The distribution of *Galeopsis ladanum* in Germany based on an analysis of herbarium material is smaller than that indicated in plant atlases

Fytogeografické atlasy v Německu udávají větší rozšíření *Galeopis ladanum*, než dokládá herbářový materiál

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The distribution of *Galeopsis ladanum* in Germany and adjacent regions was determined by a revision of specimens of *Galeopsis* subgen. *Ladanum* in major Central European herbaria. This distribution was compared with that indicated in plant atlases. For the west of Germany, beyond the range of *G. ladanum*, plant atlases are often misleading as they indicate the presence of this species throughout two German states and Luxembourg, but no herbarium records could be found for these regions. In other federal states, herbarium material indicated a historical distribution that is not reflected in plant atlases. Some Red Data Books give wrong assessments of the degree of endangerment. Exaggerated ranges are mapped if (i) guide books are misleading, (ii) recorders are unfamiliar with the species and (iii) similar species exist.

K e y w o r d s: chorology, distribution atlases, *Galeopsis*, Germany, herbaria, land use

Introduction

There is a lot of interest in the quality of biological records as large amounts of information are pooled in databases (e.g., Chapman 2005, Dalcin 2005). Determination of critical taxa is a well known problem and information on the distribution of these taxa should therefore be based upon a combination of field observations and critically assessed herbarium material. This is standard practice in many countries. Already, the pioneering atlas of the British flora (Perring & Walters 1962) mapped critical taxa on the basis of herbarium material and field observations. But even in Central Europe, plant atlases probably indicate that many critical taxa are more widely distributed than they are. This is shown for *Galeopsis ladanum*, which has a superficially similar species, *Galeopsis angustifolia*, whose range extends further to the west.

Linnaeus (1753) classified *G. angustifolia* and *G. segetum* together with *Galeopsis ladanum*. *Galeopsis angustifolia* and *G. ladanum* were consistently confused with each other and it was only in the second half of the 20th century that botanists were able to differentiate these two taxa (Townsend 1962). To the trained eye both taxa can be differentiated at first glance. Furthermore, the calyx hairs, smooth in *G. ladanum* and rough in *G. angustifolia* (Fig. 1), is a reliable feature for identification and easily seen with the aid of a good hand lens. Originally, *G. ladanum* was probably confined to open areas of scree in the high regions of the Pyrenees, the Alps, the Balkans, and the Caucasus mountains (Meusel et al. 1978). With the development of agriculture, this taxon colonized fields from Western Europe to Central Siberia. It is also known to occur as a casual in East Asia, North America and New Zealand (Hultén & Fries 1986, Gregor 2005).

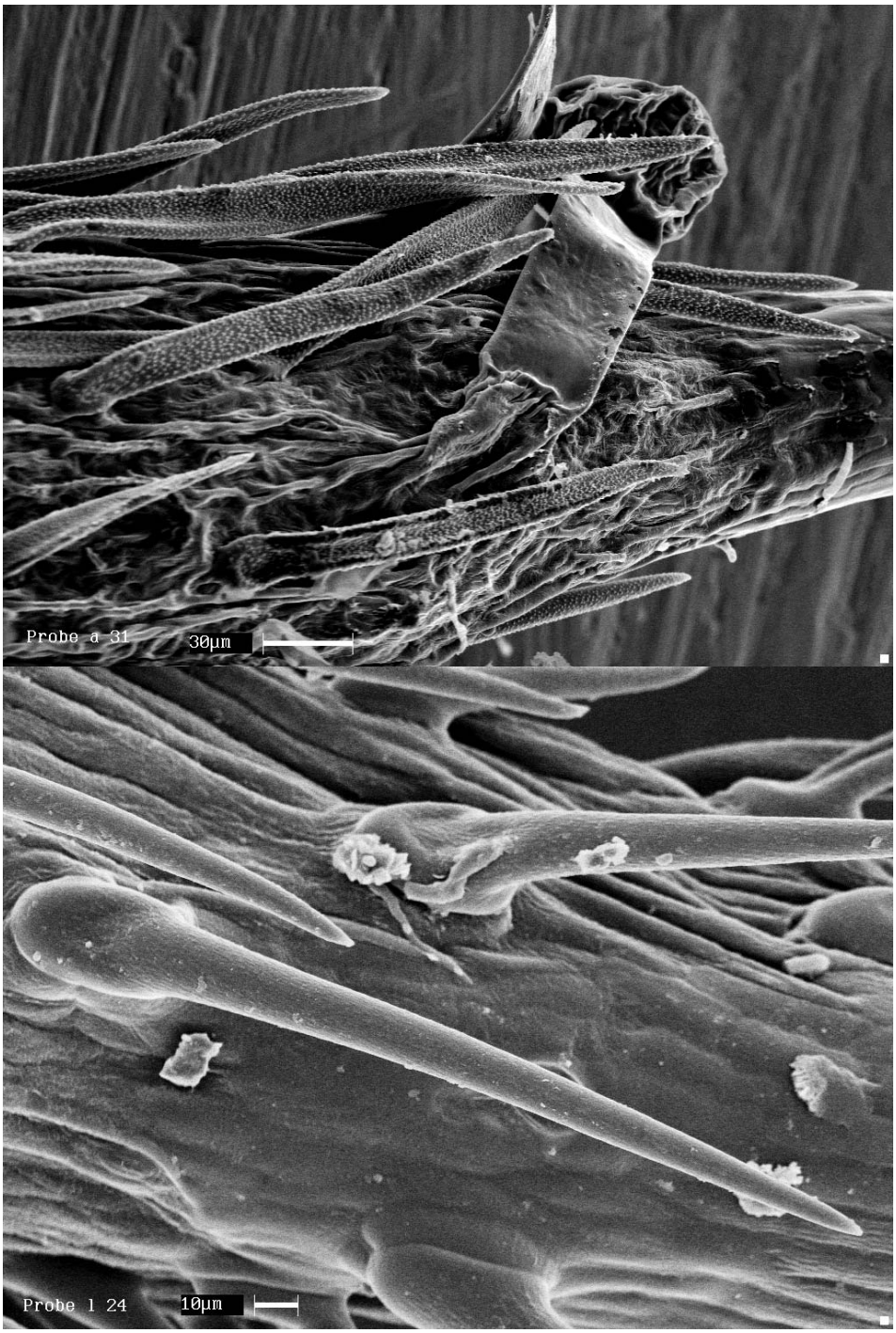

Fig. 1. – Top: Calyx hairs of *Galeopsis angustifolia* (Schlierbach/Hesse; J. Koch, 9 October 1952). Bottom: Calyx hairs of *G. ladanum* (Medelon/North Rhine-Westphalia; U. Raabe, 29 July 1984)

Material and methods

Atlas and herbarium material for the distribution of *Galeopsis ladanum* L. in Germany and adjacent parts of Luxembourg, Belgium, the Netherlands, Denmark, Poland, the Czech Republic, Austria, Switzerland and France, an area enclosed by 47°12'N, 55°06'N, 5°50'E and 15°10'E, were analyzed. Information based on herbarium material was assigned to maps with a scale of 1: 25 000 and grid units of 10' longitude × 6' latitude, typically used in Central European atlas projects (see Niklfeld 1971). Each map covers an area of about 12 × 11 km. Several thousand herbarium vouchers of *Galeopsis* subgen. *Ladanum* Briq. in the following public and private herbaria were assessed (abbreviations according to Holmgren et al. 1990, including online supplements): B, BH, BNL, BR, BREM, BRNU, C, DARM, DR, FR, FULD, GFW, GLM, GOET, HAL, HBG, HEID, JE, KIEL, KONL, KR, L, LI, LUB, LUX, M, MB, MSTR, NHG, NHV, OSN, PR, PRC, REG, ROST, STU, WIES, Z/ZT; private herbaria of S. Demuth, P. Fasel, F. Fürnrohr, G. Gottschlich, R. Götte, H. Henker, G. Hügin, W. Jansen, H. Kalheber, M. Kohl, D. Korneck, P. Kulbrock, L. Meierott, F. Müller, B. Nowak, U. Raabe, H. Reichert, M. Ristow, F. W. Sander, E. Schäfer, M. Sonnberger, I. & W. Sonneborn and others.

Casual occurrences near mills, railway lines or similar habitats, which are usually indicated in an atlas by a different symbol, were omitted from the analysis. A list of the herbarium vouchers seen is available in Electronic Appendix 1. Plant atlas and herbarium based maps were compared using Cole's coefficient of interspecific association (Cole 1949) and the commonly used phi coefficient. Both coefficients have values of between 1 (complete positive correlation) and –1 (complete negative correlation). A value near 0 indicates no correlation. The maps were produced using DMAP (Distribution mapping software from Alan Morton, Winkfield, UK).

Results

According to herbarium material, the western limit of the range of *G. ladanum* runs along an irregular, north-south axis through Germany (Fig. 3). The species is associated with the base-rich, non-calcareous soils that occur above keuper, basalt or loamy sand. This preference accounts for its rare occurrence in the state of Brandenburg, which lies within its range but has large tracts of soil derived from nutritious-poor glacial sand. Fields of winter grain, potatoes or beets are the most common habitat for *G. ladanum*. It occurs in ruderal habitats only as a casual species. A few occurrences exist for cliff habitats, e.g. the Saale valley in Thuringia and the Milseburg in Hesse. The current rapid decline of *G. ladanum* is accounted for by the intensification of farming and transformation of unprofitable fields into grassland.

Five distribution categories were identified by comparing the distributions in plant atlases and that indicated by herbarium material (Figs 2 & 3, Table 1).

Regions within the range

Herbarium material indicate a scattered distribution of *G. ladanum* within its range. The German states of Saxony-Anhalt, Mecklenburg-Western Pomerania, Brandenburg and Saxony, together with those parts of Denmark and the Czech Republic covered by the

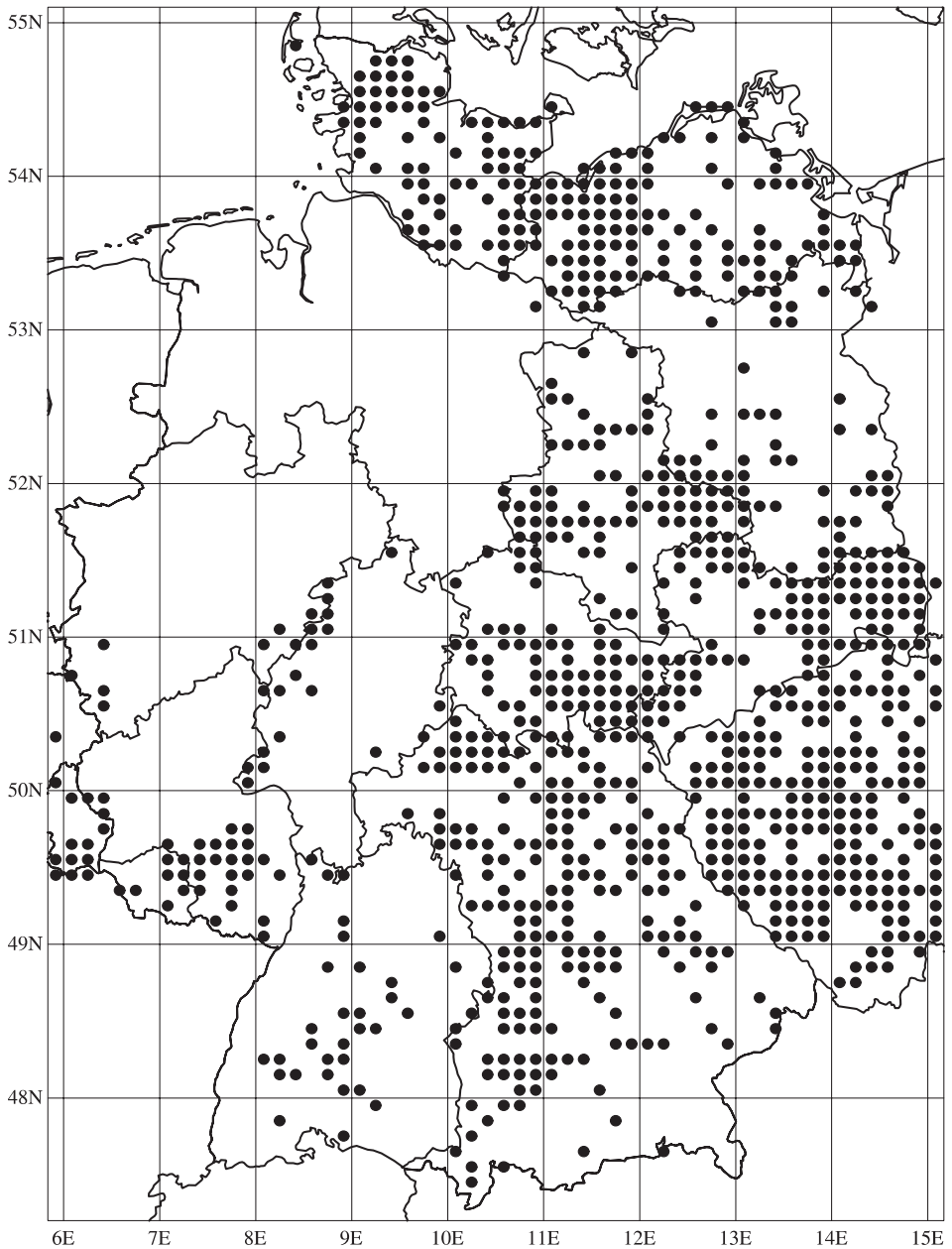

Fig. 2. – Plant atlas based distribution of *Galeopsis ladanum* in Germany, the Czech Republic, and adjacent parts of Belgium and Luxembourg. Each symbol represents an area of about 12 × 11 km (10' longitude × 6' latitude).

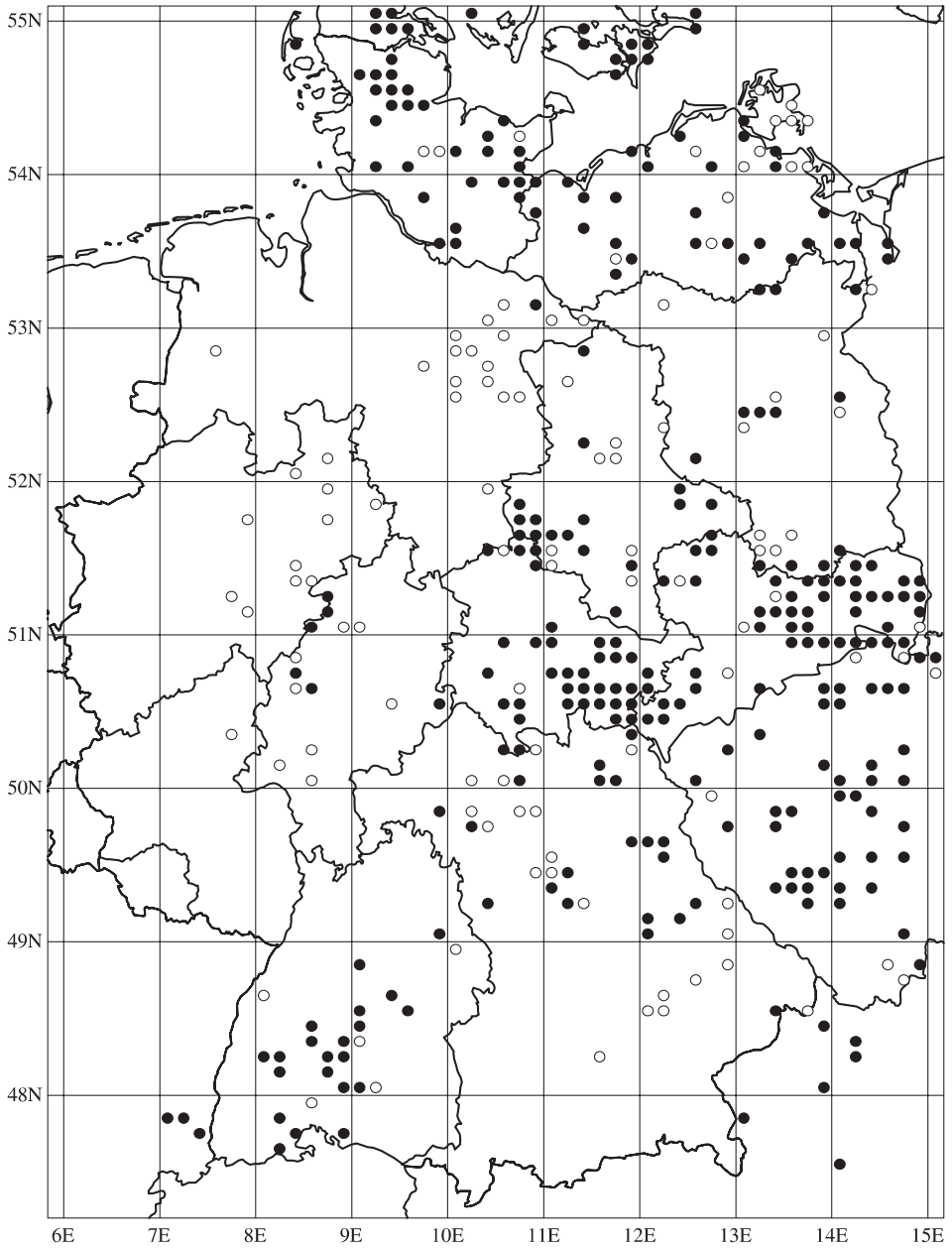

Fig. 3. – Distribution of *Galeopsis ladanum* in Germany and adjacent areas based on herbarium material. Symbols: ● herbarium data consistent with atlas data (if atlas exists); ○ herbarium data not consistent with atlas data (if atlas exists). Each symbol represents an area of about 12 × 11 km (10' longitude × 6' latitude).

Table 1. – Cole's coefficient of association with standard error (Cole) and phi coefficient (phi) for the comparison of the distributions based on herbarium and atlas data for *Galeopsis ladanum* based on grid units of 10' longitude × 6' latitude. $H^{+/-}$, herbarium data present/absent; $A^{+/-}$, atlas data present/absent. Phi coefficients above ±0.7 indicate strong correlations, between 0.3 and 0.7 weak correlations, and no or little correlation at values between –0.3 and +0.3.

	H^+/A^+	H^-/A^+	H^+/A^-	H^-/A^-	Cole	phi
A. Regions within the species' range						
Saxony (Hardtke & Ihl 2000)	45	42	7	71	0.30±0.05	0.46
Brandenburg & Berlin (Benkert et al. 1998)	12	47	10	205	0.13±0.03	0.24
Mecklenburg-Western Pomerania (Fukarek & Henker 2006 & internet suppl.[1])	28	78	9	98	0.11±0.03	0.24
Saxony-Anhalt (Benkert et al. 1998)	16	54	10	106	0.10±0.04	0.20
Czech Republic (Slavík 2000)	49	181	5	107	0.07±0.02	0.22
B. Regions at the edge of the species' range						
Baden-Württemberg (Kleinsteuber 1996)	19	12	4	261	0.59±0.05	0.68
Thuringia (Korsch et el. 2002)	30	35	4	81	0.30±0.05	0.49
Schleswig-Holstein & Hamburg (Raabe 1987)	30	45	3	85	0.25±0.04	0.45
Hesse (HMILFN 1999)	5	14	7	158	0.21±0.06	0.27
North Rhine-Westphalia (Haeupler et al. 2003)	3	11	7	277	0.19±0.05	0.22
Lower Saxony & Bremen (Garve 1994)	1	2	17	407	0.05±0.02	0.12
Bavaria (Schönfelder & Bresinsky 1990 & internet suppl.[2])	17	163	21	334	0.03±0.02	0.06
C. Regions outside the species' range						
Palatinate in Rhineland-Palatinate (Lang & Wolff 1993)	0	22	0	33	0.00	0.00
Saarland (Sauer 1993)	0	10	0	23	0.00	0.00
Luxemburg (Rompaey & Delvosalle 1979)	0	13	0	13	0.00	0.00

[1] http://geobot.botanik.uni-greifswald.de/portal/verbreitungskarten/hoeherePflanzen//Galeopsis%20ladanum.png; 27-10-2008

[2] http://www.bayernflora.de/de/info_pflanzen.php?taxnr=2522; 02-11-2008

current investigation, lie within the range of *G. ladanum*. Before 1950, *G. ladanum* could be found regularly in fields with suitable soil conditions. With the exception of Saxony, which has exceptionally good herbarium coverage, coefficients between the distributions indicated by atlas and herbarium material are low.

Regions at the edge of the range

At the edge of the range, Cole's and phi coefficients provide a good measure of the relationship between the distributions indicated by atlas and herbarium material and the following three scenarios were found.

(i) The range depicted in plant atlases is not representative. In Bavaria, scattered herbarium material is available for the northern and north-eastern parts of the state, and almost none for central and southern Bavaria. The atlas of the state flora does not reflect this situation and reports a more or less continuous distribution (Schönfelder & Bresinsky 1990). Coefficients near 0 indicate a lack of correlation between these two sources of data. The range recorded in the Bavarian atlas is not continued in the atlas of its western neighbour Baden-Württemberg.

(ii) The current range depicted in plant atlases is representative, but not the historical range. The data for Lower Saxony and North Rhine-Westphalia correctly reflect the current range but the historical range is underestimated due to insufficient analysis of herbar-

Table 2. – Red list assessments of *Galeopsis ladanum* in Germany (Korneck et al. 1996, updated for Baden-Württemberg: Breunig & Demuth 1990, Bavaria: Scheuerer & Ahlmer 2004, Hesse: Hemm et al. 2008, Lower Saxony: Garve 2004, Mecklenburg-Western Pomerania: Fukarek & Henker 2006, North Rhine-Westphalia: Wolff-Straub et al. 1999, Saarland: Delatinia & Ministerium für Umwelt des Saarlandes 2008, Saxony: Schulz 1999), Luxembourg (Colling 2005) and the Czech Republic (Holub & Procházka 2000).

Area	Endangerment according to Red Lists	Assumed endangerment
Germany	Least concern	Endangered
Baden-Württemberg	Data deficient	Critically endangered
Bavaria	Vulnerable	Endangered
Brandenburg	Vulnerable	Endangered
Hesse	Endangered	Endangered
Lower Saxony	Critically endangered	Critically endangered
Mecklenburg-Western Pomerania	Endangered	Endangered
North Rhine-Westphalia	Endangered	Critically endangered
Rhineland-Palatinate	Least concern	Extinct
Saxony	Endangered	Endangered
Saxony-Anhalt	Vulnerable	Endangered
Saarland	Least concern	No record
Schleswig-Holstein	Endangered	Endangered
Thuringia	Vulnerable	Endangered
Czech Republic	Least concern	?
Luxembourg	Least concern	No record

ium material during preparation of the atlases. In the 19th century and the first half of the 20th century the range extended considerably further to the west of the current range (for North Rhine-Westphalia see Gregor et al. 2006). Accordingly, coefficients are low.

(iii) The range is well represented by plant atlases. Those for Thuringia (Cole's coefficient of 0.3, phi coefficient of 0.49), Schleswig-Holstein and Hamburg (Cole's coefficient of 0.25, phi coefficient of 0.45) and Hesse (Cole's coefficient of 0.21, phi coefficient of 0.27) correctly reflect the current and historical ranges. Substantial areas of Schleswig-Holstein and Thuringia are still within the range and are therefore insufficiently represented by herbarium data. Baden-Württemberg had the highest value for Cole's coefficient (0.59) and the phi coefficient (0.68).

Regions outside the range

Galeopsis ladanum is recorded frequently in plant atlases as occurring in the German state of Saarland, in Palatinate (part of the state Rhineland-Palatinate) and in Luxembourg. Herbarium vouchers of *G. ladanum* from these regions could not be found. The plant atlases for Palatinate, Saarland, Belgium and Luxembourg do not refer to casual occurrences, like the documentation on *G. ladanum* in the Leiden herbarium, which includes records from the vicinity of corn mills in the Netherlands. *Galeopsis ladanum* in Palatinate, Saarland, Luxembourg and the Ardennes in Belgium is indicated as an indigenous member of the flora and the appropriate Red Lists categorize the species as being of "least concern" (see Rompaey & Delvosalle 1979 and Table 2).

Discussion

Only a few maps exist of the Central European range of *G. ladanum*. The Federal Agency for Nature Conservation collects data from atlas projects and publishes them on the internet as uncorrected distribution maps (Bundesamt für Naturschutz 2009). The data in this map are very similar to the atlas data given in Fig. 2. Hultén & Fries (1986) include all of Germany and France in the range of *G. ladanum*. Fitter (1978) indicates that the core range has a western border in Germany, which accords with that indicated by the herbarium material analyzed and presented here. To the west of this core area, in Rhineland-Palatinate, Luxembourg and southeastern Belgium, Fitter (1978) considers *G. ladanum* to be a "species [that] occurs as a native or much less frequently as a well-established introduction." Slavík (2000) published a grid map for the Czech Republic.

It is likely that the ranges of critical taxa are often exaggerated. Botanists who are unfamiliar with the species are misled by the literature and expect to find it. If a similar species occurs in the area, then this can be incorrectly recorded as the expected species. In extreme cases, botanists working outside the range for a particular species continue to record it incorrectly for decades. For *Galeopsis ladanum*, the number of incorrect determinations in herbaria often exceeded the number of correct determinations. A similar scenario is reported for *Potentilla heptaphylla* in the German state of Hesse (Gregor & Lehmann 2004) and for *Arabis sagittata* in Germany as a whole (Gregor & Hand 2006).

The production of reliable plant atlases is dependent on good quality management. Botanists in the field should collect samples of critical taxa and their determination subsequently checked by specialists. Atlas data, especially for critical taxa, should never be published without first checking records against herbarium vouchers. In Germany, as in many other countries, plant atlases are based generally on records submitted by amateur botanists with no support from botanical institutions (Horn et al. 2006). The standardization of botanical records is often discussed, with individual botanists being identified as the most significant source of variation (Rich & Smith 1996).

Herbarium material gives a good indication of the overall range of a species. However, it is not suitable for indicating short-term changes in frequency or distribution. Herbarium specimens tend to remain in private collections for long periods of time, and even after being transferred to public herbaria, years or decades can pass before they are incorporated into general collections. In areas where a given species is not rare, botanists tend not to collect specimens for each field record. In this way, the frequency of a given species within its range can be under-estimated by herbarium material.

Due to the large number of incorrect records, the decline in *Galeopsis ladanum* is not adequately indicated in Red Lists (Table 2). On this basis, the species is not considered to be endangered in many German states and therefore not endangered in Germany as a whole, which is incorrect. The abundance of *G. ladanum* has declined strongly in Germany in recent decades and will continue to do so. Except in a few cliff habitats, this species occurs only in fields where the ground is well illuminated throughout the vegetation period. Agricultural practices that favour *G. ladanum* have largely been discontinued. Areas with favourable agricultural practise, as the upper Lahn area in Hesse, are rapidly declining as fields are converted into grassland.

See www.preslia.cz for Electronic Appendix 1.

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Souhrn

Na základě revize položek *Galeopsis* subgen. *Ladanum* ve významných středoevropských herbářích bylo vymapováno rozšíření *Galeopis ladanum* v Německu a přilehlých oblastech a srovnáno s rozšířením udávaným ve fytogeografických atlasech. Na západě Německa, mimo oblast rozšíření *G. ladanum*, poskytují atlasy často zkreslené informace, neboť udávají výskyt tohoto druhu ve dvou německých státech a v Lucembursku, kde není doložen herbářovými položkami. V ostatních německých federálních státech dokládají herbáře historické rozšíření, které není podchyceno v atlasech. Některé Červené knihy udávají chybně stupeň ohrožení. K nadhodnocení rozšíření dochází, pokud (i) jsou informace v literatuře chybné, (ii) autoři údajů nejsou s druhem příliš obeznámeni a (iii) v území se vyskytují druhy, s nimiž je možné dotyčný druh zaměnit.

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