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FILIP VERLOOVE[1] & ENRIQUE SÁNCHEZ GULLÓN[2]

A taxonomic revision of non-native *Cenchrus* s.str. *(Paniceae, Poaceae)* in the Mediterranean area

Abstract

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The exact identity of non-native, naturalised populations of *Cenchrus* s.str. in the Mediterranean area has been critically assessed. A herbarium revision confirmed the presence of three species: *Cenchrus echinatus, C. longispinus* and *C. spinifex* (syn.: *C. incertus*). In the present paper *C. echinatus* is reported for the first time from Spain and confirmed for Egypt and Israel. *C. longispinus,* up to present widely confused with *C. spinifex,* is reported for the first time from Croatia, Greece, Israel and Morocco and furthermore confirmed for France (including Corse) and Italy. Finally, *C. spinifex* is confirmed for France, Italy and Spain, while records from Greece and Israel proved to be in error for *C. longispinus*. All three species are much alike and widely confused in the studied area. In some areas (especially in parts of Italy and Israel) two species occur sympatrically, which largely added to the confusion. Main features for their distinction are discussed and a dichotomous key for the identification of the native and non-native species of *Cenchrus* s.str. in the Mediterranean area is presented.

Additional key words: *Gramineae, Cenchrus echinatus, Cenchrus longispinus, Cenchrus spinifex,* taxonomy, chorology

Introduction

In its traditional circumscription *Cenchrus* L. is a genus of c. 20 species, predominantly distributed in the warmer parts of the New World and with some additional species in Africa and Asia (DeLisle 1963; Mabberley 2008). Several species are troublesome environmental or agricultural weeds beyond their native distribution range.

Cenchrus is a very complex and largely misunderstood genus, especially in areas where non-native species occur, as is the case in the Mediterranean area. In the past decades collections of non-native *Cenchrus* species from the Mediterranean have been ascribed to either *C. echinatus* L., *C. incertus* M. A. Curtis, *C. longispinus* (Hack.) Fernald, *C. pauciflorus* Benth. or *C. tribuloides* L. A herbarium revision undertaken in the past years (see also Verloove 2006) yielded a lot of interesting new data. The results of this revision are dealt with in this paper.

The three non-native species of *Cenchrus* that are finally accepted in this study (*C. echinatus, C. longispinus* and *C. spinifex* Cav.) are reputed environmental and/or agricultural weeds in as well as outside their native distribution range. In the Mediterranean area, *C. echinatus* is a relatively recent newcomer and only locally established or invasive (although a future naturalisation in a wider area seems likely). Both other species have been repeatedly and increasingly reported as invasive species, for instance in parts of Greece, the Former Yugoslavian Republic, Italy or Spain (Sanz Elorza & al. 2004; Boršić & al. 2008; Arianoutsou & al. 2010; Celesti-Grapow & al. 2010). Therefore, it is not only useful but even essential to acquire a better understanding of the non-native representatives of the genus *Cenchrus* in the area under study.

In the Mediterranean area *Cenchrus* counts five native species (see for instance Maire 1952; Clayton

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1980; Valdés & Scholz 2009+): *C. biflorus* Roxb. (Algeria, Egypt, Libya and Morocco), *C. ciliaris* L. (Algeria, Egypt, Israel, Lebanon, Libya, Morocco, Sicily, Syria and Tunesia; furthermore introduced in Greece and Spain), *C. pennisetiformis* Hochst. & Steud. (Egypt), *C. prieurii* (Kunth) Maire (Algeria, Morocco) and *C. setigerus* Vahl (Egypt). The non-native representatives have been ascribed to several species and confusion lingers on since many decades, especially in Italy. It surely is no coincidence that Italy is the initial area of naturalisation (in the 1930s) of two non-native species of *Cenchrus* in the Mediterranean. Populations were initially ascribed to *C. tribuloides* (Plicker 1943; Pellegrini 1947; D'Errico 1949; Tosco & Ariello 1951) and later corrected to *C. pauciflorus* by Grilli (1962). Eventually, Cecconelli (1975) concluded that all Italian collections pertain to *C. longispinus* (subsequently confirmed by Guzik & Pacyna 1999). However, recent Italian floristic checklists (Conti & al. 2005; Celesti-Grapow & al. 2010) correctly accept two species: *C. spinifex* (as *C. incertus*) and *C. longispinus* but both are obviously still widely confused (see below). In France all records from the past decades were assigned to *"C. incertus"*. However, a previous revision already proved that all collections from Corse in fact represent *C. longispinus* (Verloove 2006). Likewise, plants from the French Mediterranean area (dep. Vaucluse) are *C. longispinus* while genuine *C. spinifex* is only confirmed from southwestern France. In Spain all populations of non-native *Cenchrus* have been ascribed so far to *"C. incertus"* which seems to be confirmed by the present revision (although a second non-native species, *C. echinatus,* recently turned up in Andalusia). Recent records of *"C. biflorus"* from Morocco (Birouk & al. 1991) are here identified as *C. longispinus*. Elsewhere in the Mediterranean area non-native species of *Cenchrus* have been reported from several different countries but many records now turned out to be erroneous (for instance from Croatia, Greece and Israel).

Material and methods

The results of this paper are entirely based on the revision of material from selected herbaria: the herbarium of the Botanischer Garten und Botanisches Museum Berlin, Germany (B), the National Botanic Garden of Belgium (BR), the Museo di Storia Naturale in Firenze, Italy (FI), the University of Gent, Belgium (GENT), the Royal Botanic Gardens of Kew, England (K), the University of Liège, Belgium (LG), the Museo Civico di Storia Naturale in Milano, Italy (MSNM) and the Università degli Studi of Torino, Italy (TO). In addition, material of the private herbaria of the authors, as well as of J.-M. Tison and A. Soldano (Vercelli, Italy) were also revised.

The studied area encompasses the entire Mediterranean basin: Spain (incl. Balearic Islands), France (incl. Corse), Italy (incl. Sardegna, Sicily), F.Y.R. (Former Yugoslavian Republic), Albania, Greece (incl. islands) and Turkey in Europe; Turkey, Syria, Lebanon and Israel in Asia and finally Egypt (incl. Sinai), Libya, Tunisia, Algeria and Morocco in Africa.

Results and discussion

The non-native species of *Cenchrus* s.str. in the Mediterraneran area

Cenchrus echinatus L., Sp. Pl. 2: 1050. 1753.

Distribution. — Native of southern United States, Central and South America and the West Indies (DeLisle 1963). More or less widely naturalised elsewhere in warm-temperate and (sub-)tropical regions of the world (for instance Pacific Islands, Philippines, Australia, Arabian Peninsula, E Africa, China, etc.). In the Mediterranean area known so far from Egypt (omitted by Valdès & Scholz 2009+) and Israel (DeLisle 1963; Cope 2005). Here reported for the first time from Spain. In Israel *Cenchrus echinatus* now has become a noxious weed in irrigated gardens and lawns (Danin 2004).

Illustrations. — Fig. 1A–B; Caro & Sánchez (1967b); Häfliger & Scholz (1980); Stieber & Wipff (2003); Cope & Gray (2009).

Specimens examined. — Egypt: Sinai, Nuweiba, Straßenrand, 17.3.1995, *Borkowsky s.n.* (B); Sinai, Nuweiba, Parkanlage, 13.3.1996, *Borkowsky s.n.* (B); El-Hammam, 60 km west of Alexandria, weeds of cultivation, 30.9.2001, *L. Boulos 19528* (K); Assouan, berge empierrée du Nil, en pente, près de l'embarcadère, 26.3.2004, *J. Lambinon 04/Eg/50* (LG); Baltim, northern Nile delta, waste ground, 14.9.1994, *I. Mashaly & L. Boulos 20247* (K).
France: Dep. Var, Îles d'Hyères, s.d. [<1900], *Decaisne s.n.* (BR).
Israel: Near Tel Zur, Sharon Plain, sandy clay soil, 29.11.1968, *J. Mattatia s.n.* (LG); Lotan, 50 km N of Elat, weed in an irrigated flower plot, 14.3.2011, *A. Danin s.n.* (BR); Kiriat Mozkin, Acco plain, 27.8.2011, *M. Iehuda s.n.* (BR); Kfar Chabad, 20 km E of Tel Aviv, 29.8.2011, *S. Dadon s.n.* (BR); Sharon, Ramat-Aviv (Tel-Aviv), botanical garden, 30.8.2011, *M. Ron s.n.* (BR); Ketura, 60 km N of Elat, Arava valley, 20.9.2011, *A. Danin s.n.* (BR); Arad, Har Hanegev (Negev Highlands), 23.10.2011, *N. Dar Ben s.n.* (BR); Ketura, 50 km N of Elat, irrigated ornamental plot, 15.12.2011, *A. Danin s.n.* (BR).
Spain: Huelva: Palos de la Frontera, Nuevo Puerto (UTM 29SPB8516), ruderal carretera, 9.9.2008, *E. Sánchez Gullón 152* (herb. Sánchez, herb. Verloove); Palos de la Frontera, Nuevo Puerto (UTM 29SPB8516), ruderal aceras próxima a silos de cereal y grano, 20.9.2008, *E. Sánchez Gullón 163* (BR, MGC 69266, SEV 228686); Palos de la Frontera, Nuevo Puerto (UTM 29SPB8516),

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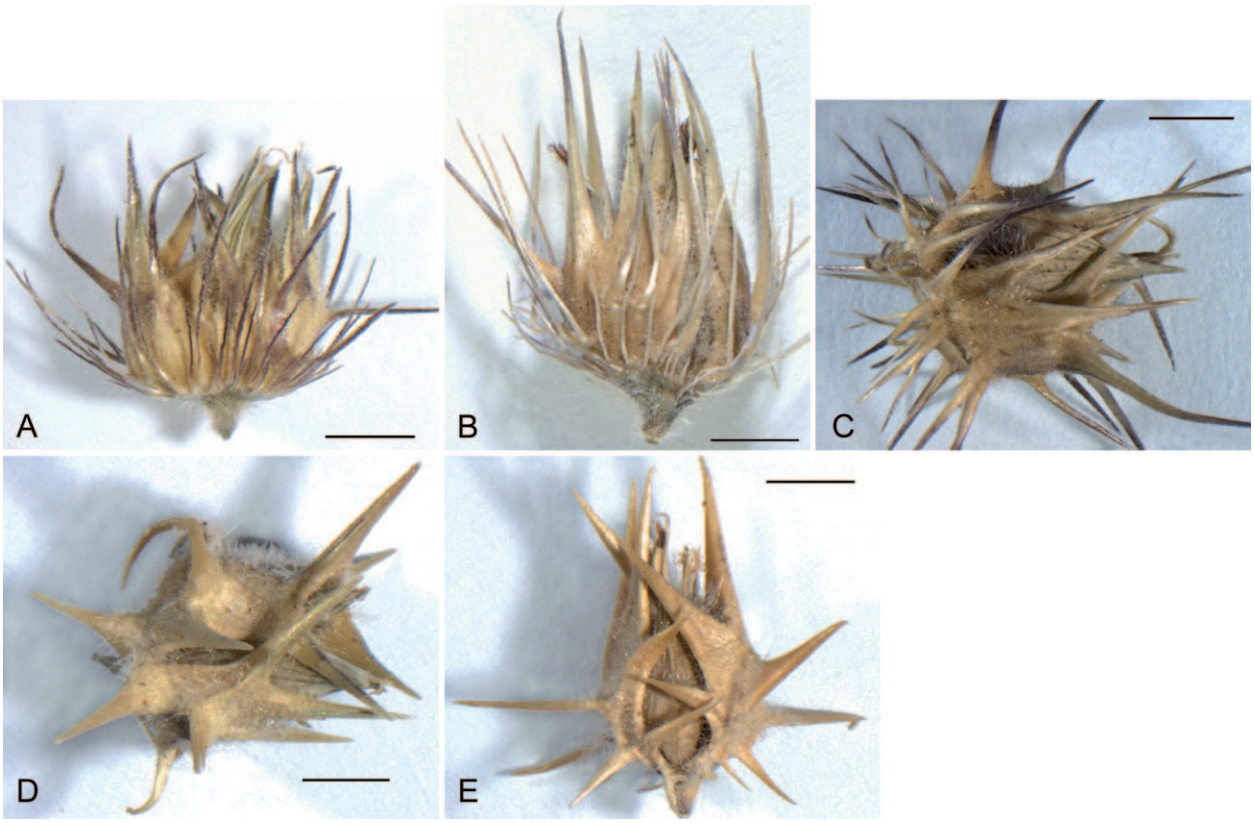


Fig. 1. Burs of the three non-native *Cenchrus* species in the Mediterranean area – A–B: *C. echinatus*, A from Egypt, *L. Boulos 19528* (K), B from Spain, *E. Sánchez-Gullón 163* (BR); C: *C. longispinus*, from Morocco, *J. Lewalle 11202* (BR); D–E: *C. spinifex*, D from Spain, *F. Verloove 5523* (BR), E from Italy, *C. Ricceri & P. Debolini s.n.* (FI). – Scale bars = 1 mm.

cuneta carretera, 11.10.2010, *E. Sánchez Gullón 311* (BR); Huelva, ruderal cuneta carretera junto via del tren, 15.9.2011, *E. Sánchez Gullón 333* (BR).

Notes. — *Cenchrus echinatus* is a troublesome weed and widely naturalised beyond its native distribution range but is a relatively recent newcomer in the Mediterranean area, where it was initially confined to its eastern part. According to DeLisle (1963) it was already spreading in Israel in the early 1960s. Dafni & Heller (1990) give 1970 as the year of introduction for *C. echinatus,* while *"C. incertus"* (doubtlessly in error for *C. longispinus*, see below) would have been present since 1953. This would be in contradiction with DeLisle (1963) and is therefore rather unlikely. More recently *C. echinatus* was also recorded in Egypt (Cope 2005). The incipient naturalisation of *C. echinatus* in southwestern Europe is here probably reported for the first time. In Spain (Palos de la Frontera), it is more or less established in sandy, ruderal road verges in the vicinity of a grain storage (recorded at least since 2008 and by 2011 reported as locally spreading). Its burs easily adhere to and are readily dispersed by man and mammals, which could enhance a future wider naturalisation.

Cenchrus echinatus is distinguished from most of its congenitors by the presence of a basal ring of numerous fine bristles that subtend the flattened spines. In *C. longispinus* (and to some extent in *C. spinifex* as well) the lowermost spines may be in part bristle-like but they are not as flexible and numerous as in *C. echinatus* and they lack the typical retrorse spinules. *C. echinatus* is obviously most closely related to *C. brownii* Roem. & Schult., another weedy New World species but less widespread than *C. echinatus*. Their separation is not always straightforward. However, the relatively larger burs (> 4.5 mm wide) that are rather loosely spaced (rachis often visible) are typical of *C. echinatus*. In *C. brownii,* in turn, the burs are much smaller (2–4.5 mm wide) and very closely crowded (completely obscuring the rachis). Other distinguishing features (e.g. length of the outer bristles and colour of burs and spines) proved to be less reliable.

Cenchrus longispinus (Hack.) Fernald in Rhodora 45: 388. 1943.

Distribution. — Native of United States and southern Canada, Mexico, Central America and the West Indies (DeLisle 1963). It is furthermore naturalised in Australia, South Africa and the Mediterranean area. Here reported for the first time from the Former Yugoslavian Republic (Croatia), Greece, Israel and Morocco.

Illustrations. — Fig. 2C; Grilli (1962: fig. 4, as *Cenchrus pauciflorus*); Caro & Sánchez (1967b); Weston (1974:

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fig. 1E); Häfliger & Scholz (1980); Stieber & Wipff (2003); Cope & Gray (2009).

Specimens examined. — Croatia: Presso Dubrovnic, costa, 9.1966, *Della-Beffa s.n.* (TO).
France: Haute-Corse: Alistro, sables maritimes à partir de la lisière des maquis jusqu'à la plage, très abondant, 22.9.1951, *T. Marchioni s.n.* (K); Le Pineto de Biguglia au sud de Bastia, langue de sable fermant l'étang de Biguglia, 11.8.1972, *P. Sotiaux s.n.* (BR); Alistro, plage [plante trouvée par T. Marchioni en août 1951 sur la plage d'Alistro, signalée par Litardière sous le nom de *Cenchrus tribuloides* L. (Candollea 14: 125, 1953). L'année suivante le même auteur a corrigé sa détermination en *Cenchrus incertus* M. A. Curtis (Etudes corses nov. sér. 1: 41, 1954)], 22.7.1975, *R. Deschatres s.n.* (LG); Linguizzetta, plage d'Alistro, 9.1986, *J.-M. Tison s.n.* (herb. J.-M. Tison); à l'ESE de Folelli, embouchure du Fium Alto, haut de plage rudéralisé entre l'embouchure et le petit village de vacances situé au sud, assez abondant, 24.8.1987, *J. Lambinon 87/Co/670* (LG); Alistro, friche sur sable près de la mer [avec *Conyza bonariensis, C. canadensis, C. sumatrensis, Portulaca oleracea, Tribulus terrestris, Amaranthus albus, A. hybridus, Chondrilla juncea, Chamaemelum mixtum, …*], 9.9.1990, *J. Lambinon 90/460* (B, BR, FI, LG, MSNM, also distributed by Soc. Ech. Pl. Vasc. Eur. Bass. Médit. n° 16676; sub *C. incertus*); Dep. Vaucluse: Buisson, cultures sur terrain sableux, 20.9.1999, *B. Girerd s.n.* (LG); Buisson, quartier de la Buissonnière, 2.10.1999, *B. Girerd s.n.* (herb. J.-M. Tison).
Greece: Makedonien, Nomos Kavalas, Eparchia Nestou, Keramoti, Südrand des Ortes gegenüber Thasos (40°51'20"N, 24°42'3"E), Sandstrand, 2 m, 27.9.2010, *T. Raus* & al. *32284* (B); südöstlich von Keramoti, Nom. & Ep., Xanthis, NE, fruchtend im Dünensand, *Salsola kali-Xanthium strumarium*-Ass. Oberdorfer & Tüxen, 29.9.2010, *I. Dinter 9831b* (B).
Israel: Sharon, near Or-Akiva, Menashe streams sedimentation, sand, 15.7.2011, *D. Melamed s.n.* (BR); Kfar Masaric, Acco plain, 27.8.2011, *M. Iehuda s.n.* (BR); Kfar Masaryk, Acco plain, 29.8.2011, *S. S. Cohen s.n.* (BR).
Italy: Abruzzo: Martinsicuro, 30.7.1986, *A. Soldano* (herb. A. Soldano). – Campania: Campolungo, destra orografica della Foce del Sele (Salerno), spiaggia calpestata, 15.9.1992, *L. Astolfi & R. Nazzaro s.n.* (FI, NAP; see Astolfi & Nazzaro 1992 sub *Cenchrus incertus*). – Emilia-Romagna: Rimini, in arenosis maritimis, c. 3 m, 10.8.1968, *E. Mayer 73073* (B); Marina di Ravenna, op het strand van de Adriatische Zee, 9.7.1972, *J.-E. De Langhe 357/72* (BR); Marina di Ravenna, op het strand, 9.7.1972, *R. D'hose* 357/72 (BR). – Friuli-Venezia-Giulia: Lignano Sabbiadoro, sabbiosi presso la foce del Tagliamento, 16.7.1983, *A. Soldano 5633* (herb. A. Soldano); sine loco, 1984, *H. Melzer s.n.* (B); urbs Udine, mare Hadriaticum, opp. Lignano, in locis arenosis in litore maris ad ostium flum. Tagliamento ad vicum Lignano Pineta (13°04–05'E, 45°37–38'N), 30.8.1996, *J. Štěpánek & J. Štěpáneková s.n.* (B); Mündung Tagliamento, Dünen, 27.7.2006 (B). – Lazio: Circeo, Baia d'Argento, in località Molella, a 300 m del lago di Sabaudia, terreno sabbioso, 1.11.1954, *A. Cacciato s.n.* (FI); Circeo (S. Felice), spiaggia, lungo la litoraneo per Terracina, copiosissimo,10.9.1968, *A. Cacciato s.n.* (FI). – Marche: Tra Pesaro e Fano, nella spiaggia, 8.1958, *A. Brilli-Cattarini s.n.* (FI, MSNM); Senigallia, dune verso la Mazzochetta, 27.7.1987, *A. Soldano 5987* (MSNM 24.117). – Pesara-Urbino: Solitarie in locis graminosis et arenosis, ad domum deversorii Miramare in oppidulo Marotta, 14.9.1995, *F. Černoch & J. Schubert 56.082* (LG). – Piemonte: Trino, ruderali presso il Po, 8.10.1975, *A. Soldano* 295 (herb. A. Soldano). – Sicily: prope Messanam, in pratis humidis et […] rivulas, 5.1871, *M. Gandoger s.n.* (K). – Toscana: Forte dei Marmi (Cinquale), abbondante sulle dune costieri e negli incolti dell'interno, s.d., *F. Montacchini s.n.* (TO); Torre del Lago, dune marine, 6.9.1970, *P. V. Arrigoni s.n.* (FI); Ronchi [di Massa], arenile, 23.9.1974, *A. Soldano 249* (herb. A. Soldano); Torre del Lago, sabbiosi lato strada per la superstrada, 24.9.1980, *A. Soldano* (MSNM 24.118); Poveromo (Massa), 8.1985, *E. Banfi 28.054, 28.058, 28.061, 28.062, 28.064* (MSNM); Monte Argentario (GR), Falde di Poggio Pertuso, nei pressi dello stabilimento balneare di "Mamma Licia", retroduna residua, 16.9.1994, *R. Baldini* (FI). – Veneto: Lido, Venedig, 8.1952, *Baschant s.n.* (B); Basso Veneto, [< 1961], *P. Zanardini s.n.* (FI); Foci del Sile, 14.9.1951, *G. Moggi s.n.* (FI); Venezia, litorale del Cavallino, beim Leuchtturm der Punta dei Sabbioni, Sandboden, 19.7.1959, *C. Simon s.n.* (LG); Venice, Lido di Jasuzo (sic), 1964, *I. J. Gibson 4* (K); Venezia, Lido de Jésolo, extrémité orientale, dépression sableuse rudéralisée, 26.7.1973, *P. Auquier 3197* (LG).
Morocco: Rabat (Souissi), terrain maraîcher, 1.7.1985, *J. Lewalle 11202* (BR, LG); Rabat, champ, 7.8.1988, *J. Lewalle 12202* (BR, JACA).

Additional collections examined. — Hungary: Prov. Nógrád, Börz / Prov. Bács-Kiskun, Rand des Kiskunsági Nemzeti Park, 2 km SE Fülöpháza (c. 25 km W Kecskemét), Salzwiesen, 16.8.1994, *D. Podlech 52202* (LG).

Notes. — *Cenchrus longispinus* most closely resembles *C. spinifex* but confusion is also likely with *C. echinatus*. From the latter it is best distinguished by the absence of a basal ring of numerous flexible, retrorsely barbellate bristles (although some bristle-like spines may occur but these are never entirely and distinctly retrorsely barbellate). Moreover its spines emerge at irregular intervals throughout the body of the bur (in *C. echinatus* the spines of equal size originate at more or less the same level). However, most problematic is the distinction of *C. longispinus* and *C. spinifex*. Both have been largely intermixed so far in the studied area. *C. longispinus* always has more spines, the inner being terete to slightly

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flattened and the outer (lowermost) often bristle-like and relatively slender. In *C. spinifex,* on the contrary, spines are always fewer, the inner distinctly flattened (up to 3 mm wide at base) and bristle-like outer spines are nearly always lacking. Photographs of burs (Fig. 1, compare C and D–E) clearly show the differences between both species, much more than words can do.

Cenchrus longispinus is by far the most misunderstood non-native species of the genus in the Mediterranean area and, in fact, appears to be the most widespread.

Its oldest centre of naturalisation in Europe probably is on the Adriatic coast in Italy: it is known since at least 1933 from Lido del Cavallino in Venezia province (Corbetta 1964) and now is widely naturalised in this area. Its distribution and invasive status elsewhere in Italy is uncertain, largely as a result of lingering confusion with *Cenchrus spinifex*. According to Guzik & Pacyna (1999) plants naturalised in Italy, known as *"C. incertus"*, represent in fact *C. longispinus*. However, genuine *C. spinifex* also exists in Italy (see below). Part of the confusion surely is induced by the fact that in many Italian regions both species occur sympatrically: in all(!) regions where *C. spinifex* is confirmed in the present study, also *C. longispinus* occurs. In some places, for instance in Poveromo in Tuscany, both grow nearly side by side. Celesti-Grapow & al. (2010) correctly accepted both *C. longispinus* and *C. spinifex* (as *C. incertus*) for Italy but their distribution and degree of naturalisation are obviously wrongly assessed, giving *C. longispinus* only for Veneto (casual) and Friuli-Venezia-Giulia (naturalised). The present study, in contrast, confirms its presence also in Abruzzo, Campania, Emilia-Romagna, Lazio, Marche, Piemonte, Sicily and Tuscany. Its status of occurrence should be critically assessed but *C. longispinus* is probably naturalised (or invasive) in all regions except Piemonte and Sicily.

In France, *Cenchrus longispinus* has been recorded since 1951, at first in Corse. All voucher specimens seen from that area (see above), indeed, belong to *C. longispinus* (Verloove 2006). They were initially wrongly referred to as *C. tribuloides* and subsequently as *C. incertus* (see for instance Deschâtres 1986, Natali & Jeanmonod 1996, Vagnet & Vadam 2005). At present, *C. longispinus* is commonly naturalised on the eastern coast of Corse, at least between Bastia and Alistru (Jeanmonod & Gamisans 2007). More recently, a locally naturalised population from continental France (Buisson; dep. Vaucluse) published as *C. incertus* (Girerd & Roux 2000), also represents *C. longispinus*. In this locality it was still confirmed in 2010 by Christophe Girod (pers. comm. J.-M. Tison) but environmental and climatological conditions seem to be less favourable than elsewhere in the Mediterranean area and a future, wider naturalisation in continental France appears to be rather unlikely.

In Croatia and Greece *"Cenchrus incertus"* was recently reported as an invasive alien plant species (Boršić & al. 2008; Arianoutsou & al. 2010). Relatively few collections of non-native *Cenchrus* were seen for the present study but all proved to be ascribable to *C. longispinus.* Moreover, pictures of *"C. incertus"* from other Croatian localities surely also pertain to *C. longispinus* (see for instance: island Rab, Lopar, 2007, J. Nejc, record no. 30847 in Flora Croatica Database 2004+). The records from Greece here presented were previously also ascribed to *C. incertus* (Raus & Schuler 2005).

In Israel, two non-native species of *Cenchrus* are known (Dafni & Heller 1990): *C. echinatus* and *"C. incertus"* but both have been widely confused. The latter is apparently confined to the northern half of the country and is, at least for the time being, a non-invasive weed (Danin 2004). All records seen from this area are here corrected to *C. longispinus* as well. Moreover, additional photographs of *"C. incertus"* from Israel (see for instance Gold & Eshel 2012) also belong with *C. longispinus*.

In Morocco non-native *Cenchrus* must be either a fairly recent introduction (compare with Le Floc'h & al. 1990, Valdés & al. 2002) or it must have been overlooked for quite some time. Dobignard & Chatelain (2010) only cite *C. biflorus* and *C. ciliaris* for Morocco but the presence of the former is questioned (see also Ibn Tattou & Fennane 2008). Indeed, the only collections seen of *C. biflorus* (all from the surroundings of Rabat and dating back to the 1980s) pertain to *C. longispinus*. According to A. Dobignard (pers. comm. 2011) reports of *C. biflorus* in Morocco are referable to J. Lewalle but collections of the latter all proved to belong to *C. longispinus*.

In neighbouring regions, outside the studied area, identical identification problems have occurred in the past: plants from Hungary (voucher in LG!) and Ukraine (Guzik & Pacyna 1999), for instance, are ascribable to *Cenchrus longispinus,* not to *C. spinifex*. In Hungary *C. longispinus* (as *C. incertus*) is considered to be an invasive xenophyte in disturbed open grassland in the Great Hungarian Plain (Szigetvári 2002). The same applies to Ukraine where it is considered among the worst invasive species (Mosyakin 2006).

Cenchrus spinifex Cav., Icon. 5: 38, t. 461. 1799
= *Cenchrus incertus* M. A. Curtis in Boston J. Nat. Hist. 1: 135. 1837.
= *Cenchrus carolinianus* Walter, Fl. Carol.: 79. 1788, nom. rejic. (see Brummitt 1995: 608).
= *Cenchrus pauciflorus* Benth., Bot. Voy. Sulphur: 56. 1844.
?= *Cenchrus bambusoides* Caro & E. A. Sánchez in Kurtziana 4: 44. 1967.

Distribution. — Native of southern United States, Mexico, Central and South America and the West Indies. More or less widely naturalised as a noxious weed, for instance in S Africa, China, Australia, the Mediterranean area, etc.

Illustrations. — Fig. 1D–E; Vivant (1961 as *Cenchrus pauciflorus*); Grilli (1962: fig. 3 as *C. pauciflorus*); Caro & Sánchez (1967b as *C. incertus* and *C. pauciflorus*);

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Weston (1974: fig. 1B); Häfliger & Scholz (1980 as *C. incertus* and *C. pauciflorus*); Sanz Elorza & al. (2004 as *C. incertus*); Cope & Gray (2009 as *C. incertus*).

Specimens examined. — France: Pyrénées-Atlantiques: Anglet, Blancpignon, adventice dans les clairières sablonneuses de la pinède, aux abords de l'Eglise des Sables, du cimetière et de l'Allée de l'Empereur sur une distance de plus d'un km, 24.8. et 1.10.1960, *J. Jallu 7149* (BR, LG; also distributed by Soc. Fr. Ech. Pl. Vasc. N° 3688); Anglet, Blancpignon, près de l'église St. Joseph, 19.7.1975, *N. Cnops 75.129* (BR); Anglet, à la Chambre d'Amour, arrière-plage rudéralisée, [plante pérennante, épines fortes et peu nombreuses], 7.2005, *J. M. Tison s.n.* (herb. J.-M. Tison; photocopy herb. Verloove); id., Bayonne, Anglet (Chambre d'Amour), arrière-plage rudéralisée, très commun, 9.9.2006, *F. Verloove 6480* (herb. Verloove).
Italy: Abruzzo: Presso la foce del Borsacchio, si è diffusa più presso l'abitato di Roseto, 10.1950, *G. Zodda s.n.* (FI); Roseto degli Abruzzi, sabbiosi, 30.7.1986, *A. Soldano 5390* (herb. A. Soldano). – Emilia-Romagna: Bei Comacchio, Lido Dogli Stucchi, Dünengelände, 21.7.1969, *H. Scholz s.n.* (B). – Toscana: Marina di Massa, fra la Colonia Edison e la foce del Brugiano, nel tratto di littorale arenoso, in numerosi esemplari, 23.6.1947, *P. Pellegrini s.n.* (FI); Marina di Massa, Poveromo, dune litoranee [con *Echinophora spinosa*, *Solidago litoralis*, *Stachys maritima, Pycnocomon rutifolium,* etc., 16.7.1978, *E. Banfi s.n.* (LG); Marina di Massa, Poveromo, sabie marittime, 20.8.1985, *E. Banfi s.n.* (LG); Poveromo (Massa), 8.1985, *E. Banfi 28.063* (MSNM); Poveromo di Massa (MS), spiaggia del Tornado, 2.9.1992, *E. Ferrarini s.n.* (FI); Marina di Massa, arid grassland near the sea, very common (perennial), 22.6.2006, *F. Verloove 6361* (BR, RO; herb. Verloove); Marina di Carrara, Partaccia, sandy grassland, dunes, locally, 22.6.2006, *F. Verloove 6632* (BR; herb. Verloove). – Veneto: Mesola, bosco della Mesola, sabbie del litorale, notato anche all'interno, 22.7.1964, *P. Stampi s.n.* (FI); Mesola, bosco della Mesola, strada adiacenti al Canale Elciola, 22.7.1964, *P. Stampi s.n.* (FI); Mesola, bosco della Mesola, al Taglio della Falce, 14.8.1964, *P. Stampi s.n.* (FI); Mesola, bosco della Mesola, 7.1965, *P. Stampi s.n.* (FI); Mesola, bosco della Mesola, Taglio della Falce, 24.7.1975, *C. Ricceri & P. Debolini s.n.* (FI).
Spain: Cadíz: El Puerto Santa Maria (Fuentebravia), sandy road verge at military base, 8.10.2007, *F. Verloove 6993* (B, BR, LG). – Huelva: Huelva, ruderal en orillas carretera N-442, 4.10.2002, *E. Sánchez Gullón 91* (BR). – Tarragona: Cambrils (Vilafortuny), sandy ruderal road verge, one tall specimen, 27.9.2003, *F. Verloove 5523* (herb. Verloove).

Notes. — Distinguishing features between this species and *Cenchrus longispinus* are discussed under the latter. Confusion with *C. echinatus* is unlikely.

The first naturalised populations of *Cenchrus spinifex* in Europe were discovered in Italy near Viareggio in 1939 (Plicker 1943, as *C. tribuloides*). In this part of Tuscany it is still present and more or less widely naturalised in ruderalised coastal dunes, for instance in Marina di Massa and Marina di Carrara. In Veneto, *C. spinifex* seems to be well-established in the surroundings of Mesola, while local occurrences are here confirmed from Abruzzo and Emilia-Romagna. Elsewhere in Italy *C. spinifex* has been widely confused up to present with *C. longispinus*. Celesti-Grapow & al. (2010) also cite the former (as *C. incertus*) from Campania, Lazio, Marche, Molise, Puglia and Valle d'Aosta but these records are either erroneous (and ascribable to *C. longispinus,* see above) or require confirmation. In Italy *C. spinifex* exclusively occurs in regions where *C. longispinus* also is present. This surely added to the confusion between both species.

In southwestern France *Cenchrus spinifex* was recorded in the surroundings of Anglet near Bayonne from 1960 onwards (Vivant 1961, as *C. pauciflorus*). It is still (very) locally abundant in this area (for instance near Chambre d'Amour, see above) but many of its original localities probably disappeared (pers. comm. J. Vivant). To our knowledge, *C. spinifex* is absent from other parts of France: all populations from Corse belong to *C. longispinus* (Verloove 2006) and the same holds true for plants from the Vaucluse (see above).

In northeastern Spain the species was discovered in Torre de la Mora, near Tarragona, for the first time in 1972, correctly referred to as *Cenchrus incertus* by Torrella & al. (1974). In this area it has become a widespread and noxious weed in coastal dunes, at least between Cambrils and Baix Llobregat (see map in Sanz Elorza & al. 2004 and BDBC 2011). *C. spinifex* is recently also naturalising in Garrotxa (Oliver 2009). Since 1996 it is known from few localities in País Vasco (Campos & Herrera 2008), relatively close to the localities in the French Pays Basque (see above). In 2002, *C. spinifex* (as *C. incertus*) was recorded for the first time in Andalusia (San Juan del Puerto, near Huelva; Sánchez Gullón & al. 2006) but did not establish. Soon afterwards, in 2007, *C. spinifex* was observed in abundance (and obviously naturalised) in a worked-up, sandy roadside by a military base in El Puerto Santa Maria, close to Cádiz (Verloove & Sánchez Gullón 2008). In Spain *C. spinifex* is now considered to be an invasive species on sandy beaches, especially in the northeastern part of the country (Sanz Elorza & al. 2004).

Reports of *Cenchrus spinifex* from other countries in the Mediterranean (for instance Greece, Israel, Libya, Serbia and Turkey; see Valdés & Scholz 2009+) should be critically reviewed. At least part of the reports is ascribable to *C. longispinus*.

Cenchrus spinifex is usually considered to be conspecific with *C. pauciflorus* nowadays (DeLisle 1963; Stieber & Wipff 2003; Zuloaga & al. 2003) but Ward (2010) recently rejected this synonymy. According to

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him both are best distinguished on life form (respectively annual and perennial) but it is doubtful if this warrants specific rank. Duration seems to be variable in *C. spinifex* in the studied area and therefore often critical to assess: some plants are reported to be annuals (see for instance Sanz Elorza & al. 2004) while others are obviously (short-lived) perennials. Ward (2010) admits that where *C. incertus* and *C. pauciflorus* meet, fertile hybrids are produced. Twentyman (1972) experimentally showed that culm length, habit and the ability for overwintering merely depends on day-length and environmental conditions. This issue possibly requires additional research in the Mediterranean area but, at least for the time being, all of these plants are best referred to as *C. spinifex* (incl. *C. pauciflorus*).

Likewise, *Cenchrus bambusoides* is sometimes accepted as a good species (Caro & Sánchez 1967a; Ward 2010). In general habit it looks like *C. spinifex* but its leaves are inrolled on drying, without an obvious keel (instead of flat or folded). It probably merely belongs to the variability of the latter (Stieber & Wipff 2003; Zuloaga & al. 2003). Moreover, plants with foliar characteristics of *C. bambusoides* apparently have not been recorded so far in the studied area.

The application of the binomial *Cenchrus spinifex* is not uncontested. In addition to the aforementioned taxonomic difficulties there is still a nomenclatural problem. DeLisle (1963) already evoked that the correct name for *C. incertus* might be *C. spinifex*, which, indeed, antedates the former (1837 versus 1799). As he had not been able to study the holotype of *C. spinifex* and the correctness of the isotype label had not been verified, he rejected this binomial. In the recent treatment of *Cenchrus* for North America (Stieber & Wipff 2003) the plants here concerned are referred to as *C. spinifex* but it is unclear whether or not these authors had effectively resolved the nomenclatural problem. Moreover, *C. incertus* is not even mentioned as a synonym by these authors. In the recent catalogue of New World grasses (Zuloaga & al. 2003), *C. incertus* is upheld and it is stated that "… if *C. spinifex* turns out to be conspecific, a conservation proposal will be considered". According to Ward (2010), *C. spinifex* is an unidentifiable name that should be rejected. Symon (2010), who examined a digital image of the holotype, on the contrary confirms that both are conspecific and hence *C. spinifex* should finally be accepted as the correct name for this species. Joseph Wipff recently also investigated the type of the latter name and states that it definitely refers to the taxon traditionally called *C. incertus* (pers. comm. March 2012).

Key to the species of *Cenchrus* s.str. in the Mediterranean area

In an attempt to avoid future misidentifications within *Cenchrus* s.str. (excl. *Pennisetum;* see Verloove 2012) in the Mediterranean area, a revised identification key is presented here. This key is mostly based on the results of our examination of numerous herbarium collections and considerably differs from that of DeLisle (1963) who probably gave too much weight on the degree of fusion of the spines. *C. setigerus,* for instance, was accommodated in a dichotomy with "spines connate only at the base", while they are connate usually for at least half their length. Moreover, even in species having burs with distinctly fused inner bristles, this holds true only for one side of the bur, while on the other side the spines are always nearly free to the base, largely exposing the spikelets.

For convenience, *Cenchrus ciliaris,* a species often transferred to *Pennisetum* recently, and its look-alike *C. pennisetiformis* are also included in the key.

Mature burs are absolutely required for a reliable determination.

1. Burs with numerous outer flexible bristles, these distinctly antrorsely barbellate; all other bristles also flexible and therefore burs never prickly at maturity . . 2
– Burs with or without outer flexible bristles, these (if present) either not at all or hardly barbellate or (predominantly) retrorsely barbellate; all (other) bristles stout, stiff and/or flattened, burs therefore always prickly at maturity (often only faintly so in *C. setigerus*) 4
2. Inner bristles 15–27 mm long, all more or less equal in length; plant annual . . . . . *C. prieurii*
– Inner bristles 7–14 mm long, one distinctly longer and wider than the others; plant perennial or annual . 3
3. Caespitose perennial, ultimately with hard, knotty base; inner bristles connate only at their extreme bases, forming a disc c. 0.5–1 mm in diameter . . . . . *C. ciliaris*
– Annual to pauciennial; inner bristles connate to form a disc c. 1.5–3 mm in diameter . *C. pennisetiformis*
4. Inner bristles only fused at the base, each with 1–3 distinct grooves on the outer face (hence the back distinctly veined) . . . . . *C. biflorus*
– Inner bristles fused for at least $^1/_3$ of their length, with or without grooves on the outer surface 5
5. Burs cup-shaped, with inner bristles short and broad (2–4 mm long); outer bristles always fewer in number and mostly lacking; inner bristles fused for c. $^1/_3$–$^1/_2$ of their length . . . . . *C. setigerus*
– Burs ovoid to globose, with inner bristles usually longer; outer bristles sparse or numerous, rarely absent; inner bristles mostly fused for at least $^1/_2$ of their length. 6
6. Burs with numerous flexible, distinctly retrorsely barbellate outer bristles; inner bristles originating almost in a single whorl and forming flattened spines, more or less erect at maturity . . . . . ***C. echinatus***
– Burs without flexible, retrorsely barbellate outer bristles [in some burs a few bristle-like spines may be present that are not thin and flexible as in *C. echinatus*

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and that under high magnification appear slightly barbellate with a mixture of retrorse and antrorse barbs but not with exclusively retrorse barbs as in *C. echinatus*]; inner flattened spines originating at irregular intervals throughout the body of the bur, distinctly diverging at maturity 7

7. Spines relatively long and numerous (usually c. 30–50), slenderly pointed; most of the outer spines very slender (bristle-like) and ranging from patent to reflexed; inner spines terete, not or hardly flattened at their base (at most 1 mm wide); plant always annual . . . . . ***C. longispinus***

– Spines shorter and fewer (usually c. 20–30), very stout; bristle-like outer spines fewer to almost lacking, if present reflexed; inner spines stout and more or less conical, distinctly flattened with a base up to 3 mm wide; plant annual or (more often) pauciennial . . . . . ***C. spinifex***

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