurrence of *G. suecicum* at the locations given by Decker



**Fig. 1.** Sites of *Galium pumilum* (*G. silvestre*) in the vicinity of Frankfurt/Oder–Słubice reported by Decker (1911) and verified for the presence of *G. suecicum* in the current studies. ● = localities not confirmed, ■ = confirmed stands and identified as *G. suecicum*, ? = location uncertain.

(1911) under *G. pumilum* (*G. silvestre*), we visited all the identified localities during the years 2012 and 2013. At two of the sites, we found plants belonging to *G. pumilum* agg. that after thorough morphological and cytological studies turned out to be *G. suecicum*. These are presently the only known sites of this species in central Europe.

## Material and methods

Field studies were performed in 2012 and 2013 in the regions of western Poland where *G. pumilum* (*G. silvestre*) was reported to occur by Decker (1911). Identification of the localities described by Decker was performed using maps from Map Archives of Western Poland (<http://mapy.amzp.pl/maps.shtml>). An ATPOL map was created using Gnomon 3.3 software. Geographical coordinates were determined with a Garmin Legend HCx GPS receiver. The species nomenclature follows Mirek *et al.* (2002).

For cytological studies, the plant material collected in the field was grown for several weeks in a phytotron chamber to stimulate for-

mation of new roots. The root fragments with growth tips were incubated in saturated water solution of  $\alpha$ -bromonaphtalene for ca. 24 hours at 4 °C. Next, the root fragments were fixed in absolute ethanol/glacial acetic acid (3:1, vol/vol). Fixed root tips were rinsed with distilled water, hydrolyzed in 1 N HCl at 60 °C for 10 min and squashed in 45% acetic acid. After freezing in liquid nitrogen, the cover glasses were removed and the squashes were stained with 0.1% aqueous solution of toluidine blue. Chromosome observations were performed using a Nikon Microphot-FXA microscope. The images were captured and processed with a Nikon DS-Fi1c camera and the NIS Elements software.

## Results

Revision of the localities described by Decker (1911) revealed the presence of *G. pumilum* agg. only at sites 4 and 5 (Fig. 1) in the southern part of the investigated area. Those sites correspond to AD03 and AD13 squares, respectively in the ATPOL grid (10 × 10 km squares) (Fig. 2). Although the sites are situated in differ-

ent ATPOL squares, they are close to each other, ca. 3 km apart.

The investigated species is loosely caespitose (Fig. 3), with fragile, thin stems 5–15(20) cm long and with elongated middle internodes (Fig. 4). The leaves are 0.5–1 cm long, in whorls of 5–6, and usually strongly hairy (Fig. 5). The stems are most frequently also hairy, mainly in the middle and upper parts (Fig. 5). The flowers are densely arranged on very short pedicels (Fig. 5). The fruits are distinctly acutely papillose (Fig. 6), very similar to those of *G. cracoviense* and clearly different from those of *G. pumilum s. stricto* (Kucowa 1962, Ehrendorfer 1976). The species is diploid ( $2n = 22$ ; Fig. 7). All these data indicate unequivocally that the species is *G. suecicum*.

Among the two stands of *G. suecicum* found, the one located near Zielony Bór (Green Forest) (stand 4 in Fig. 1) was very small and covered about 1 m<sup>2</sup> at the edge of a pine forest (52°18'4.5''N, 14°40'49.3''E), while the second (stand 5 in Fig. 1) was considerably larger and the area covered (N limit 52°16'47.5'', S limit 52°16'44.9'', W limit 14°42'2.2'', E limit 14°42'21.6'') was estimated to be 0.13–0.14 km<sup>2</sup> (Fig. 8) situated at 40–50 m a.s.l. In the most western part of the area, *G. suecicum* was found in an open mixed forest dominated by

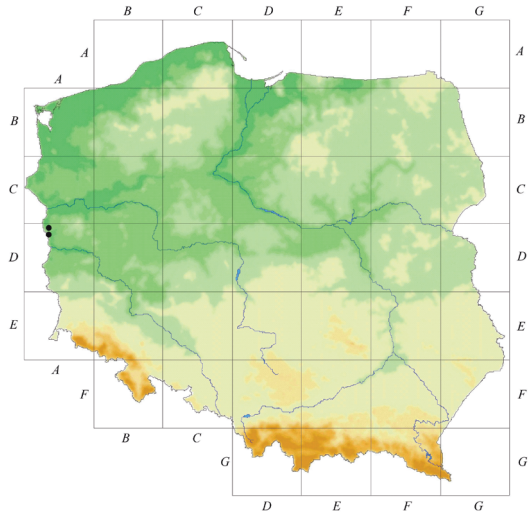


Fig. 2. Distribution of *Galium suecicum* in Poland in the ATPOL grid.

*Quercus robur* (continental mixed forest; Fig. 9), while in the other area, the species grew in open pine forest (ca. 30 years old) with *Fagus sylvatica* and sporadically seedlings of *Acer platanoides*, *Quercus robur* and *Sorbus aucuparia* (Fig. 10). Among herbaceous species, *G. suecicum* was associated with *Achillea millefolium*, *Anthoxanthum odoratum*, *Calamagrostis arundinacea*, *Euphorbia cyparissias*, *Festuca duvalli*,



Fig. 3. *Galium suecicum* (site 5 in Fig. 1; photo by J. Kruk, 3 May 2012).



**Fig. 4.** *Galium suecicum* in bloom (site 5 in Fig. 1; photo by J. Kruk, 1 June 2013).

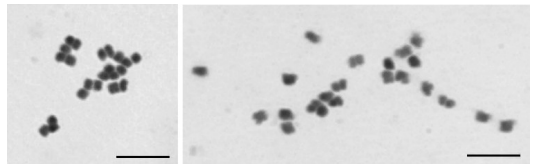


**Fig. 6.** Fruits of *Galium suecicum* (site 5 in Fig. 1).

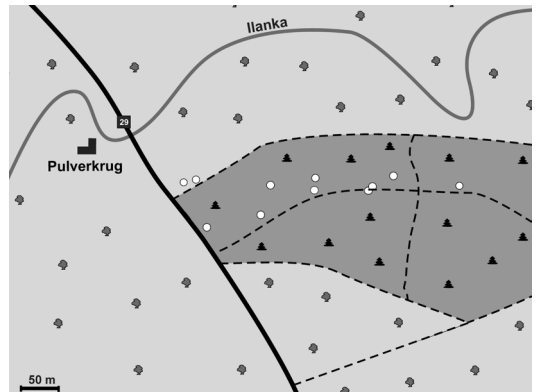
*Festuca ovina s. stricto*, *Fragaria vesca*, *Galium verum*, *Hypericum perforatum*, *Melica nutans*, *Peucedanum oreoselinum*, *Pimpinella nigra*, *Pleurozium schreberi* (moss), *Poa pratensis*, *Rumex acetosella*, *Vaccinium myrtillus*, *Veronica officinalis*, *V. teucrium*, *Vicia hirsuta*, and *Viola tricolor*. In this area *G. suecicum* was found usually in patches covering up to 1–4 m<sup>2</sup>. Its blooming period was estimated to be at end of May and beginning of June.



**Fig. 5.** *Galium suecicum* close-up before blooming (site 5 in Fig. 1; photo by J. Kruk, 3 May 2012).



**Fig. 7.** Metaphase plates ( $2n = 22$ ) of *Galium suecicum* collected from site 5 in Fig. 1. Bar = 5  $\mu$ m.



**Fig. 8.** Detailed distribution map of *Galium suecicum* near the remnants of Pulverkrug (Rosiejewo) (site 5 in Fig. 1). The white dots indicate abundant occurrences.



**Fig. 9.** Habitat of *Galium suecicum* at the western border of site 5 in Fig. 1 (photo by J. Kruk, 1 June 2013).



**Fig. 10.** Typical habitat of *Galium suecicum* (site 5 in Fig. 1; photo by J. Kruk, 1 June 2013).

The *G. pumilum* sites reported by Decker (1911) are as follows (numbers as in Fig. 1): (1) Kunersdorf (Kunowice): zwischen Bäcker- und Rätschmühle, (2) bei Pauls Born (name of spring area), (3) am Wege im Walde von der Chaussee nach der Försterei, (4) Grüner Tisch (Zielony Bór), (5) Pulverkrug (Rosiejewo; a village no longer there).

## Discussion

The present discovery of *G. suecicum* is valuable taking into consideration the fact that this species has probably been extinct since long time ago in northern Germany (Kolář *et al.* 2013), at the southern limit of its general distribution. At the currently found sites, it grows in similar

habitats as described in the literature, i.e. in open pine forests (Ehrendorfer 1962, Kolář *et al.* 2013). Although the identified area covered by *G. suecicum* is very small, it is highly probable that it grows also at other sites in the spacious forest area east and south-east of Frankfurt/ Stubice.

The relict stand of *G. suecicum* is interesting in light of the origin of endemic species in deglaciated areas of central and northern Europe (Kolář *et al.* 2013), as well as of the evolution of species in the whole *G. pumilum* complex in Europe. Regardless of which of the several theories (Kolář *et al.* 2013) of the origin of the present distribution of species in the *G. pumilum* complex in northern and central Europe is valid, it cannot be questioned that the presently existing diploid species of the complex (e.g. *G. cracoviense*, *G. oleandicum*, *G. sternieri*) originate from a diploid species, while polyploid species evolved later. If the *G. pumilum* complex is monophyletic, the ancestor of the whole complex was certainly diploid with a more or less wide distribution, most probably in western and/or central Europe, from where it spread to the present area. Among the diploid species that could have given rise to other species in the complex might be a direct ancestor of *G. suecicum* or *G. valdepilosum*. Although *G. suecicum* is currently mainly distributed in Sweden, its original distribution was probably in western and/or central Europe and after climate change, during a deglaciated period, the species moved to colder areas in Sweden and northern Germany–Poland and became extinct at its original area of distribution. Thus, the present sites of *G. suecicum* in western Poland may be relicts of its original distribution range.

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