Phytotaxa 670 (1): 001–017
https://www.mapress.com/pt/

Article

ISSN 1179-3155 (print edition)
PHYTOTAXA
ISSN 1179-3163 (online edition)

https://doi.org/10.11646/phytotaxa.670.1.1

Critical notes on grasses (Poaceae) of Madeira, Portugal

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Abstract

As a result of fieldwork in the island of Madeira (Portugal) in the autumn of 2021 and the spring of 2022, nine non-native grasses are newly reported: *Axonopus fissifolius*, *Chloris pycnothrix*, *Digitaria radicosa*, *D. violascens*, *Eragrostis multicaulis*, *Nassella hyalina*, *Paspalum notatum*, *P. urvillei* and *Sporobolus* aff. *fertilis*. All are at least locally naturalized in the island of Madeira and, elsewhere in the world, they are often considered invasive species or weeds. In addition, the identity of species from the *Hyparrhenia hirta* and *Setaria verticillata* complexes is discussed. Finally, some miscellaneous notes on other noteworthy grasses are also presented.

Introduction

The grasses family (Poaceae) of the Flora of Madeira is relatively well documented, for both native and non-native species (e.g. Press & Short 1994, Vieira 2002, Jardim & Sequeira 2008, Menezes de Sequeira *et al.* 2012), although a reliable checklist for the grasses of the island of Madeira does not exist. Increasing taxonomic expertise and new fieldwork nevertheless still reveal new records, particularly of non-native species (e.g. Cabral *et al.* 2020, Gonçalves Silva & Ferreira 2020, Verloove & Gonçalves Silva 2022).

Here we record nine additional species of the Poaceae family from the island of Madeira, with no previous known records in herbaria or literature, which have apparently recently been introduced and become naturalized. Some records raise concerns over their potential ecological impact and we believe our records provide an opportunity for improving biosecurity relating to potentially invasive but hitherto undetected non-native grasses. Some further notes are presented for other grass species from the island of Madeira that are also of particular interest. We hope this work will encourage further collections and records of Madeira's grasses.

Materials and methods

Field work in the island of Madeira by the first author (FV) was carried out between 10 and 24 September 2021 and between 18 April and 2 May 2022. On that occasion, numerous localities were explored throughout the island, especially along the coast and in the lowland areas. The focus was on riparian and anthropogenic (often urban) habitats, agricultural fields, etc. In addition, relevant specimens from the BR and MADM herbaria (for herbarium acronyms, see Thiers 2023) were revised.

Herbarium specimens were collected for all records and these are preserved in the herbarium of the Meise Botanic Garden, Belgium (BR) with duplicates deposited in the herbarium of the Funchal Natural History Museum, Madeira (Portugal) (MADM). All records were also registered on the observation.org online platform (https://observation.org/), data which were subsequently loaded into GBIF (Global Biodiversity Information Facility; https://www.gbif.org/).

For two taxonomically challenging taxa, *Sporobolus* and *Hyparrhenia*, molecular phylogenetic analyses were employed to aid species identification and assess possible geographical origins. For *Sporobolus*, we analyzed the nuclear

Accepted by Arjun Tiwari: 4 Oct. 2024; published: 24 Oct. 2024

rDNA internal transcribed spacer (ITS) region following Peterson *et al.* (2014), as well as the plastid encoded *matK* gene. For *Hyparrhenia*, we analyzed the ITS region and the plastid encoded *trnL-F* spacer. Total genomic DNA was extracted from silica-dried leaf material using a modified CTAB protocol (Verloove *et al.* 2020). The ITS region was amplified using primers ITS4 (5'-TCCTCCGCTTATTGATATGC-3') and ITS5 (5'-GAAGTAAAAGTCGTAACAAGG-3') (White *et al.* 1990); *matK* was amplified using primers *matK*-MALPR1 (5'-ACAAGAAAGTCGAAGTAT-3') and *matK*-xF (5'-TAATTTACGATCAATTCATTC-3') (Ford *et al.* 2009, Dunning & Savolainen 2010); *trnL-F* was amplified using primers *trnL-c* (5'-CGAAATCGGTAGACGCTACG-3') and *trnL-f* (5'-ATTTGAACTGGTGACACGAG-3') (Taberlet *et al.* 1991). PCR conditions are described in Verloove *et al.* (2020), and PCR quality control was performed with a BioAnalyzer (Agilent Inc.). After purification using ExoSAP-IT (ThermoFisher Scientific), PCR products were sequenced by Macrogen (Seoul, South Korea). Forward and reverse sequences were assembled using Geneious Prime v2023.2.1. (Biomatters, Auckland, New Zealand). Sequences have been deposited in EMBL/GenBank under study number PRJEB73530 and accession numbers OZ060446-OZ060451. For *Sporobolus*, two datasets of 32 ITS (679 positions) and 23 *matK* sequences (894 positions) were constructed, including the sequences generated in this study and publicly available sequences obtained from GenBank, including the sequences from Peterson *et al.* (2014) and closest BLAST hits. For *Hyparrhenia*, two datasets of 14 ITS (609 positions) and 34 *trnL-F* sequences (915 positions) were constructed in a similar way. Sequences were aligned using MUSCLE (Edgar 2004). Phylogenetic relationships were reconstructed using maximum likelihood and 1000 ultrafast bootstrap replicates in IQ-TREE 2.2.2.7 (Nguyen *et al.* 2015) on the CIPRES Science Gateway portal (Miller *et al.* 2010).

Results

New records for the island of Madeira

Axonopus fissifolius (Raddi) Kuhlm. (1922: 87)

Specimen examined: PORTUGAL. Quinta do Palheiro Ferreiro, Jardim "Sunken", lawns, between cobble stones, a common turf weed, 29 April 2022, *F. Verloove* 14315 (BR, MADM).

This species is native to the New World but increasingly found as a weed in subtropical and warm-temperate regions of the Old World. In Europe, it is in the process of local naturalization in the Iberian Peninsula (Portugal and Spain: Bartoli *et al.* 2007, Giraldo-Cañas 2008) where it is found as a weed of irrigated lawns and in riparian meadows, on wet sand. In mainland Portugal, it has been known since the 1960's but the species was initially erroneously assigned to the morphologically similar *A. affinis* Chase (Almeida 1999). Claims of the latter from the Azores (Menezes de Sequeira *et al.* 2012) are probably also referable to *A. fissifolius* (Euro+Med Plantbase 2023).

In the island of Madeira, *Axonopus fissifolius* was first identified in April 2022 in the Quinta do Palheiro estate, in Funchal, where it grows as a weed in lawns and between cobble stones; it looks firmly established. In this area, several other exotic grasses have been recorded in the past, e.g. *Nassella neesiana* (Trin. & Rupr.) Barkworth, *N. trichotoma* (Nees) Hack. & Arechav. and *Rytidosperma tenuius* (Steud.) O.E. Eriks., A. Hansen & Sunding. At least the former is naturalized and quite abundant.

Axonopus fissifolius is much reminiscent of another weedy congeneric species, *A. affinis*, and both are often confused. The plants recently found in the island of Madeira have glabrous nodes, relatively narrow leaves 2–4 mm wide, spikelets up to 2 mm long and obtuse at apex, equaling the lemma. These characters point to *A. fissifolius*.

Chloris pycnothrix Trin. (1824: 234)

Specimen examined: PORTUGAL. Santa Cruz, at drive in of Quinta Albatroz, lawn, roadside, several 100's, also on the other side of the VR-1 motorway, 1 May 2022, *F. Verloove* 14372 (BR, MADM).

This weed is distributed throughout the tropics in Africa and America and is frequently recorded outside its native distribution range as an introduction (Anderson 1974). In climatologically suitable areas, it is increasingly naturalizing. In the Mediterranean area, it is, at present, known from Egypt and Israel/Palestine (Euro+Med Plantbase 2023). In Macaronesia, it was recorded for the first time in La Palma (Canary Islands) in 2011 (Otto & Scholz 2012) and it has locally naturalized there, especially in banana plantations and lawns. In Cape Verde, in contrast, it is considered to be a native species (Arechavaleta *et al.* 2005).

In the island of Madeira, *Chloris pycnothrix* was first found in May 2022. The species occurs in and near a lawn and along sidewalks and under crash barriers on both sides of the VR-1 motorway at the Cristiano Ronaldo International Airport, in Santa Cruz. It is most abundant in a lawn at the Quinta Albatroz and may initially have been introduced with lawn seed, whether or not intentionally. It is obviously spreading and a future, wider naturalization in the area is likely.

Two further (alien) species of *Chloris* have previously been recorded from the island of Madeira, viz *C. gayana* Kunth and *C. virgata* Sw. (Press & Short 1994, Vieira 2002, Jardim & Sequeira 2008, Menezes de Sequeira *et al.* 2012, Muer *et al.* 2020). These three species are separated as follows (Anderson 1974, Landge & Shinde 2022):

1 Lowest lemma with a crown of long spreading hairs at apex ..... *Chloris virgata*
1' Lowest lemma without a crown of long spreading hairs at apex 2

2 Annual, usually geniculately ascending and rooting at the nodes. Leaf blade obtuse at apex. Spikelets 2-flowered, the sterile floret greatly reduced ..... ***C. pycnothrix***
2' Perennial, usually erect. Leaf blade acute or tapering at apex. Spikelets 3–4-flowered, the sterile floret(s) well developed .... *C. gayana*

Digitaria radicosa (J. Presl) Miq. (1857: 437)

Specimens examined: PORTUGAL. Funchal, Santa Luzia, parque, lawn, 12 September 2021, *F. Verloove* 14177 (BR); Funchal, Jardim de Santa Luzia, plantation weed, relatively frequent, 25 April 2022, *F. Verloove* 14318 (BR, MADM).

This species is native to tropical and subtropical Asia and the Pacific. In addition, it is found as a weed in some other tropical and subtropical areas of the world, e.g. in Hawaii, Madagascar, Tanzania and Venezuela (e.g. Nozawa *et al.* 2017, Imada & Kennedy 2020). In Macaronesia, it is locally naturalized in the Canarian islands of La Palma (Otto & Scholz 2009), Gran Canaria and Tenerife (Verloove 2017). It is usually found in irrigated lawns or as a weed in ornamental plantations in parks and gardens.

Digitaria radicosa belongs to the *D. ciliaris* complex and is much reminiscent of it. It is, however, easily separated based on its rachis margins that are smooth (vs. scabrid). In addition, it is a slender, sprawling annual that often roots at the nodes, typically with only 2–3 racemes.

In the island of Madeira, *Digitaria radicosa* is naturalized in Jardim de Santa Luzia, in Funchal and should be looked for elsewhere in similar habitats.

Digitaria violascens Link (1827: 229)

Specimens examined: PORTUGAL. Funchal, Santa Luzia, parque, lawn, 12 September 2021, *F. Verloove* 14176 (BR); Machico, Portela, track near Caminho do Lameirão, track in open woodland, common, 13 September 2021, *F. Verloove* 14123 (BR).

Digitaria violascens is native to tropical and subtropical Asia and parts of Australia (Henrard 1950). As a weed, it is naturalized in many other climatologically suitable areas across the world, especially in the Americas. It recently also naturalized in southwestern Europe (Verloove 2008). In Macaronesia, it is known from Tenerife (Verloove & Reyes-Betancort 2011). Otto & Verloove (2016) presented a key for the identification of *Digitaria* in the Canary Islands.

Only two species of *Digitaria* were known so far from the island of Madeira, *D. ciliaris* (Retz.) Koeler and *D. sanguinalis* (Press & Short 1994, Vieira 2002, Jardim & Sequeira 2008, Menezes de Sequeira *et al.* 2012). *D. violascens* is easily distinguished from these two species (and *D. radicosa*) based on its very small spikelets (always at most 2 mm long) that are ternate (in groups of 3) on the middle portions of the primary branches (vs. spikelets binate), its upper glumes being subequal in length to the upper lemmas and its upper (fertile) lemmas that are becoming dark brown when mature.

In the island of Madeira, *Digitaria violascens* was found in relative abundance along a woodland track in Machico, where it seems quite well established. It should be looked for in similar circumstances in that area. In the city of Funchal, it was also recorded as a lawn weed in a park.

Eragrostis multicaulis Steud. (1854: 426)
[syn.: *E. pilosa* (L.) P. Beauv. subsp. *damiensiana* (Bonnier) Thell.]

Specimens examined: PORTUGAL. Machico, near beach, cracks between tiles, 11 September 2021, *F. Verloove* 14138 (BR); Câmara de Lobos, Ribeira dos Socorridos, gravelly riverbed, few plants, 12 September 2021, *F. Verloove* 14146 (BR); Funchal, Rua Dr. Pita, roadside, in the city, several dozens, 18 September 2021, *F. Verloove* 14134 (BR); Calheta, Praia do Calhau, Av. Manuel I, roadside, rather frequent, 28 April 2022, *F. Verloove* 14327 (BR).

Eragrostis multicaulis is a member of the *E. pilosa* complex and is sometimes reduced to the synonymy of *E. pilosa* (L.) Beauv. (Ryves *et al.* 1996) or treated at subspecific or varietal level under the latter species (for extended synonymy, see Conert 1998). In our opinion, both are usually readily distinguished and merit specific recognition (see also Portal 2002, etc.). It naturally occurs in Asia but, as a weed, has much extended its distribution range in the past decades; it is now naturalized in much of Europe, parts of North and South America and perhaps also here and there in Africa.

Plants observed in the island of Madeira show some morphological variation: the junction of the leaf blade and leaf sheath may be glabrous or hairy (even within a single individual; *F. Verloove* 14134) and pulvini are usually glabrous but sometimes pilose (*F. Verloove* 14146). Overall, however, Madeira specimens are much closer to *E. multicaulis* than to *E. pilosa* s.str., especially on behalf of the typical inflorescence characters: panicle wide and pyramidal (with longest panicle branches in the lower ¼ of the panicle; vs. panicle narrower, long remaining contracted) and lower panicle branches solitary or paired (vs. whorled).

From Macaronesia, *E. multicaulis* was previously reported only from the Azores (Menezes de Sequeira *et al.* 2012). *E. pilosa* (s.str.?) was cited from Cape Verde by Arechavaleta *et al.* (2005). It seems to be a recent introduction in the island of Madeira that may be more widespread in urban areas, especially in the area of Funchal where it is clearly naturalized.

Nassella hyalina (Nees) Barkworth (1990: 610) (Figure 1)
(syn.: *Stipa hyalina* Nees)

Specimen examined: PORTUGAL. Funchal, Ribeira de João Gomes N of ER-118, track along river, rocky slope, etc., quite invasive but only locally, 20 April 2022, *F. Verloove* 14317 (BR, MADM).

This species is native from southern Brazil to northern Argentina (Cialdella *et al.* 2013). Since the 1950's it is a naturalized, troublesome weed in parts of Australia (New South Wales, Victoria; McLaren *et al.* 2004) where it primarily is a weed of indigenous grasslands. Climatic modelling suggests that the potential distribution of this weed in Australia is up to 900,000 hectares in areas with high rainfall zones. If this species was to become widespread, it could pose a significant threat to rangelands and grazing systems (Humphries & Florentine 2021).

To our knowledge, *Nassella hyalina* is here reported for the first time as a naturalized alien in Europe and Macaronesia (Verloove 2005a). In the past it was exceptionally recorded as an ephemeral introduction in sheep wool in e.g. Belgium and the British Isles (Ryves *et al.* 1996, Verloove 2006).

In the island of Madeira, *Nassella hyalina* was discovered in April 2022 in the valley of the João Gomes stream, in the city of Funchal. The species is most abundant along a little-used track that leads to the stream. Locally, it forms a dense massive stand with at least 1,000 individuals. In addition, it also grows on basaltic rocks bordering the track. It appears to have been present in that locality for quite some time (it is clearly visible on Google Streetview images from June 2021 but earlier images, from the appropriate season, are unfortunately lacking). Its vector of introduction is unknown; the Botanic Garden of Funchal is nearby but the species is not known from there (pers. comm. Carlos Lobo, May 2022). Taking into account the bad reputation of several exotic stipoid grasses in climatologically similar regions (see e.g. McLaren *et al.* 2004), it would perhaps be useful to closely monitor this population.

Two further (alien) species of *Nassella* were already known from the island of Madeira, *N. neesiana* (Trin. & Rupr.) Barkworth and *N. trichotoma* (Nees) Hack. & Arechav. (Press & Short 1994, Vieira 2002, Jardim & Sequeira 2008, Menezes de Sequeira *et al.* 2012, Muer *et al.* 2020), and four additional taxa are naturalized in the Mediterranean area (Verloove 2005a, Andrieu & Verloove 2020). Because all of these species are potentially invasive and correctly determining their identity is important, an expanded key for their identification is presented below:

1	Lemma small, ± 2 mm long, strongly swollen and tuberculate in its upper half at maturity, terminated by an eccentric awn ca. 15–30 mm long which remains straight when dried	*Nassella trichotoma*
1'	Lemma always longer, cylindrical to spindle-shaped, awn almost centric	2
2	Lemma ca. 3–4 mm long; crown surmounting the lemma indistinct and poorly differentiated from the body of the lemma	*N. tenuissima*
2'	Lemma often longer, clearly constricted below the crown	3

FIGURE 1. *Nassella hyalina* in Funchal, 20 April 2022 (Photos F. Verloove).

3	Lemma glabrous between the veins at maturity	4
3’	Lemmas hairy between the veins at maturity	5
4	Lemma ca. 4 mm long, with corona 0.5 mm high and awn 35–40 mm long	***N. hyalina***
4’	Lemma 6–10 mm long, with corona 1.5 mm high and awn 40–85 mm long	*N. neesiana*
5	Glumes (8–)13–14(–17) mm long, awn included; lemma around 7(–9) mm long, slightly papillate on its surface, sparsely hairy, those on veins nearly reaching apex; small and discrete corona, barely 0.5 mm high, not constricted at base and continuous to body of lemma; awn (50–)65(–90) mm long	*N. poeppigiana*
5’	Glumes very long, (18–)24–32(–35) mm long; lemma, 8–12 mm long, papillose and rough throughout, sparsely hairy in basal part, denser on veins; corona more developed, about 1 mm high and narrowed at the base; awn ≥ 90 mm long	*N. longiglumis*

Paspalum notatum Flüggé (1810: 106)

Specimens examined: PORTUGAL. Funchal, Marina, cracks in pavement, near lawn, 18 September 2021, *F. Verloove* 14149 (BR); Santa Cruz, drive-out of VR1 motorway at crossing with Estrada de Santa Catarina (ER207), lawn, commonly naturalized, 23 September 2021, *F. Verloove* 14113 (BR).

In addition to the two herbarium collections mentioned above, *Paspalum notatum* was occasionally seen elsewhere, for instance in Ponta do Sol (at the VE-3 roundabout) and in Santa Cruz (Gaula, bridge at crossing of VR-1 motorway and Estrada do Portinho). The species was certainly initially introduced on purpose, as a lawn grass (‘Bahia Grass’), but very easily escapes wherever planted.

The narrow leaves (< 0.4 cm wide) and relatively small spikelets (ca. 3.2 × 2 mm) of the Madeira plants are characteristic of var. *saurae* Parodi [syn.: *P. saurae* (Parodi) Parodi], the taxon usually observed in southern Europe and Macaronesia (e.g. Carretero 1987, Verloove 2003, Verloove 2005b). The taxonomic value of this variety, however, is probably limited and plants with intermediate features are sometimes observed (Zuloaga *et al.* 2004). In Macaronesia, this species was already known from the Canary Islands (Verloove & Reyes-Betancort 2011, Siverio Núñez *et al.* 2013) and the Azores (Silva *et al.* 2005). Muer *et al.* (2020) also recently reported it from the island of Madeira (Machico).

Paspalum urvillei Steud. (1853: 24)

Specimens examined: PORTUGAL. Santa Cruz, Santo António da Serra, S side of Golf Court, half-open grassland on the verge of golf court, an established population with +100 individuals, 17 September 2021, *F. Verloove* 14150 (BR); Ponta do Sol, mouth of riverlet, beach, a single huge individual, 21 September 2021, *F. Verloove* 14153 (BR); Ambas as margens na foz da ribeira da Ponta do Sol, formando tufos [Both river banks at the mouth of Ponta do Sol stream, forming tufts], 27 October 2022, *J. Silva, J. Ferreira & A. Nóbrega* 7397 (MADM).

This South American weed has its native range from Bolivia to Brazil and in southern South America. It is widely introduced elsewhere as a forage species in tropical and subtropical regions across the world and has established itself in highly disturbed natural ecosystems, agricultural fields, etc. It is listed as an invasive species in, among others, Hong Kong, Japan, Réunion, U.S.A., Cuba, Australia, New Caledonia and New Zealand. In Europe, it has a limited distribution in the Iberian Peninsula where it is naturalized in both Portugal and Spain (Pinto da Silva 1971, Litzler 1979). In Macaronesia, it is well-known from the Azores (Santa Maria, São Miguel, Terceira; Silva *et al.* 2005) whereas in the Canary Islands it has only been reported from La Palma (Santos 1983) where it has become a common weed. It is here recorded for the first time from the island of Madeira.

Paspalum urvillei is much reminiscent of *P. dilatatum* Poir., the latter being widely naturalized, especially in lowland parts, in the island of Madeira. Perhaps both have been intermingled up to the present. *P. urvillei* usually is a taller species, with robust stems up to 2 m tall; its spikelets, however, are smaller (2–3 mm vs. 3–4 mm) and the inflorescence branches are much more numerous (10–25 vs. 2–10). In September 2021, *P. urvillei* was observed in two localities (see above). At least in Santo António da Serra it looks well-established. It should be looked for elsewhere in the island of Madeira.

Sporobolus aff. ***fertilis*** (Steud.) Clayton (1965: 291)
[syn.: *Sporobolus indicus* (L.) R. Br. var. *major* (Buse) Baaijens]

Specimens examined: PORTUGAL. Santo da Serra [popular short name for Santo António da Serra; FV], champ cultivé à l’abandon du village vers Porto da Cruz, 15 July 1977, *E. Jacques* 10796 (BR, dupl. TAIF); Matur [in fact,

this probably refers to the same locality as the previous collection, since both collections were made during the same expedition to Madeira; FV], 300 m alt., bord du chemin, July 1977, *L. Delvosalle* s.n. (BR); São Jorge, R101 road near village center, roadside, ca. 30 individuals, 15 September 2021, *F. Verloove* 14625 (BR); Santa Cruz, drive out of VR1 motorway near airport, lawn weed, very common, ca. 500 individuals, 23 September 2021, *F. Verloove* 14647 (BR).

The *Sporobolus indicus* complex is a taxonomically challenging group (e.g. Clayton 1965, Baaijens & Veldkamp 1991, Simon & Jacobs 1999). Plants from this complex that are naturalized in the island of Madeira are at present usually ascribed to *S. africanus* (Poir.) Robyns & Tournay (syn.: *S. indicus* var. *capensis* Engl.) (Press & Short 1994, Vieira 2002, Jardim & Sequeira 2008, Menezes de Sequeira *et al.* 2012). The first records, however, were published as *S. indicus* (Hansen 1971). These two species are morphologically very similar and not easily told apart. During our recent field work, another member from this complex was observed. Compared to the two aforementioned species, these plants stand out for being significantly taller, with stems easily exceeding 100 cm in length, inflorescences with slightly patent lowermost branches up to 50 mm long and small spikelets (up to 2 mm long) and sometimes only 2 (vs. usually 3) anthers. For its tallness, inflorescence shape and anther number, these plants mostly resemble *S. fertilis*. The latter shows some resemblance to the Australian weed *S. elongatus* R. Br. and both species have often been confused (e.g. Yang 1987, Baaijens & Veldkamp 1991).Yet, these species are not related: *S. elongatus*is not a member of this complex and its placement in fact remained unresolved in a recent molecular phylogenetic study (Peterson *et al.* 2014). *S. elongatus* has shorter (up to 20 mm long), more patent and distant lower panicle branches. Most recent studies in fact have shown that *S. fertilis* is most closely related to *S. africanus* (Shrestha *et al.* 2003, Shrestha *et al.* 2005, Peterson *et al.* 2014). These two species have the position of the grain vs. lemma and palea in common: the lemma and palea exceed the grain by up to its own length, gaping widely open beyond its top (Clayton 1965), which apparently is an important synapomorphy.

Given the complexity of the group, we also genetically analyzed the Madeira plants (collection *F. Verloove* 14647) based on ITS and *matK* DNA sequence data (Figure 2). The *matK* sequence was identical with sequences labelled as *Sporobolus fertilis* (*M.W. Chase* 19305 from K) and *S. indicus* (*M.W. Chase* 9275, also from K), both obtained from cultivated material of uncertain provenance, as well as a sequence labeled as *S. indicus* from Brazil (USDA-NPGS PI 310309), and a sequence labeled as *S. africanus* from mainland Portugal (BM 2008/148). The ITS sequence was identical with two sequences of *S. jacquemontii* Kunth [syn.: *S. pyramidalis* P. Beauv. var. *jacquemontii* (Kunth) Jovet & Guédès] from Mexico (*P.M. Peterson* 15902 & *J. Valdes-Reyna* from US and *Estrada* 18964 *et al.* from CIIDIR), and was closely related to sequences of *S. berteroanus*, *S. indicus*, *S. pseudairoides* and *S. fertilis* from various (sub)tropical locations (Peterson *et al.* 2014). In general habit, *S. jacquemontii* certainly shows some resemblance to the Madeira plants but it is readily and unequivocally distinguished based on floral details: in the plants from the island of Madeira, the upper and lower glume are very unequal in length (respectively ca. 1–1.5 and 0.5 mm long) and the upper glume is acute at apex and at least ½ as long as the spikelet (ca. 55% as long). In *S. jacquemontii*, in contrast, the upper glume is only slightly longer than the lower and the upper glume is erosely truncate at apex and less than ½ as long as the spikelet. It usually also is a smaller plant, much unlike the tall plants observed in the island of Madeira. Examination of reliably identified herbarium material in BR confirmed that *S. jacquemontii* is not a good match for the Madeira plant.Therefore, it is here tentatively assigned to *S.* aff. *fertilis*. *Sporobolus fertilis* is native to tropical and subtropical southeast Asia. It was trialed as a pasture species in Australia and now has become a very noxious weed there (Giant Parramatta grass; very numerous online references); it is, moreover, resistant to particular herbicides (Harrington & Ghanizadeh 2024). It is also naturalized in some South Pacific islands (Clayton & Snow 2010). Plants from the *S. indicus* complex that are naturalized in southwestern Europe since the 20th century were initially ascribed to this species (Jovet & Guédès 1968), erroneously so, as pointed out by Veldkamp (1990). According to the Euro+Med Plantbase (2023), *S. fertilis* is not known from Europe and the Mediterranean area. However, it is locally naturalized in Turkey (Byfield & Baytop 1998, Uludağ *et al.* 2017) and even considered to be an invasive (transformer) species in the Caucasus (Kolakovsky *et al.*1990, Lytvinskaya & Abdyeva 2021). As far as Madeira is concerned, *S. fertilis* appears to be a locally naturalized species. A small roadside population was recorded in São Jorge in September 2021 and an impressive stand was found in a lawn next to the airport in Santa Cruz, also in September 2021. Interestingly, this species was already collected in the island of Madeira in the 1970's (as *S. indicus*), in Santo da Serra (see Specimens examined). Thus, it probably has been present for about half a century, yet is less common than the other representatives of this complex in Madeira, viz *S. africanus* and *S. indicus*.

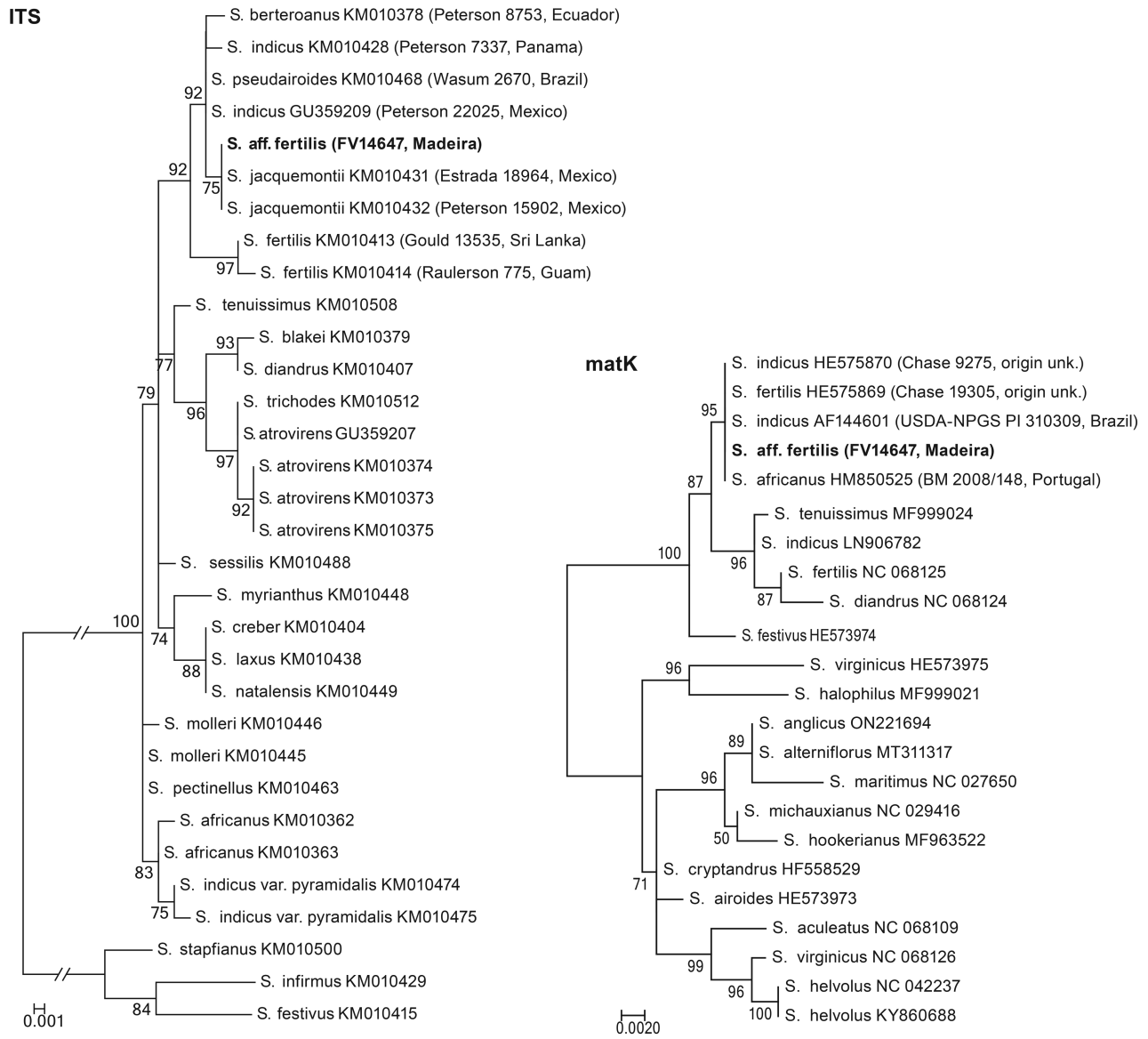

FIGURE 2. Maximum likelihood trees (IQ-TREE) inferred from nuclear rDNA internal transcribed spacer (ITS) region and the plastid encoded *matK* gene, showing the position of the *Sporobolus* aff. *fertilis* specimen from Santa Cruz (*F. Verloove* 14647, BR0000027058626V, ENA/GenBank accessions). Values at branches correspond to UFBoot2 supports (1000 replicates). Scale represents estimated substitutions per site.

Taxonomic issues in *Hyparrhenia* and *Setaria* from the island of Madeira

Hyparrhenia E. Fourn. (1886: 51 & 67)

It is quite unclear which species of *Hyparrhenia* occur in the island of Madeira. Historical sources evidently only reported *H. hirta* (L.) Stapf (back then as *Andropogon hirtus* L.) since *H. sinaica* (Delile) Llauradó ex G. López was only relatively recently resurrected (López González 1994). Recent Madeiran authors refer all records to the latter species (Jardim & Sequeira 2008, Menezes de Sequeira *et al.* 2012, Muer *et al.* 2020) whereas Jardim & Menezes de Sequeira (2021) reported *H. hirta* (s.str.?) from Desertas. However, according to Scholz *et al.* (2021) all collections from the island of Madeira that are preserved in LPA belong to *H. hirta* s.str. and Dobignard & Chatelain (2010) also only mentioned *H. hirta* s.str. from the island of Madeira. Yet, Menezes (1914) already reported the presence of two taxa in the island of Madeira, i.e. var. *genuinus* and var. *pubescens*, probably corresponding to the species currently named as *H. hirta* and *H. sinaica*, respectively. Our recent fieldwork and a study of specimens preserved at MADM

confirm the presence of both *H. hirta* (but see below) and *H. sinaica* in the island of Madeira, the latter apparently being most widespread.

H. hirta:
Specimens examined
Funchal, July 1934, *M. Grabham* (MADM 5215);
Pico dos Barcelos [Funchal], May 1937, *Costa* (MADM 5218);
Vereda entre o Pico do Facho (Machico) e a Ribeira do Natal (Caniçal), 27 January 2005, *J. Silva* (MADM 5216);
Funchal, Levada dos Piornais, 131 m, 29 July 2015, *J. Silva et al.* (MADM 5217).

H. sinaica:
Specimens examined
Arrudal (Porto Moniz), May 1932, *Costa* (MADM 6521);
Caniço, May 1937, *Costa* (MADM 6528);
Pico da Cruz, May 1937, *Costa* (MADM 6529);
S. Gonsalo [São Gonçalo, Funchal], May 1938, *Costa* (MADM 6527).
Câmara de Lobos, at the estuary of Ribeira dos Socorridos, roadside, 19 April 2022, *F. Verloove* 14389 (BR).

Although not given any taxonomic relevance by Clayton (1969), these two taxa are accepted as distinct species by all contemporary authors in the Mediterranean area (e.g. Tison & de Foucault 2014, Pignatti 2017, Rico 2021). They are usually readily separated: *H. hirta* has a peduncle with 2-5 mm long hairs in the distal portion and spathes that are at least hairy and/or ciliate at the margins. In *H. sinaica*, in contrast, the peduncle is glabrous or with a few hairs that are not more than 1 mm long and spathes are glabrous to subglabrous. The latter also is a markedly shorter plant, rarely exceeding 60 cm in height. In the island of Madeira, these two species are easily separated.

In his world monograph, Clayton (1969) distinguished some further, African species that closely resemble *H. hirta*. The latter was said to never have deflexed raceme bases. However, in the island of Madeira, especially in the area of Funchal, rather numerous populations are found in which the raceme bases are obviously deflexed, at least at maturity (Figure 3). Such plants could be ascribed to the tropical African *H. quarrei* Robyns, a widespread weed that also was reported from Australia by Clayton l.c. Simon (1989), however, placed this species in synonymy of *H. hirta*, judging that raceme base deflection is probably not genetically fixed. Even if this were the case, the Madeira plants further differ from true *H. hirta* (and *H. quarrei*) in the upper raceme base being distinctly flattened (Figure 3). This is a characteristic feature of sect. Pogonopodia Stapf in general and of the East African weed *H. dregeana* (Nees) Stapf ex Stent [syn.: *H. aucta* (Stapf) Stapf ex Stent] in particular. This species is naturalized in the Hawaiian islands (Herbst & Clayton 1998). However, in *H. dregeana* raceme bases are short and subequal and usually bear stiff, glassy bristles, whereas in the Madeira plants, the upper raceme base is usually clearly longer than the lower (although some variation can be observed in this respect, even in a single inflorescence!) and both are covered with soft, not bristly hairs. According to Clayton l.c., *H. dregeana* intergrades almost imperceptibly with *H. hirta* (see also Gibbs Russell 1983). Such putative hybrids of *H. dregeana* and *H. hirta* have been reported from Australia (e.g. Queensland Government 2023); it is unknown whether or not the taxonomic identity of these plants could be resolved but contemporary Australian floras and databases do not mention *H. dregeana* or hybrids of it (e.g. AusGrass2 2023).

Additional studies, involving molecular phylogenetic methods, are required to elucidate the identity of this enigmatic taxon from the island of Madeira: do such plants belong to *Hyparrhenia hirta* (which then would be more variable than previously thought, especially with regard to the shape of the inflorescence) or are they complex hybrids or hybridogenic species? In any case, a preliminary molecular analysis, based on the collection *F. Verloove* 14638 from Funchal, already showed that the ITS sequence of this collection clearly differs from a collection identified as *H. hirta* from Morocco (*Skendzic* 5103; Skendzic *et al.* 2007), and instead were more closely related to sequences from Kenya, labeled as *H. papillipes* (Gill *et al.* 2019) (Figure 4). While the *trnL-F* spacer exhibited a higher taxon sampling, it proved to be less informative, with only eight parsimony informative sites in its alignment (in comparison, the ITS alignment contained 64 parsimony informative sites). The phylogenetic tree derived from the *trnL-F* spacer sequences supports the ITS analysis, revealing a clear distinction between the plant from the island of Madeira and sequences identified as *H. hirta* (including a specimen collected from Tenerife, *F. Verloove* 14843). However, unlike the ITS analysis, it does not suggest a connection with *H. papillipes*.

Specimens examined: PORTUGAL. Funchal, Rua da Amoreira, roadside, common, 19 Apr. 2022, *F. Verloove* 14638 (BR); Funchal, valley of Ribeira de João Gomes at VR-1 motorway, roadside slope, common, 20 Apr. 2022, *F.*

Verloove 14651 (BR); Funchal, São Martinho, Travessa do Amparo, roadsides, grassy slopes, etc., common all over the hill, 20 Apr. 2022, *F. Verloove* 14660 (BR); Funchal, Papagaio Verde, Levada dos Piornais, along track, irrigation canal, common, 27 Apr. 2022, *F. Verloove* 14699 (BR).

FIGURE 3. *Hyparrhenia* spec. in Funchal, April 2022 (Photos F. Verloove).

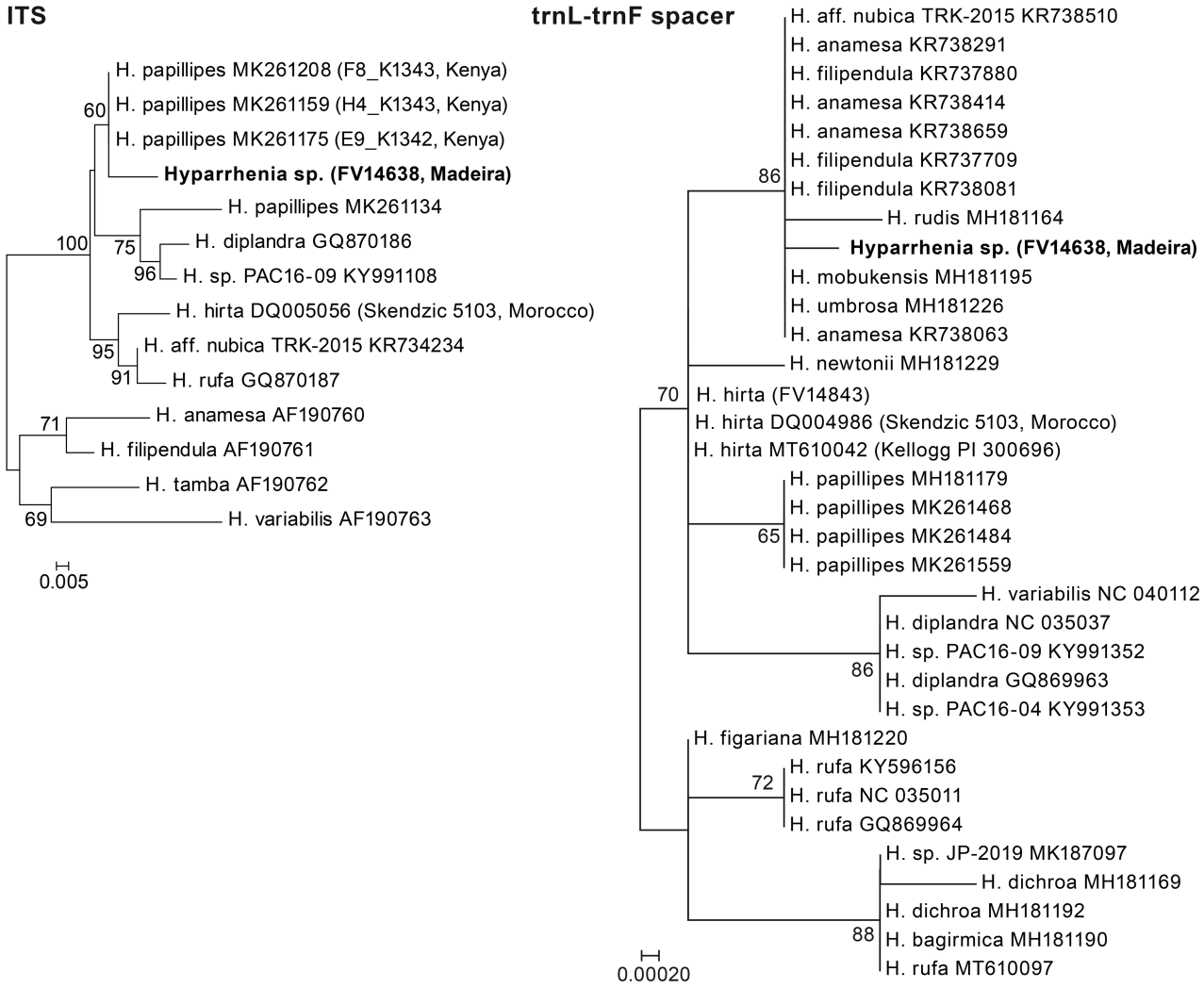

FIGURE 4. Maximum likelihood trees (IQ-TREE) inferred from nuclear rDNA internal transcribed spacer (ITS) region and the plastid encoded *trnL-F* spacer, showing the position of the *Hyparrhenia* specimen from Funchal (*F. Verloove* 14638, BR0000027058633V, ENA/GenBank accessions). Values at branches correspond to UFBoot2 supports (1000 replicates). Scale represents estimated substitutions per site.

Setaria P. Beauv. (1812: 51)

Setaria adhaerens (Forssk.) Chiov. is the warm-temperate/subtropical counterpart of *S. verticillata* (L.) P. Beauv. Both have spikelets with clinging, retrorsely barbed bristles in common but *S. adhaerens* differs due to its leaf sheath margins that are perfectly smooth (vs. long ciliate). In Macaronesia, like in other regions with a subtropical climate, it is the usual weed of the two. In Cape Verde, for instance, only *S. adhaerens* is known (Arechavaleta *et al.* 2005). Yet, only *S. verticillata* was mentioned from Madeira in a recent checklist, whereas both were cited from the Azores (Jardim & Sequeira 2008, Menezes de Sequeira *et al.* 2012). It is very unlikely that *S. adhaerens* is indeed a recent introduction in the island of Madeira: it was already collected there in 1900 by Bornmüller (Funchal, in incultis, Aug. 1900, *J. Bornmüller* n° 1313 Plantae exsiccatae Maderenses; BR!). More plausible is that these species have been confused so far in the island of Madeira or considered to be conspecific (see also Vieira 2002), erroneously so. In a recent monograph of *Setaria* in the Old World (Morrone *et al.* 2014) both were accepted as distinct species (see also Rominger 2003 and other contemporary floras).

Specimen examined: PORTUGAL. Machico, cemetery, as a weed, very common everywhere, apparently confused with *S. verticillata*, 11 September 2021, *F. Verloove* 14120 (BR).

Miscellaneous notes

Cenchrus setaceus (Forssk.) Morrone [syn.: *Pennisetum setaceum* (Forssk.) Chiov.]

This species from North and East-Africa and southwestern Asia is one of the most invasive species in the Canary Islands (González-Rodríguez *et al.* 2010) and its potential area even will increase under future climatic scenarios (Da Re *et al.* 2020). Yet, in the island of Madeira, *Cenchrus setaceus* is a very recent newcomer: it was first found in 2018 and 2019, in Santa Cruz and Funchal (Cabral *et al.* 2020). Soon afterwards, it was also recorded for the first time in Porto Santo (Jardim & Menezes de Sequeira 2021). In Santa Cruz, the species was already abundant at the time of its discovery (+1000 individuals), whereas in Funchal a single specimen was found (and eradicated).

During our fieldwork in 2021 and 2022 the species' presence and spread were confirmed. In Santa Cruz, *C. setaceus* has become very common, especially in the valley of the Ribeira de Santa Cruz, but also elsewhere in the area, e.g. near the airport. A new population with ca. 30 individuals was discovered in Funchal, along the Rua da Ribeira de João Gomes, below the VR-1 motorway. Scattered plants were also seen in Garajau, along the road that leads to the Garajau beach. Finally, a single individual was observed near the sea in Porto Novo (Gaula). From the above, it is obvious that the species is in the early stages of invasion and urgently needs to be removed by local authorities to prevent further harm.

Ehrharta erecta Lam.

This South African weed is a recent introduction in the island of Madeira from where it has been known since 2019 (Gonçalves Silva & Ferreira 2020). Back then, it was reported from Porto da Cruz, Funchal, Santa Cruz, Machico and Ponta Delgada. In 2021 and 2022, the massive presence and spread of this invasive species was confirmed. In addition to the areas from where it was already known, it was also observed in, among others, Ponta do Sol, Porto Moniz, São Vicente, Santo António da Serra, São Jorge, Faial and Serra de Água. In few years' time, *Ehrharta erecta* has invaded almost all lowland areas, except perhaps in the extreme western part of the island. Moreover, the species has also started to intrude inland localities, some of which are located above 500 m a.s.l. *Ehrharta erecta* is considered to be some of the most invasive species worldwide (Stinca & Mei 2019).

Eragrostis tenuifolia (A. Rich.) Hochst. ex Steud.

This Afro-Asian weed was formerly mentioned from the island of Madeira by Hansen (1987). It was found in a waste place in Funchal, in 1982. However, *Eragrostis tenuifolia* was not upheld by Press & Short (1994), neither by Jardim & Sequeira (2008) and Sequeira *et al.* (2012), suggesting that it is not a permanent member of the Madeiran flora. According to Vieira (2002), its status on the island was unclear.

In fact, *Eragrostis tenuifolia* is still present and apparently locally naturalized in the area of Funchal. In 2021 and 2022 populations with numerous individuals were observed in irrigated lawns in park areas (Jardim de Santa Luzia and Jardins do Lido). The species was also observed along an irrigation channel (*levada*) in the northwestern part of Funchal.

Specimens examined: PORTUGAL. Lido-Funchal, Passeio Público Marítimo, num relvado [in a lawn], 4 July 2019, *J. Ferreira, J. Silva & Y. Gonçalves* 7442 (MADM); Funchal, parque Santa Luzia, lawn weed, 12 September 2021, *F. Verloove* 14182 (BR); Funchal, Papagaio Verde, Levada dos Piornais, along track, irrigation canal, ca. 500 individuals but only locally, 27 April 2022, *F. Verloove* 14316 (BR).

Discussion and conclusion

Based on recent fieldwork in the island of Madeira some noteworthy changes can be made to the catalogue of grasses found on the island. Nine non-native species are newly reported herein. Although most of them probably are (relatively) recent introductions, these species are at least locally well established. Without exception, they are considered to be unwanted weeds or invasives, in regions with similar climatic conditions, elsewhere in the world (Holm *et al.* 1979, Randall 2017). Therefore, it is important to correctly assess their identity and further document the first observations in the island of Madeira of these potentially invasive species; possible measures can thus be taken to prevent their future

spread. It is well known that early detection is crucial in plant invasions and that taxonomic resources are essential for the effective management of invasive plants (inadequate taxonomic resolution limits options for early detection and rapid response) (Pyšek *et al.* 2013).

In addition, a number of taxonomic issues are raised with regard to certain genera. The identity of members from the *Hyparrhenia hirta* complex in the island of Madeira needs to be revisited. At least two species are present but the genuine identity of one of these remains uncertain and should be reassessed, preferably applying modern techniques. Also, the presence of *Setaria adhaerens* on the island of Madeira was confirmed. In recent local floras and checklists, it had been confused with *S. verticillata*.

Finally, new records are presented for two introduced species that were recently reported for the first time from the island of Madeira and that are currently at the beginning of an imminent invasion, viz *Cenchrus setaceus* and *Ehrharta erecta*. Especially for the former – a highly invasive species elsewhere in Macaronesia – eradication measures may still prevent the species' further spread. Our recent records of the Old World tropical weed *Eragrostis tenuifolia* in the area of Funchal, confirm that this species is locally naturalized in the island of Madeira, which was being doubted.

Acknowledgements

Mrs. Alison Moore, Royal Botanic Gardens Kew, sent images of the relevant M.W. Chase collections of *Sporobolus*. Dr. Olof Ryding, collection manager of the C herbarium, is thanked for sending images of herbarium specimens relevant for this study. Finally, the authors would also like to thank Wim Baert and Arne Mertens (Meise Botanic Garden, Belgium) for their assistance in the molecular lab.

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