

## **Digitaria ciliaris in Europe**

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THOMAS WILHALM<sup>1</sup>

## *Digitaria ciliaris* in Europe

### Abstract

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A survey of the current treatment of the allochthonous grass *Digitaria ciliaris* and of its actual distribution in Europe is offered. It is based on a comprehensive revision of vouchers from selected European herbaria and on a literature survey carried out with the goal of collecting additional reports and of reviewing the treatment of the species in national and regional European floras. The results suggest that *D. ciliaris* is still not well known in Europe and thus overlooked in many areas, particularly in Italy and Spain. First records or at least definitely confirmed records are given for Portugal, Montenegro and Turkey, as well as for several regions of Spain, Italy and Greece. Substantial evidence is provided that *D. ciliaris* is naturalized in large areas of S Europe, particularly along the Mediterranean coasts of the Iberian Peninsula, Italy and Greece, including the islands. Diagnostic morphological features of *D. ciliaris* are described in order to better understand the species and an elaborated key is provided to distinguish it from the very similar and common autochthonous *D. sanguinalis* and other allochthonous species of the *D. ciliaris* complex that occur or may occur in Europe as casuals.

Additional key words: southern crabgrass, *Digitaria sanguinalis*, herbarium revision, literature survey, new records, identification key, taxonomy

### Introduction

*Digitaria ciliaris* (Retz.) Koeler of *D.* sect. *Digitaria* Fabr. belongs to a group of morphologically closely related taxa, some of which are separated merely by subtle characters. Their delimitation and circumscription are still insufficiently understood due to the great variability expressed particularly by the venation of the lower lemma, the size of the lower and upper glumes, the indumentum of the spikelet and due to obviously integrating forms. As a consequence, the taxonomic treatment is often controversial, for instance in the case of *D. bicornis* (Gilani & al. 2003).

The group includes species with quite a limited distribution area such as *Digitaria henryi* Rendle (SE Asia) and *D. cruciata* Nees ex Steud. (Himalayan region; Shouliang & Phillips 2006). Others cover a more extended area, such as *D. radicata* (C. Presl) Miq. and *D. setigera* Roem. & Schult., both in warmer parts of Asia, on islands in the Pacific and Indian Oceans, and in Australia,

*D. setigera* also in E Africa and the tropical Americas, and *D. horizontalis* Willd. in Central and South America and parts of Africa (Häfliger & Scholz 1980). Most widespread are *D. sanguinalis* (L.) Scop., with a worldwide distribution in warm-temperate regions, and *D. ciliaris*, which is common throughout the entire tropics and subtropics. Although the latter two species show clearly separated centres, they grow sympatrically in a zone of overlap. This is the case, for instance, in the United States of America (Barkworth & al. 2003) and in China (Shouliang & Phillips 2006). Overlapping distribution areas appear to be enforced by synanthropic introduction of each species into the other's area and subsequent naturalization (Barkworth & al. 2003).

It is becoming a more and more important issue in Europe to investigate the neophytic flora and to deal with exotic species, both with regard to their taxonomy and their ecological implications. The fact that the introduc-

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tion of exotic *Digitaria* species has to be faced can impressively be shown by the list of species reported for Great Britain in Ryves & al. (1996), which amounts to twenty. Only recently, Verloove (2008) provided a detailed diagnostic survey of *D. radicata*, which he found new to Europe, and of *D. violascens*, a species that had hitherto apparently been ignored and was already naturalized in France and Italy. The same author stresses the high probability of exotic *Digitaria* species, particularly *D. ciliaris*, being overlooked in many parts of S Europe due to insufficient knowledge about them.

According to Tutin & al. (1980), three species of *Digitaria* are native to Europe: *D. ischaemum*, *D. debilis* and *D. sanguinalis*. The authors refer to a fourth species, *D. ciliaris*, as a “common weed of rice fields in Italy and probably elsewhere” of tropical or subtropical origin.

It will be demonstrated in this paper that there is an ongoing ambiguity associated with the name *Digitaria ciliaris* in several parts of Europe. In fact, the type material of its basionym *Panicum ciliare* Retz. is from China, whereas that of *D. sanguinalis* (basionym *Panicum sanguinale* L.) originated in Europe (Henrard 1950; Veldkamp 1973). At least since that time, the morphological discrimination of both species has been clearly defined and broadly accepted in accordance with that state of knowledge.

The point of departure for this work was a previous publication (Wilhelm 2002), in which the author pointed out the erroneous species concept of *Digitaria ciliaris* provided in the flora of Italy (Pignatti 1982) and in which he offered an updated and detailed identification key to all *Digitaria* species in Italy known at that time. Among them was also the genuine *D. ciliaris*, which on that occasion was definitely confirmed for Italy. The new findings stimulated an expansion of the investigations with two main questions: Where are assured records of *D. ciliaris* in Europe? What is its chorological status in Europe? This study aims at raising awareness of *Digitaria ciliaris* in order to dedicate greater attention to the species and to better document its presence.

## Material and methods

This study is based on a revision of specimens from selected European herbaria as well as on a literature survey.

When addressing possible herbarium specimens of *Digitaria ciliaris* from Europe, it was necessary to take into account not only specimens labelled as such but also those of species which *D. ciliaris* may be confused with. The present investigation was primarily meant to find “overlooked” specimens of *D. ciliaris* and therefore particular attention was given to specimens of *D. sanguinalis*, all the more so since it is by far the most common *Digitaria* species in Europe.

A revision of all European specimens of *Digitaria ciliaris* and *D. sanguinalis* would be logistically unfeasible and too time-consuming. A selection was thus made by

focusing, on the one hand, on representative herbaria in countries of S and Central Europe and, on the other hand, on the largest European collections, which were supposed to contain a representative cross section.

The following herbaria were consulted (herbarium abbreviations following Thiers 2008+): APP, B, BC, BEOU, BM (only c. 50 % of the European material studied), BOZ, FI, M, MA, MSB, P (only small parts of the collection accessible due to construction work), RO, ROV, UPA, W, WU, Z, ZT and the personal herbaria of Carlo Argenti (Belluno, Italy) and Helmut Melzer (Zeltweg, Austria).

In most cases, the loan requests included possibly all European specimens labelled with “*Digitaria ciliaris*”, “*D. adscendens*” (synonym of *D. ciliaris*), and “*D. sanguinalis*”. In total, some 1800 herbarium specimens were revised. Of the investigated vouchers, those of “*Digitaria sanguinalis*” covered by far the largest segment (around 1700 specimens).

## Results

### *Digitaria ciliaris* and its treatment in European floras

The imprecise or even erroneous morphological description of *Digitaria ciliaris* in several regional and national floras has accounted for insufficient knowledge of the species in Europe. For instance, as revealed in Wilhelm (2002), in the current flora of Italy (Pignatti 1982), *D. ciliaris* appears with the synonym *D. adscendens* (Kunth) Henrard, leading one to think of the species in question. However, the given diagnostic features belong in part to *D. ciliaris* and in part to *D. sanguinalis* subsp. *pectiniformis* Henrard, therefore making it impossible to recognize *D. ciliaris*. Moreover, assigning diagnostic value to the ciliate fringe at the margin of the sterile lemma has induced Italian florists to maintain the misinterpretation of *D. ciliaris* by earlier European authors, actually referring to forms of *D. sanguinalis*, particularly (but not always!) to *D. sanguinalis* subsp. *pectiniformis* (see Blake 1969 and Veldkamp 1973 for details). In the previous flora of Italy (Zangheri 1976) the name “*Digitaria ciliaris* (auct.)” was properly applied as a synonym for *D. sanguinalis* subsp. *pectiniformis*. Due to the misapplication of the name *D. ciliaris* in Pignatti (1982) the distribution map of the species shown in that work is completely unreliable.

A similar problem is encountered in the flora of Catalonia (Bolòs & Vigo 2001). The authors describe “*Digitaria ciliaris*” using mixed diagnostic features of *D. ciliaris* and *D. sanguinalis*, while according to Pyke (2008), the only quoted herbarium voucher in this work actually belongs to *D. sanguinalis* subsp. *pectiniformis*. A similar situation holds true for the field flora of the Canary Islands published by Hohenester & Welss (1993), in which “*Digitaria ciliaris*” appears to be distinguished from *D. sanguinalis* through its pectinate spikelets and other, scarcely relevant glume and lemma characters.

Sagredo (1987) and Pallarés (1994) are examples of the erroneous treatment of *Digitaria ciliaris* as a synonym of *D. sanguinalis*.

The recognition of *Digitaria ciliaris* is often hampered if in identification keys diagnostically less important features are given too much importance or if they do not cover the main variation range of the species, such as in Valdés & al. (1987).

Some recent European floras with an adequate treatment of *Digitaria ciliaris* stand out, such as the one by Stace (1997) for Britain, the one by Martinčič & al. (1999) for Slovenia, or the field floras by Jahn & Schönfelder (1995) for Crete and by Fischer & al. (2008) for Austria.

### Key to *Digitaria ciliaris* and allied species in Europe

To enable a correct assessment of the variability of *Digitaria ciliaris* and to not run the risk of determining it simply by excluding *D. sanguinalis*, other representatives of the *D. ciliaris* complex are included in the key, but the focus is on the distinction of *D. ciliaris* from *D. sanguinalis*. The other species included demonstrate a certain tendency to spread from their native distribution area and to get introduced in other regions. Presumably, their current occurrence in Europe does not go beyond some sporadic individual records in connection with casual introductions.

*Digitaria bicornis* (Lam.) Roem. & Schult. is not taken into account, because its circumscription and delimitation from *D. ciliaris* are very controversial (compare, for example, concepts provided by Bor 1955, Veldkamp 1973, Webster 1987, Barkworth & al. 2003 and Shouliang & Phillips 2006; also see the discussion in Gilani & al. 2003: 271–272). Some authors consider *D. bicornis* (including *D. chrysolephara* Fig. & De Not.) as synonymous with *D. ciliaris* (Böhling & Scholz 2003). Plants referred to as *D. bicornis* ought to usually be heteromorphic with regard to the pubescence and the venation pattern of the lower lemma of the sessile and pedicelled spikelet, the latter bearing distinctly more hairs (of various kinds). The spikelets are described as relatively large (2.6–3.7 mm long) with, in the case of the sessile spikelet, prominent venation (especially midvein).

The following identification key is based upon descriptions by Veldkamp (1973), Häfliger & Scholz (1980), Webster (1987), Wilhalm (2002), Barkworth & al. (2003), Clayton & al. (2006+) and Shouliang & Phillips (2006), as well as on the author's own observations.

The species treated are annuals or of indefinite duration. The winged primary raceme branches are characteristic. Hairs of leaf sheaths and blades are, if present, usually papillose-based. With the exception of *Digitaria sanguinalis* (and of *D. acuminatissima* Stapf from W and Central Africa, Cope 1995), the nerves of the lower lemma are smooth or nearly smooth in all species of the complex.

1. Rhachis with scattered 1–4 mm long hairs at its proximal portion . . . . . 2
  - Rhachis without such hairs . . . . . 3
2. Adaxial surface of the leaf blades glabrous or with a few long hairs near the base. Spikelet 1.7–2.5 mm long, narrowly lanceolate, sharply acute. Lower glume absent or an obscure rim up to 0.1 mm long, upper glume  $\frac{2}{5}$ – $\frac{4}{5}$  as long as spikelet. Origin: Africa, established in the tropics throughout the world . . . . . *D. nuda* Schumacher.
  - Adaxial surface of the leaf blades (often densely) pubescent. Spikelet 2–2.5 mm long, narrowly ovate. Lower glume minute (0.1–0.2 mm long), upper glume  $\frac{1}{3}$ – $\frac{1}{2}$  as long as spikelet. Origin: tropical America . . . . . *D. horizontalis* Willd.
3. Lower primary raceme branches bearing strongly divergent secondary branches. Rhachis narrowly winged, wings less than  $\frac{1}{2}$  as wide as the midrib. Spikelet 1.5–2 mm long, c. 0.5 mm wide. Lower glume absent or up to 0.2 mm long, upper glume usually  $\frac{3}{4}$  as long as spikelet. Leaf blades pilose adaxially. Origin: Africa . . . . . *D. velutina* (Forssk.) P. Beauv.
  - No secondary raceme branches present (rarely so in *D. horizontalis*). Rhachis wings more than  $\frac{1}{2}$  as wide as the midrib . . . . . 4
4. Rhachis smooth or with few prickles. Slender plant with 2–4 raceme branches. Spikelet 2.2–3 mm long, 4–5× as long as wide (0.6–0.7 mm wide). Lower glume minute (0.1–0.2 mm long), upper glume  $\frac{1}{3}$ – $\frac{1}{2}$  as long as spikelet. Adaxial surface of leaf blades almost glabrous. Origin: Africa, SE Asia, Oceania . . . *D. radicata* (C. Presl) Miq.
  - Rhachis rough, serrate . . . . . 5
5. Upper glume  $\frac{1}{10}$ – $\frac{1}{3}$  as long as spikelet. Lower glume absent or to 0.1 mm. Spikelet (2–)2.5–3.5 mm long, 3–4× as long as wide. Leaf blades glabrous on the adaxial surfaces, usually with some scattered hairs on the base, sometimes with hairs all over. Origin: SE Asia . . . . . *D. setigera* Roth
  - Upper glume at least  $\frac{1}{3}$  as long as spikelet . . . . . 6
6. Lower glume absent or no more than 0.2 mm long 7
  - Lower glume at least 0.2 mm long . . . . . 8
7. Adaxial surface of leaf blades glabrous or with a few long hairs near the base. Lower glume absent or an obscure rim up to 0.1 mm long . . . . . *D. nuda* (see point 2)
  - Adaxial surface of the leaf blades (often densely) pubescent. Lower glume minute (0.1–0.2 mm long) . . . . . *D. horizontalis* (see point 2)
8. Lateral (often also central) nerves of the lower lemma scabrous for the distal  $\frac{2}{3}$  (spicules 0.04–0.1 mm long). Spikelets (2–)2.5–3.3 mm long, mostly oblong-elliptic to elliptic-acute (3× as long as wide). Lower glume c. 0.2 mm long, acute, upper glume  $\frac{1}{3}$ – $\frac{1}{2}$  as long as spikelet. Leaves lanceolate, their adaxial surface moderately to densely pubescent (most hairs 0.5–1 mm long). Ligula 1–2 mm long. Origin: temperate zones of Eurasia. Plants with stout hyaline bristles (0.5–2 mm long, papillose-based) inserted between the outermost nerves of the lower lemma (“pectinate

- form”) are described as subsp. *pectiniformis* Henrard. The subspecific rank seems exaggerated because this sole feature is very often imperfectly developed and possibly determined only by a simple genetic factor (Veldkamp 1973) . . . . . *D. sanguinalis* (L.) Scop.
- Nerves of the lower lemma glabrous throughout, sometimes with a few spicules near the apex. Spikelets 2.5–3.5 mm long, mostly narrowly elliptic (4× as long as wide) with a distinctly acute apex. Lower glume 0.2–0.5 mm long, acute to sharply acute, upper glume  $\frac{1}{2}$ – $\frac{4}{5}$  as long as spikelet. Leaves linear, their adaxial surface glabrous throughout except for some scattered 3–8 mm long patent hairs near the base of the blade. Ligula (1–)2–3.5 mm long. Origin: tropics and subtropics. Var. *rachiseta* (Henrard) A. S. Vega & Z. E. Rúgolo from South America is described as bearing 4–5 mm long hairs near the insertion of pedicels, similar to *D. horizontalis* and occasionally to *D. nuda* (Renvoize & al. 2006). The pectinate form (also see *D. sanguinalis*) is known as var. *chrysoblephara* (Fig. & De Not.) R. R. Stewart. There is some disagreement in assigning such forms either to *D. ciliaris* or to *D. bicornis* . . . . . *D. ciliaris* (Retz.) Koeler

The assignment of the examined herbarium vouchers to *Digitaria ciliaris* was based essentially upon the morphological features being given high diagnostic value by Ebinger (1962) and particularly by Webster (1987). According to these authors and those cited as sources for the key, above, the following serve best to distinguish the species from *D. sanguinalis*: (1) the smooth nerves of the lower lemma (spicules, if present, only few and near the lemma apex, Fig. 1C-D); (2) the relatively narrower and distinctly linear leaves with a glabrous upper surface throughout but with scattered long hairs near the base (Fig. 1A-B); and (3) the relatively longer upper glume (Fig. 1E-F). The attribution to *D. ciliaris* was considered as doubtless when the first two characters were perfectly developed, whereas an upper glume measuring more than  $\frac{1}{2}$  of the spikelet length served only as a reinforcing additional character.

Other features are less diagnostic (see also Webster 1987), though often strongly correlated with the main characters. Among them are the ligula tending to be longer than in *Digitaria sanguinalis*, the relatively longer and more acute lower glume, and the shape of the spikelet, which tends to be narrower and more acute than in *D. sanguinalis*.

*Digitaria ciliaris* is said to be highly variable in the lemma texture, i.e., for the presence or absence of setaceous hairs on the lower lemma. While authors such as Henrard (1950) and Ebinger (1962) gave great importance to this, others such as Veldkamp (1973), Webster & Hatch (1983) and Webster (1987) stressed a large range of variation. In the present study, specimens of typical *D. ciliaris* very often possessed appressed setaceous hairs between the lateral nerves of the lower lemma as well as at the margins and the tip of the upper glume.

With regard to the length of the anthers, there seems to be no difference between the species with reported measures of 0.5–1 mm (Bor 1955; Barkworth & al. 2003). Incidentally, this feature could hardly be examined, because in the specimens studied the anthers were seldom found well-developed.

Integrating forms between *Digitaria ciliaris* and *D. sanguinalis* observed in this study encompassed primarily plants with the following combinations of diagnostic characters: (1) plants with smooth lemma nerves but with a spikelet shape and leaf characters typical for *D. sanguinalis*; (2) plants with spikelets more or less typical for *D. ciliaris* but with the adaxial surface of the leaves densely pubescent.

Plants bearing spikelets otherwise characteristic for *Digitaria ciliaris* but showing scabrous lemma nerves in most cases had leaves typical for *D. sanguinalis* and were thus attributed to this species.

### Distribution of *Digitaria ciliaris* in Europe

#### Literature records

Extensive literature research with an emphasis on S Europe was intended to reflect current knowledge about distribution, introduction vectors and the chorological status of *Digitaria ciliaris* in Europe. No claim is made as to the completeness of the survey.

MADEIRA: Treated as an equivalent species along with *Digitaria sanguinalis*: “An introduced weed of roadsides and waste places” (Press & Short 2001).

CANARY ISLANDS: In Santos Guerra (1983) the species is noted for Tenerife: “Barranco de Las Nieves” and “La Galga, túnel de La Galga”, in Hansen & Sunding (1993) for Gran Canaria, Tenerife, Gomera and La Palma. Scholz & Böcker (1996) confirmed the species for La Palma but referred to incorrect assigned herbarium vouchers, which is why the indications in Hansen & Sunding (1993) should be verified in detail. Recently, *Digitaria ciliaris* was also found in Fuerteventura (Otto & al. 2008).

IBERIAN PENINSULA: *Digitaria ciliaris* either does not appear at all in synoptic regional and national floristic works (Coutinho 1939; Guinea Lopez & Ceballos Jimenez 1974; Malagarriga 1980; Aseginolaza Iparragirre & al. 1984; Smythies 1986; Mateo Sanz 1992; Mateo Sanz & Crespo Villalba 1995; Samo Lumbreras 1995; Garcia Rollan 1999; Dana & al. 2001; Mayor & Díaz 2003) or is mentioned only generally or marginally (Valdés & al. 1987; Sanz Elorza & al. 2004). In the survey of the neophytes of Spain by Del Monte & Aguado (2003), *D. ciliaris* is noted only for the province of Cordoba with only one reference cited. First reports date back to the beginning of the twentieth century, e.g., Barcelona, Arenales de Can Tunis, 1911 (Cadevall Diars 1911). It remains to be examined, however, as to whether these actually refer to *Digitaria ciliaris* and not to *D. sanguinalis* subsp. *pectiniformis*.

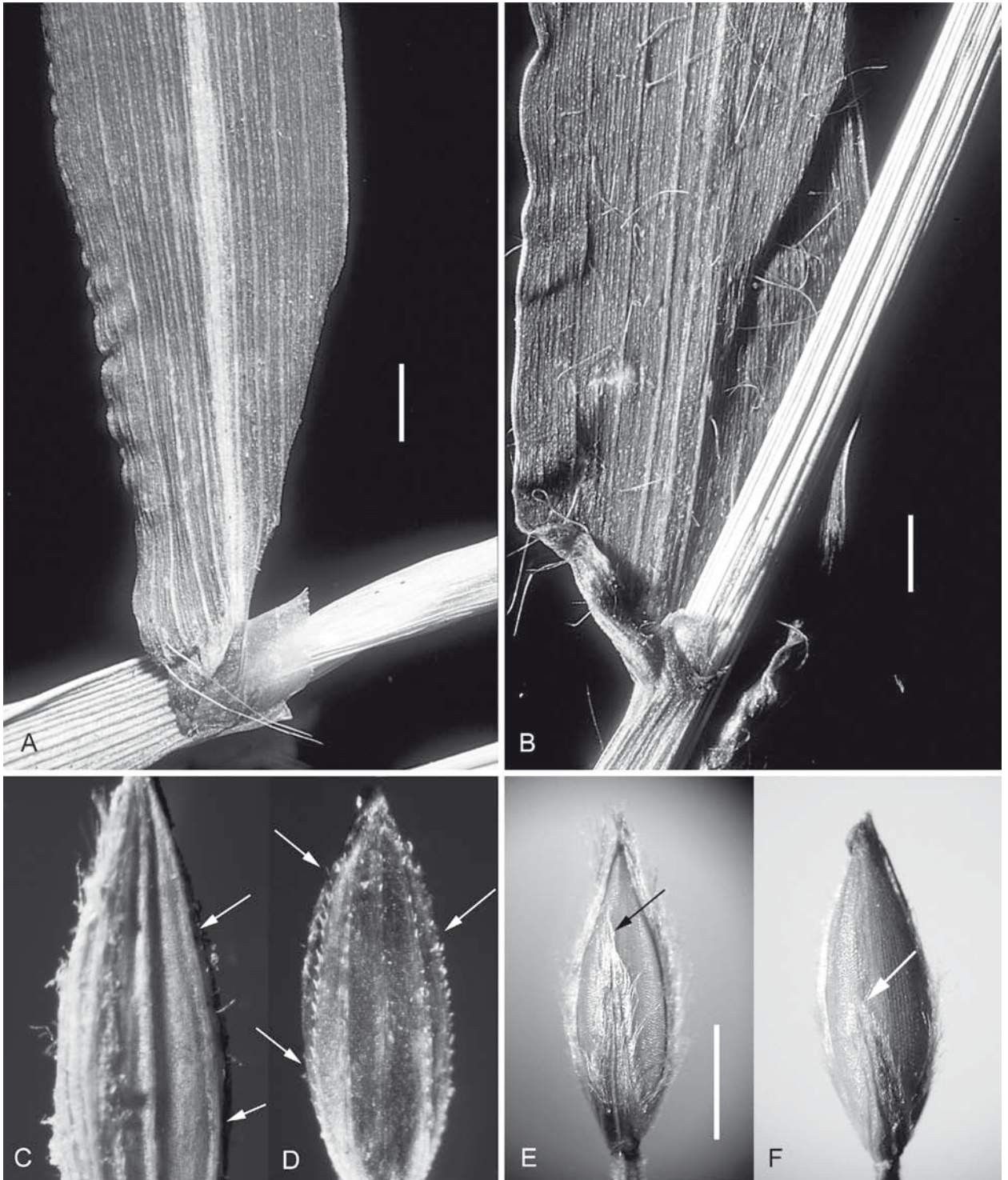


Fig. 1A-B: leaf characters of *Digitaria ciliaris* (A) and *D. sanguinalis* (B): adaxial surface of the blade and ligula; C-D: spikelet characters of *D. ciliaris* (C) and *D. sanguinalis* (D): texture of the lower lemma with spicules on the lateral nerves present in *D. sanguinalis* and absent in *D. ciliaris* (indicated by arrows); E-F: spikelet characters of *D. ciliaris* (E) and *D. sanguinalis* (F): length of upper glume, its tip indicated by an arrow. – Scale bars: A-B = 2 mm, E-F = 1 mm; origin: A, C, E from Italy, district of Salerno, Marina di Ascea, 2006, *T. Wilthalm*, BOZ; B, D, F from Italy, district of Bolzano, Graun/Kurtatsch, 2003, *F. Zemmer*, BOZ.

According to Samuel Pyke (pers. comm.), *Digitaria ciliaris* today is quite frequent throughout the warm regions of the peninsula but not well documented. It commonly grows in the littoral zone of Barcelona and Girona, while it becomes rarer inland until it is completely

absent. Detailed locations are listed in Pyke (2008) for Catalonia: Barcelona (Montjuïc, Sants), L'Hospitalet de Llobregat, Bordils, Begur, L'Escala.

The report by Llamas & al. (2002) for León (province of Castilla y León) sub *Digitaria marginata* must be con-

sidered with reservations, since the associated description appears misleading.

ITALY: As indicated above, the concept of *Digitaria ciliaris* has widely been misinterpreted resulting in a complete lack of information about its distribution in this country. Conti & al (2005) warn in a note on *D. sanguinalis* subsp. *pectiniformis*: “The distribution area is to be defined, since it was confused with *Digitaria ciliaris* (Retz.) Koeler whose distribution includes also the one of *D. sanguinalis* (L.) Scop. subsp. *pectiniformis* Henrard.” Indeed, while the authors indicate *D. ciliaris* for nearly all provinces they provide no records for *D. sanguinalis* subsp. *pectiniformis*. According to Conti (pers. comm.), the data in the Italian checklist for *D. ciliaris* are based primarily upon personal communications by regional referees without literature references and disregarding possible confusion with *D. sanguinalis* subsp. *pectiniformis*. This is obvious, for instance, in the case of the province of Abruzzo: the indication is based solely upon that of “*Panicum sanguinale* var. *ciliare*” reported in Zodda (1954) (Conti, pers. comm.).

On the other hand, *Digitaria ciliaris* is not mentioned in current distribution atlases or checklists for regions where it has been confirmed in the present study or where it is very likely to occur (Poldini & al. 2001; Poldini 2002; Bonali & al. 2006; Mele & al. 2006; Giardina & al. 2007). In actual fact, there seem to exist only two unambiguous records of genuine *D. ciliaris* for Italy in the literature. The first was published by Cook (1973) for the rice fields in the region near Vercelli (Piedmont), quoted both in Tutin & al. (1980) and in Pignatti (1982). The other one is provided by Wilhalm (2001) for the district of Bolzano: Lana, Prad, and St Leonhard.

GREECE (excluding the Aegean islands): *Digitaria ciliaris* is likely to have been recognized only recently. It is mentioned by Giannitsaros (1990) and Anagnou-Veroniki & al. (2008) as a potential weed species. Records are given by Zotos & al. (2006) for W Greece: in the vicinity of Lake Trichonis and Lake Lisimachia (Sterea Ellas, Etoloakarnania: three locations cited).

MEDITERRANEAN ISLANDS: *Digitaria ciliaris* is indicated for Crete in Jahn & Schönfelder (1995), detailed records are provided by Böhling & Scholz (2003): Neos Kournas, Lake Kournas, Deres, Kamisiana, Fodele, Xerokambos, east of Malia. According to Scholz (1985), no data have been available for the southern Aegean islands until recently.

No data seem to have been collected for the Balearic Islands (Bonafè Barceló 1977; Smythies 1986) and for Corsica (Jeanmonod & Gamisans 2007).

TURKEY: Reliable data seem still to be missing. This was first observed by Scholz (1985) and appears still to be true. In fact, *Digitaria ciliaris* neither appears in the first

supplement to the Flora of Turkey (Davis 1988) nor in the later supplemental checklists published by Özhatay & al. (1994, 1999, 2006). Some recent reports are given by Eminağaoğlu & al. (2008) and in the Turkish Plants Data Service (TUBIVES 2009) for NE Anatolia, but they seem somewhat questionable due to the circumstances described and in any case need to be verified.

BALKAN PENINSULA: The species in question is not discussed in the historical flora, covering the whole region, by Hayek & Markgraf (1933). As emphasized, for example, by Martinčič & al. (1999) for Slovenia, no reliable data seem available even in the current literature. In national floras the name “*Digitaria ciliaris*” is still applied to *D. sanguinalis* subsp. *pectiniformis* (FCD 2004+; Josifovič 1976). Moreover, in several cases, even the description of the latter and its delimitation from subsp. *sanguinalis* appear inappropriate, as is the case in Josifovič (1976).

CENTRAL EUROPE: Historical records refer almost exclusively to casual occurrences in connection with shipping centres and wool and cotton processing operations. In some cases, bird seed and other mixtures may have played a role as vectors. Such records, as reported in Conert (1979-98) for Germany (Aken, Colmar, Kettwig, Rodleben), France (Alsace: Issenheim) and Switzerland (Derendingen) mostly date back before 1950. In recent times, the introduction of *Digitaria ciliaris* as a companion mixed with fodder plants is playing an increasingly important role, as a casual with grains, oil seeds, and especially soybeans. Such occurrences have been observed in Germany: harbour of Neuss/Düsseldorf (Stieglitz 1981, also see specimens viewed).

In current German floras and checklists, *Digitaria ciliaris* is not discussed, probably because, as explicitly expressed, for example, by Buttler & Hand (2008), only established neophytes are accepted. One exception constitutes the latest edition of the field flora for Austria (Fischer & al. 2008), in which the species is reported for Austria for the first time. The herbarium vouchers from Styria are those examined within the framework of this project (see above). The (general) presence of the species in France is confirmed by Kerguélen (1973).

W EUROPE: Ryves & al. (1996) indicate the grass for several localities in Great Britain that are not itemized, among them mainly historical records. In Palmer’s (1977) list of plant species introduced with oil-seeds in NW Kent *Digitaria ciliaris* is told to be abundant. According to Stace (1997) *D. ciliaris* is scattered in southern England, casually introduced but not naturalized. Clement (2000), however, reports the naturalization in a coastal region in southern England (Gosport).

*Digitaria ciliaris* is indicated as a companion of fodder plants in Belgium: Antwerp, Izegem, Roeselare (Verloove & Vandenberghe 1996). Recently, *D. ciliaris* subsp. *nubica* (Stapf) S. T. Blake, originating from Africa, was

observed as a new adventitious grass in Belgium (Verloove & Vandenberghe 1999). Lambinon & al. (2004) obviously refer to these reports in the flora of the Low Countries, in which *D. ciliaris* appears only in a note. Confirmed records of *Digitaria ciliaris* for the Netherlands are cited in Jansen (1951).

E EUROPE: No indications of *Digitaria ciliaris* can be drawn from Tzvelev (1976) for the European part of the former Soviet Union. In recent Russian floras, the species is indicated as exotic to the Caucasus region (Czerepanov 1995; Zernov 2006). In the checklist of the vascular plants of Ukraine (Mosyakin & Fedoronchuk 1999), "*Digitaria ciliaris*" appears with the following note: "A very rare alien species. Almost all Ukrainian records of *D. ciliaris* refer to *D. pectiniformis*". Likewise, it is neither treated in Dostál (1986) for the former Czechoslovakia nor in the current field flora for the Czech Republic published by Kubát & al. (2002). Because of the ongoing erroneous application of the basionym in the current flora (Simon 1992), possible data in the literature referring to "*Digitaria ciliaris*" in Hungary must be regarded with reservations.

N EUROPE: Introductions in connection with grain fodder are reported for Finland: Naantali (Lahtonen & Kaantonen 1992). In current Scandinavian floras (Lid & Lid 2005), however, the species is not taken into consideration. Several recent occurrences are known from Lithuania: Kaunas (first record in 1987), Joniškis, Kretinga, Marijampolė, Plungė, Tauragė (Gudžinskas 1997).

### Specimens examined

The herbarium revision carried out demonstrates that vouchers of European origin labelled as "*Digitaria ciliaris*" are to be assigned for the most part to *D. sanguinalis*, particularly to subsp. *pectiniformis*. In the majority of cases, this is true for historical collections, due to the misapplication of the binomial *D. ciliaris* by earlier European authors (Veldkamp 1973). Since only relatively few such collections were available, it is obvious that most European specimens formerly labelled as "*Digitaria ciliaris*" had already been correctly arranged under *D. sanguinalis* (subsp. *pectiniformis*).

Overall, nearly a hundred specimens of genuine *Digitaria ciliaris* were found, with about one fourth of them deposited in collections with recent specimens that were correctly identified, the same proportion of them labelled as *Digitaria* sp., and one half hidden among the huge number of examined vouchers labelled as "*Digitaria sanguinalis*". Their origins are scattered throughout Europe but clearly concentrate on the Mediterranean coast of the Iberian Peninsula, Italy and Greece. The records are arranged by countries in alphabetical order.

AUSTRIA: STEIERMARK: Köflach, auf dem Müllplatz am Karlschacht, 20.9.1987, *H. Melzer* (herb. Melzer); Graz, in Ritzen der Gehsteige, 3.9.1980, *H. Melzer* (herb. Melzer).

CZECH REPUBLIC: KRÁLOVÉHRADECKÝ KRAJ: Harta, auf faulem Baumwollabfall, 7.9.1908, *V. von Cypers* (BC 831149).

DENMARK: HOVEDSTADEN: Copenhagen, Islands Brygge, waste place, 9.1972, *Kaj Vollesen* (W).

FINLAND: LÄNSI-SUOMI: Turku, Iso-Heikkilä, in margine viae, 7.10.1938, *K. J. Lounamaa* (W).

FRANCE: PROVENCE-ALPES-CÔTE D'AZUR: Vaucluse, Avignon, ex herb. Gral Antg [?] (MA 147092).

GERMANY: BADEN-WÜRTTEMBERG: Karlsruhe, "kultiviert", 1909, *Kunnter* (?) (W); Mannheim, Bonadieshafen bei Getreidespeicher, 6.10.1996, *G. Hügin* (B). – BAYERN: Bamberg, Schützenstraße, Baumscheibe, 18.9.1996, *G. Hetzel* (B). – HAMBURG: (?) Fluss hinter Blankenese, 29.9.1892, *Lahan* (BC 66239). – NORDRHEIN-WESTFALEN: Neuß, Hafenböschung, 11.10.1979, *Stieglitz* (B). – SACHSEN: Leipzig, <1860, *C. F. Hochstetter* (W).

GREECE: ATTIKI: ATHINA (ATHENS): Filadelfia, lawn, 20.12.1983, *M. Damanakis* (B); Votanikos, lawn, 20.12.1983, *M. Damanakis* (B). DYTIKI ATTIKI: Elefsina, lawn, 23.7.1996, *Kislev & Melamed* (B). – DYTIKI ELLADA (WESTERN GREECE): ACHAÍA: Aegio, 5.1.1984, *Milion* (B); city of Patras, 30.6.1993, *G. Chronopoulos 546* (UPA); SW part of Rion village, 14.12.1995, *Nielsen* (B); Rion, ruderal, 0–50 m, 14.12.1995, *Nielsen 10999* (UPA); Cape Drepanon, Kato Arachovitika, 15 km NE of Patras, garden weed, 23.9.1996, *Nielsen 11681* (B, UPA). ETOLOAKARNANIA: Mesolongion, ruderal, 26.10.1995, *Nielsen 10805* (UPA). – KRITI (CRETE): CHANIA: Souda, 7.8.1984, *H. Scholz & Damanakis* (B); LASITHI: E of Malia, road fissures, 21.4.1994, *H. Scholz* (B). – NOTIO EGEO (SOUTH AEGEAN): KIKLADES: Isle of Paros, Eparchia Parou, Ruderalstellen und Segetalvegetation, 10–20 m, 21.9.1993, *T. Raus* (B). – PELOPONNISOS: ARGOLIDA: Laloukas, 5.12.1983, *Milion* (B). – THESSALIA: TRIKALA: Kalambaka, Maquis edge, 21.7.1996, *Kislev & Melamed* (B).

ITALY: CALABRIA: COSENZA: Scalea, Eingang Hotel Rose, 20 m, 18.10.2001, *N. Hölzl* (BOZ PVASC13863); Scalea, Zentrum, 25 m, 18.10.2001, *N. Hölzl* (BOZ PVASC13864); Scalea, in Beeten, 15 m, 18.10.2001, *N. Hölzl* (BOZ PVASC13865); Scalea, Stadtpromenade, 19.10.2001, *N. Hölzl* (BOZ PVASC13866). REGGIO CALABRIA: Africo, Straßenrand, 10 m, 9.10.2002, *N. Hölzl* (BOZ PVASC13832); San Martino di Taurianova, Via Petroneo, Gartenbaubetrieb, 10 m, 17.10.2001, *N. Hölzl* (BOZ PVASC13867); Siderno, 22.10.2004, *N. Hölzl* (BOZ PVASC13850). VIBO VALENTIA: Pizzo, Contrada da Speciale, Gartenbaubetrieb, 10 m, 17.10.2001, *N. Hölzl* (BOZ PVASC13868); *ibid.*, 16.10.2008, *N. Hölzl* (BOZ PVASC13853). – CAMPANIA: BENEVENTO: Benevento, Contrada Olivola, Gartenbaubetrieb, 100 m,



- 15.10.2001, *N. Hölzl* (BOZ PVASC13869). CASERTA: Curti, Gartenbaubetrieb, 50 m, 18.10.2001, *N. Hölzl* (BOZ PVASC13870). NAPOLI: Ischia, bei den Fumarolen von Casamicciola, 19.7.1952, *Höpflinger* (BC 122776); Pozzuoli, Parco Solfatara, 7.10.2002, *N. Hölzl* (BOZ PVASC13871); Ischia Porto, Park des Hotel Continental, 9.10.2002, *N. Hölzl* (BOZ PVASC13833). SALERNO: San Marzano sul Sarno, Gartenbaubetrieb, 50 m, 15.10.2001, *N. Hölzl* (BOZ PVASC13872); Marina di Ascea, Touristendorf "Elea", Wegrund, 5 m, 2.7.2006, *T. Wilhelm* (BOZ PVASC9032); Marina di Ascea, Straßenrand, 5 m, 2.7.2006, *T. Wilhelm* (BOZ PVASC13852); Eboli, Gartenbaubetrieb, 14.10.2008, *N. Hölzl* (BOZ PVASC13854).
- FRIULI VENEZIA GIULIA: GORIZIA: Monfalcone, Panzano, auf Ödland, 21.9.1985, *H. Melzer* (herb. H. Melzer).
- LAZIO: LATINA: Sabaudia, 23.2.2009, *N. Hölzl* (BOZ PVASC13856). ROMA: Roma, Trastevere, Orto Botanico, Rasen und Wegrund, 10.11.2000, *T. Wilhelm* (BOZ PVASC13823, RO).
- LIGURIA: SAVONA: Albisola, Strandpromenade, 18.10.2002, *N. Hölzl* (BOZ PVASC13826).
- LOMBARDIA: VARESE: Ligurino, 7.9.1983, *H. Scholz* (B).
- PIEMONTE: ASTI: Moncalvo, Regione di S. Martino, 23.9.2008, *N. Hölzl* (BOZ PVASC13855).
- VENETO: BELLUNO: Belluno, cimitero, 370 m, 8.9.2000, *C. Argenti* (BOZ PVASC13814); Belluno, Lambioi, incolto, 340 m, 8.9.2000, *C. Argenti* (BOZ PVASC13812). TREVISO: Treviso, margine strada, 8.12.2000, *C. Argenti* (BOZ PVASC13825).
- SICILIA: MESSINA: Messinese, 2.1889, *Zwierlein* (FI); Tonnarella di Furnari, Wegrund, ruderal, 2.2.2009, *N. Hölzl* (BOZ PVASC13807). TRENTO-ALTO ADIGE: BOLZANO/BOZEN (SOUTH TYROL): Burgstall, Bahnhof Lana-Burgstall, Bahnhofsgelände, 13.9.2000, *T. Wilhelm* (BOZ PVASC4742).
- TRENTO: Malè, Mangiasa, terreno smosso, 29.10.1995, *F. Prosser* (ROV).
- MONTENEGRO: Sveti Stefan, 1.9.1992, *D. Lakušić* 653/92 (BEOU).
- PORTUGAL: ALGARVE: Lugar da Fornalha, estrada Olhã-Moncarapacho, 24.6.1986, *A. Moura* (MA 395500); Portimão, Colinas de Arge, 19.7.1972, *Malato-Beliz & J. A. Guerra* 11963 (MA).
- SPAIN: ANDALUCÍA: MÁLAGA: pr. Torremolinos, 12.9.1976, *E. Sierra-Ràfots* (BC 652517).
- ARAGÓN: HUESCA: Sariñena, campo maiz, 7.9.1996, *M. Sanz Elorza* (MA 614999).
- CATALUNYA: TARRAGONA: L'Ampolla, Cap Roig, Vordda cami, urbanització, 10 m, 2.11.1973, *R. Folch & E. Velasco* (BC 626948); Cambrils, Riera del Regueral, 30 m, 22.8.1998, *E. Sobrino & M. Sanz* (MA 627835).
- EXTREMADURA: BADAJOZ: Campo de la Granadilla, 1.9.1987, *M. C. Viera* (MA 522175).
- ISLAS CANARIAS: SANTA CRUZ DE TENERIFE: Orotava, Sitios immedos, 30.8.1878, *Masferrer* (BC 66216).
- PAÍS VASCO: VIZCAYA: Algorta, 1918, *Hno Elias* (MA).
- VALENCIA: ALICANTE: Denia les Marines, 5 m, 28.9.1992, *J. X. Soler* (MA 572045); Xàbia, Muntanyar de Baix, 10.1992, *A. Barber* (MA 537101).
- VALENCIA: Serra, escombreras junto al pueblo, 300 m, 28.11.1983, *G. Matteo* (MA 286033); Carcaixent, 100 m, 21.10.1986, *S. Piera* (MA 388869).
- SWEDEN: VÄSTRA GÖTALANDS LÄN: Göteborg, Gamlestaden, in horto adventicia, 28.9.1927, *Ragnar Ohlsén* 7317 (W); Göteborg, Mölndal: Krokslätt, in ruderatis, 9.1953, *Carl Blom* (W); ibid., inkommen med bomull, 2.10.1943, *Carl Blom* (W).
- SWITZERLAND: SOLOTHURN: Derendingen, 8.8.1920, *R. Probst* 9484 (Z); Derendingen, Baumwollkompost der Spinnerei Emmenhof, 29.8.1920, *A. Thellung* (Z); Derendingen, Kompostgrube, 17.10.1920, *R. Probst* 9495 (Z).
- TICINO: Centovalli, bei Intragna, 20.9.1983, *H. Scholz* (B).
- ZÜRICH: Albisrieden, häufig im Garten eines Gärtners, 420 m, 15.6.1930, *Gavioli* 25158 (FI); Gärtnerei Werffeli [without location, presumably Weinigen W of Zurich], 23.9.1930, *A. U. Däniker* (Z).
- TURKEY: ANTALYA: Belek, 21.7.2005, *N. Hölzl* (BOZ PVASC13842).
- UNITED KINGDOM: ENGLAND: Northamptonshire, "introduced with wool 'shoddy' Blackmoor", 27.9.1970(?), *M. McCallum Webster* 14179 (BM).
- SCOTLAND: Mid Lothian, Borthwick, cinder tip, 24.10.1962, *M. McCallum Webster* 8327 (BM).
- WALES: Cardiff, waste ground, 9.1932, *A. E. Wade* 2095 (BM).
- Specimens examined of intermediate forms between Digitaria ciliaris and D. sanguinalis.* — AUSTRIA: TIROL: Osttirol, Lienz, locis cultis, 9.1868, *R. Huter* (FI).
- HUNGARIA: KÖZÉP-MAGYARORSZÁG: In cultis praedii Rákos prope Budapestinum, 11.7.1900, *A. de Degen & C. de Flatt* (BC 831147).
- ITALY: BASILICATA: POTENZA: Pignola, Pontoni (?), 28.8.1926, *Gavioli* (FI).
- CAMPANIA: NAPOLI: Casamicciola, 7.9.1875, *E. Levier* (FI); Pozzuoli, Campi Flegrei, Straßenrand, 7.10.2002, *N. Hölzl* (BOZ PVASC13831).
- EMILIA ROMAGNA: MODENA: Appennino modenese, Montefiorino, 1979, *V. Mori* (FI).
- FRIULI VENEZIA GIULIA: TRIESTE: nei vigneti e terreni incolti presso Trieste, 1857(?), *M. Tommasini* (FI).
- LAZIO: ROMA: Porta Pia, incolto, 19.9.2000, *C. Argenti* (BOZ PVASC13824); Roma, Stazione Termini, incolto, 20.9.2000, *C. Argenti* (BOZ PVASC12961).
- SARDEGNA: NUORO: Arbatax, Umgebung der Feriensiedlung "Borgo degli Ulivi", Bauland, 15 m, 25.7.2007, *T. Wilhelm* (BOZ PVASC10810).
- SICILIA: [without location] 1841, *Parlatore* (FI).
- TOSCANA: S. Maria Macerata, presso S. Casciano, Val di Pesa, 1880, *R. Ricci* (FI).
- TRENTO-ALTO ADIGE: BOLZANO/BOZEN (SOUTH TYROL): Niedervintl, Bahnhofsgelände, 750 m, 26.8.1999, *S. Matzneller* (BOZ PVASC4164).
- VENETO: BELLUNO: Vaso, greto del Piave, 21.9.2003, *C. Argenti* (BOZ PVASC13851).
- VICENZA: Bassano del Grappa, Parkanlage der Villa Giusti, 130 m, 11.9.2005, *T. Wilhelm* (BOZ PVASC8153).



Fig. 2. *Digitaria ciliaris* in Europe. – Revised herbarium vouchers (empty stars: collected before 1950, filled stars: after 1950) and records drawn from the literature (empty squares: before 1950, filled squares: after 1950). In the event that literature records and herbarium vouchers coincide, only the latter are presented on the map. Symbols may stand for more than one record if sites are too close to be indicated separately. The Atlantic islands (Macaronesia) with their respective records are not shown. See the text for details.

MONTENEGRO: Tivat, Lastra, st. betonski zid iznad mora, 15.9.1996, *Karamari* (?) 1005 (BEOU).

SWEDEN: SÖDERMANLANDS LÄN: Nyköping, Perioden, inford med bomull, 9.1915, *Carl Blom* (W).

SWITZERLAND: TICINO: Sessa (Malcantone) Scree, Sasso Biotta, felsige Stellen in Waldlichtung, 18.8.1991, *E. Landolt* (ZT). – ZUG: Lorenzital östlich von Baar, Unkraut in Maisfeld, 4.9.1983, *K. U. Kramer* (Z). – ZÜRICH: Schlieren, Schlatt, Waldschlag, 12.10.1990, *E. Landolt* (ZT); Stallikon, Maisfelder S Baldern, 31.8.1991, *E. Landolt* (ZT); Fluntern, Zürichberg, hinter dem Chlösterli, Maisacker, 14.9.1992, *E. Landolt* (ZT); Uitikon, Maisacker N Kantonalen Erziehungsanstalt, 24.9.1994, *E. Landolt* (ZT).

### Conclusions

The herbarium revision and literature survey indicate that *Digitaria ciliaris* is still little known and thus largely ignored in regions where *D. sanguinalis* and *D. ciliaris* grow sympatrically and that it must thus be considered as definitely more widespread than it appears from the current literature. Although scattered reliable reports of

the species exist in the literature, these have hardly been accepted in synoptic checklists and floras. This holds true especially for Spain. Finally, current floristic references of E and SE Europe still adhere to the obsolete concept of *D. ciliaris*, causing the continued report of either erroneous or uncertain data. One of the very few reliable pictures drawn of the distribution of *D. ciliaris* in Europe is provided by Clayton & al. (2006), who indicate SE Europe and Macaronesia as distribution area. A map of the currently known distribution of *Digitaria ciliaris* in Europe is shown in Fig. 2.

*New records.* — *Digitaria ciliaris* is here reported for the first time or at least definitely confirmed for Portugal, Montenegro and Turkey, for the Spanish provinces of Aragón, Extremadura, País Vasco and Valencia, and for the Greek regions of Attiki, Notio Egeo (Southern Aegean), Peloponnesus and Thessalia. Current records are also provided for Switzerland. For Italy, the following can be asserted: the species must be regarded as new to Calabria, Campania and Sicily and is definitely confirmed for Friuli Venezia Giulia, Liguria, Lombardia and

Veneto. Indications for other regions except for Piemonte (see Cook 1973) and Trentino-Alto Adige (see Wilhelm 2001) still need verification.

*Ecology.* — The habitats invaded by the species, as drawn from the herbarium labels, are directly associated with the introduction vector in N Europe and include harbour areas, dumps, waste places, gardens, roadsides, etc. In S Europe, it does not exclusively grow in typical ruderal sites (waste grounds, roadsides) but also appears as a constant accompanying grass in lawns and plantations (also Pyke, pers. comm., and own observations).

*Chorological status.* — Little insight has gained from the literature into the actual chorological status of *Digitaria ciliaris* in individual European countries. Spanish references either ignore the species or classify it as an occasionally introduced grass (Valdés & al. 1987) in regions where our results strongly suggest a naturalized status. According to Giannitsaros (1990, cited after Anagnou-Veroniki & al. 2008), *D. ciliaris* is among those non-indigenous grass species in Greece that appear to be in an establishing stage showing the potential of becoming a weed species. Thus far, there seem to be only few unambiguous references to the species in question (and not to “*Digitaria ciliaris* auct.”) that definitely consider it as naturalized, such as Cook (1973) for the rice fields in N Italy and Jahn & Schönfelder (1995) for Crete. It may, however, be inferred from the data gathered from our study that *D. ciliaris* is widely distributed and very likely naturalized over large areas along the Mediterranean coast. This is supported by the observation that among the material of “crabgrass” randomly collected by N. Hölzl in coastal regions of Italy there was always proportionately more *D. ciliaris* than *D. sanguinalis*. Of course, more data are required, such as from the Mediterranean coast of France, and the Balkan Peninsula, as well as from Sardinia and Corsica, to verify the statement for the Mediterranean area in general.

The presence of *Digitaria ciliaris* in more continental locations in N Italy is possibly unrelated to its recent spreading in coastal areas of the Mediterranean. In fact, it was already well-established as a weed of rice in that area several decades ago (see Cook 1973).

While *Digitaria ciliaris* is very likely to be established in the Mediterranean area (and in rice fields of N Italy) through proliferation in situ, this is largely to be excluded for other parts of Europe at present. The scattered occurrences observed throughout Central and N Europe are strictly casual and likely ephemeral: while the species vanish in one place after a certain time, it may occur in another one.

## Discussion

*Distribution.* — The data gathered from the present study give an overall picture of the distribution of *Digitaria ciliaris* in Europe but are far from being complete. Fur-

ther in-depth studies, hopefully stimulated by this work, are required to close obvious gaps, such as in (southern) France, Sardinia, Corsica and along the Mediterranean coast of the Balkan Peninsula.

Furthermore, the results should prompt researchers to search for “pure” *Digitaria ciliaris* in regions, such as the eastern coast of Sardinia or the urban area of Zurich, where only integrating forms with *D. sanguinalis* are known at present.

*Integrating forms.* — No clarity exists how the amalgamation of morphological features of *Digitaria ciliaris* and *D. sanguinalis* comes about. Ebinger (1962) and Gould (1963) carried out crossing experiments demonstrating that hybrids between the two species occur but are sterile. Ebinger (1962) emphasized that there is little evidence of extensive hybridization and backcrossing taking place because of a rather restricted zone of intermediates and because of a rather limited introgression of characters from one species into the other. According to Gilani & al. (2003, also see Cope 1982), intermediate plants suggest in some way that there is some gene flow between the two species. Particularly affected by that is the presence or absence of spicules on the nerves of the lower lemma.

*Introduction and naturalization.* — With regard to introduction vectors, it may be noted that the current sporadic occurrences in Central and N Europe are apparently connected with shipping centres, with the import of fodder (e.g., grain and soybeans) and possibly other goods. On the other hand, there must also be efficacious ways of the grass dispersing into regions where such vectors are missing, e.g., by means of transit traffic. This is obviously the case in the interior Alpine region of South Tyrol, where *Digitaria ciliaris* has been found in a few sites including an industrial park, a railway station and roadsides.

No concrete indications are available for S Europe. The presence of the species over large areas (Fig. 2) suggest spontaneous introductions and a subsequent establishment and self-maintaining of populations. Since *Digitaria ciliaris* has widely been overlooked in the past, no reliable statement can be made about the time of first introduction and about patterns of subsequent naturalization in S Europe. Only a few herbarium vouchers from this area were detected that date back to the nineteenth century, whereas the majority of specimens were collected in the past twenty years. It may thus be surmised that the species has spread heavily and established broadly only in recent times, but examined vouchers from the Canary Islands of 1878 and from Sicily of 1889 suggest that it has been present in S Europe for a long time. However, it is not known if these two examples refer only to singular casual introductions in connections with, for example, shipping traffic.

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