






New records of alien and potentially invasive grass (Poaceae) species for southern Africa

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Background: The grasses (Poaceae) of the Flora of Southern Africa (FSA) region (i.e. Botswana, Eswatini, Lesotho, Namibia and South Africa) are relatively well documented, for both native and non-native species. Visiting taxonomic expertise nevertheless reveals new FSA and in-country records, particularly of non-native species. Such records provide an opportunity for improving biosecurity relating to potentially invasive but hitherto undetected non-native Poaceae in the FSA region.

Objectives: To improve floristic data for non-native Poaceae occurring in the FSA region.

Method: Field collections were made, herbarium collections, databases and relevant literature were studied.

Results: New records are presented for non-native grasses that were encountered as locally common populations in the Drakensberg Mountain Centre of Floristic Endemism (DMC, Lesotho and South Africa). *Festuca rubra* and *Agrostis capillaris* are newly reported for sub-Saharan Africa and southern Africa and are also the first verified specimens reported for the African continent, with previous reports from northern-most Africa (Morocco, Algeria and/or Tunisia) uncertain. *Jarava plumosa*, introduced from South America and previously known for the whole of Africa from a single population in the Western Cape of South Africa, is newly reported from the border between the Eastern Cape, South Africa and Lesotho. The ecological implications, including the potential to become invasive, are discussed for each species, with taxonomic notes given to help differentiate them from closely resembling taxa.

Conclusion: These new records of alien grass species raise concerns over their potential ecological impact, particularly as they are found in an area of conservation importance, the DMC. Future efforts to monitor their distribution are of utmost importance.

Keywords: exotic grasses; non-native grasses; Gramineae; Drakensberg Mountain Centre of Floristic Endemism; Lesotho; South Africa

Introduction

The grass family Poaceae is relatively well-documented for the Flora of Southern Africa (FSA) region (comprising Botswana, Eswatini, Lesotho, Namibia and South Africa), with old and recent country-level treatments (e.g. Gibbs Russell et al. 1990; Fish et al. 2015) that incorporated efforts of numerous researchers who focused on different individual genera (Fish et al. 2015, see references therein), as well as more recent treatments of individual genera e.g. *Anthoxanthum* L. (Mashau 2016); *Festuca* L. (Sylvester et al. 2020a); *Poa* L. (Soreng et al. 2020).

In many countries, grasses have become the most damaging of invasive plants (D'Antonio & Vitousek 1992; D'Antonio et al. 2011; Gaertner et al. 2014), with knowledge of the distribution and ecology of these non-native grasses

crucial for effective habitat management (e.g. Gaertner et al. 2014; Visser et al. 2017; Monnet et al. 2020). Visser et al. (2017) notes that there is much uncertainty regarding the identity, numbers of species, distributions, abundances and impacts of alien grasses in the FSA region, with only 37 of the known 256 non-native species in the region considered to be invasive. Despite this lag in non-native Poaceae knowledge, South Africa has some of the most progressive invasive species legislation in the world, including for known invasive Poaceae: 18 species are listed in the National Environmental Management: Biodiversity Act's Alien and Invasive Species Lists (2016).

Even less known is the impact of invasive or alien grasses in the high-elevation Drakensberg Mountain Centre of Floristic Diversity and Endemism (DMC) of southern Africa (Carbutt 2019). The DMC, covering some 40 000 km², contains the only true alpine region in Africa south of Mount Kilimanjaro (Carbutt 2019). These high-elevation Afromontane and alpine areas are renowned for their high levels of plant diversity and endemism, with the DMC hosting \pm 2 520 angiosperm species (Carbutt & Edwards 2004) of which 227 are endemic (Carbutt & Edwards 2006; Carbutt 2019). This high importance for biodiversity is matched by the socio-ecological importance of these ecosystems, with a significant rangeland-based agrarian community relying on the DMC for their livelihoods (subsistence-based livestock herding being the dominant land-use). Any potential threat to this, such as that posed by potential invasive alien plants, should be taken very seriously.

During extensive field collecting and ecological research by the authors in the DMC area, new records of alien grass species were discovered that add a further three species to the known flora of the DMC (Carbutt & Edwards 2004, 2006; Carbutt 2019), and raise concerns over their potential ecological impact.

Materials and Methods

The new records were collected during extensive fieldwork conducted by SPS, RJS, MDPVS and AM in the DMC between 1 Feb. and 9 Mar. 2020, with specimens deposited in the PRE, NU and US [exported, awaiting accession] herbaria (Herbarium acronyms follow Thiers [continuously updated]). Herbarium study was also conducted at PRE between 13 and 20 Mar. 2020.

Ethical considerations: Permits

Collecting permits were kindly granted by the Eastern Cape Department of Economic Development, Environmental Affairs and Tourism (DEDEAT), Ezemvelo

KZN Wildlife (EKNZW), and the Lesotho Ministry of Tourism, Environment and Culture – Department of Environment.

Taxonomic Treatment

***Agrostis capillaris* L.**, Sp. Pl. 1: 62 (1753). *Agrostis polymorpha* var. *capillaris* (L.) Huds., Fl. Angl. 1: 31 (1778). *Trichodium capillaris* (L.) Roth, Nov. Pl. Sp. 41 (1821). Type: [Habitat in Europae pratis], *Herb. A. van Royen s.n.* (lectotype, designated by Widén 1971: 65: L0052645 left-hand specimen [image!]; isolectotype: L [not seen]) (Figures 1, 2).

= *Agrostis tenuis* Sibth., Fl. Oxon. 36 (1794). *Agrostis capillaris* Huds., Fl. Angl.: 27 (1762), hom. illeg., non L., 1753. Type: ENGLAND (not located).

Many other heterotypic synonyms (POWO 2020).

Distribution: Of Eurasian origin; introduced into many other temperate areas of the World (POWO 2020, and references therein). This is the first report of the species for sub-Saharan Africa and the FSA region; it may also be the first verified specimen from the African continent, as it is noted with '?' for Morocco and Tunisia by Dobignard and Chatelain (2010: 213) (Figure 2).

New record: SOUTH AFRICA. **Eastern Cape:** Tiffindell Ski Area, on path to Ben Macdhui summit, S30.6516648 E27.92767, 2745 m alt., side of dirt road through alpine grassland (specifically, Mucina and Rutherford 2006's Lesotho Highland Basalt Grassland vegetation unit in the Grassland Biome), 10 Feb. 2020, *S.P. Sylvester et al.* 3451 (NU, PRE, US).

Common vernacular names: bent grass (USA); brown top (UK, USA); colonial bent (USA); common bent (UK).

Notes: *Agrostis capillaris* is generally not considered invasive in the areas where it has been introduced and naturalised, and is not included in the IUCN Global Invasive Species Database (<http://www.iucngisd.org/gisd/>). Nevertheless, given the current perceived fragility of the alpine sub-centre of the DMC (Global Mechanism of the UNCCD 2018, 2019; Bentley et al. 2019; Carbutt 2019), the demographics and spatial extent of this species should be examined, and its behavior closely monitored (by e.g. the South African National Biodiversity Institute's (SANBI) Invasive Species Programme). The species was found to be locally frequent and occurs alongside *Festuca rubra*, also detailed in this paper, and may have been sown as a lawn mix by the Tiffindell Ski Resort to ensure adequate cover of their ski slopes. Other native species such as *Lachnagrostis barbuligera* (Stapf) Rugulo & A.M. Molina or *Poa binata* Nees, which were found in the vicinity, and are just as capable of forming a close sward, should rather be

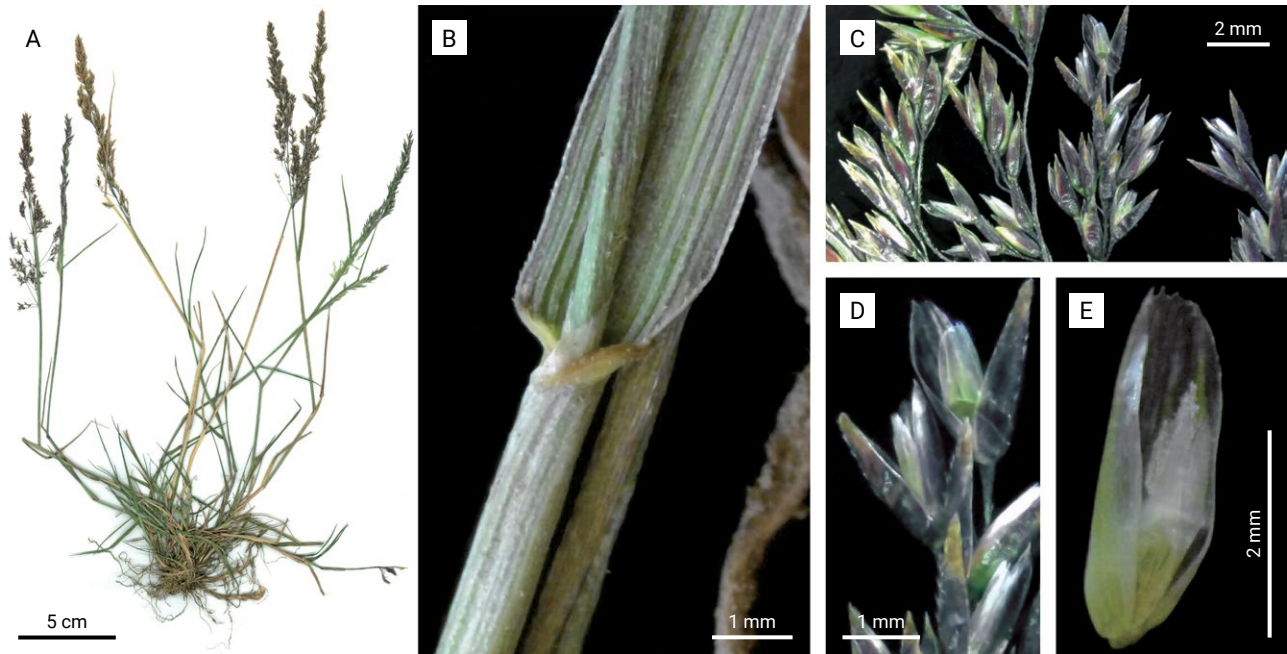


Figure 1. *Agrostis capillaris*; A, whole plant; B, junction of sheath and blade of a tiller [sheath should be expanded to see clearly that the ligule is shorter than broad]; C, inflorescence close-up; D, spikelets, lateral view; E, floret, ventral view, showing the well-developed palea. Image A of *S.P. Sylvester et al. 3451* (US), B–E of *S.P. Sylvester et al. 3451* (PRE).

used in seeding projects as opposed to these non-native species.

Similar species: *Agrostis gigantea* Roth, an alien species now naturalised in the FSA region (Fish et al. 2015), is closely related and similar in terms of: plants always with extensively creeping rhizomes, usually without stolons; leaf blades generally flat (*A. capillaris* often with basal blades involute and culm blades flat); panicles open or only partially contracted after flowering, generally

> 5 cm long (sometimes as short as 3 cm in *A. capillaris*); primary panicle branches without branchlets at least in the proximal half; floret notably shorter than the glumes, usually $\frac{1}{3}$ – $\frac{3}{4}$ the length of the glumes, without a rachilla prolongation; paleas reaching $(\frac{2}{5}$ –) $\frac{2}{3}$ – $\frac{3}{4}$ the length of the lemma; lemmas mucous or with an awn of varying length, ranging from a short straight awn, 0.2–1.0 mm long, to a long geniculate and twisted awn to 4 mm long, inserted basally, medially or in the upper half of the lemma, not surpassing or greatly surpassing the glumes.

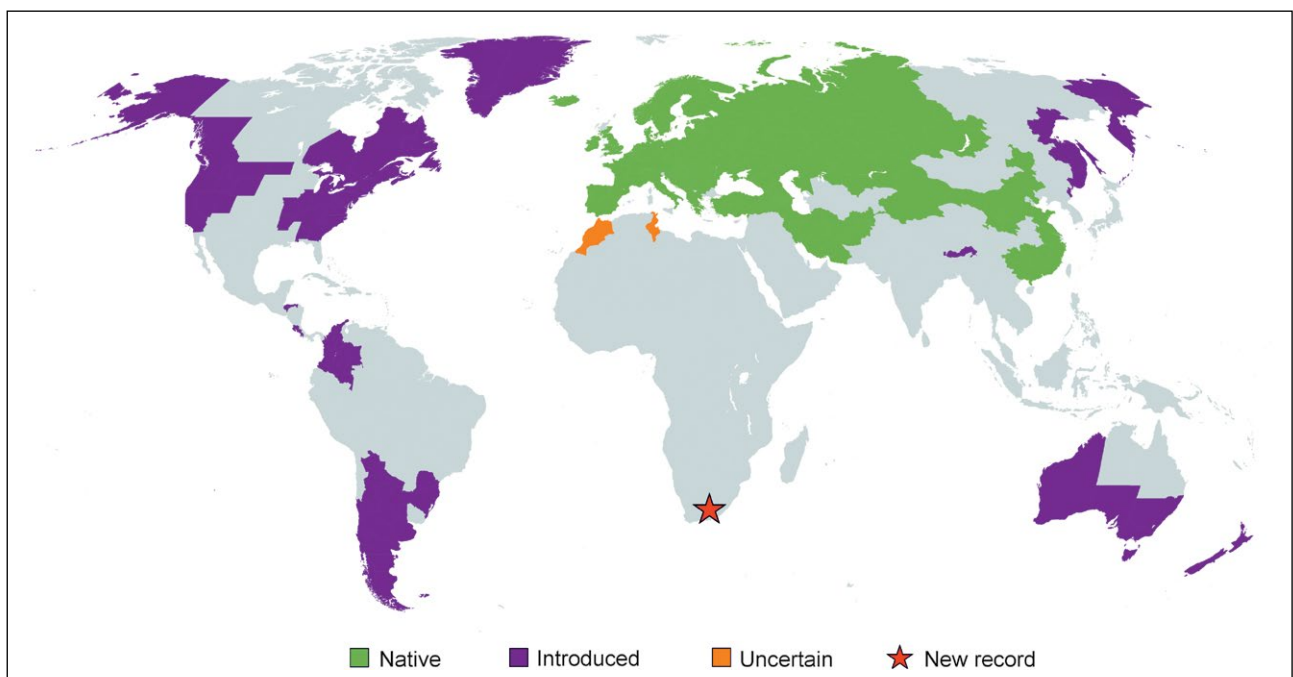


Figure 2. *Agrostis capillaris* global distribution map, with country- or regional-level shading, taken and modified from POWO (2020).

Agrostis capillaris is primarily differentiated from *A. gigantea* by the ligule of the tiller leaves being distinctly shorter than wide [sheath should be expanded to be able to see this clearly] and ≤ 1 mm long (Figure 1B) (vs. as long as or distinctly longer than wide, 1–3 mm long in *A. gigantea*), ligules of culm leaves 0.5–1.5(–2.9) mm long, shorter to sometimes longer than wide (vs. 2–8 mm long, as long as or distinctly longer than wide in *A. gigantea*). *Agrostis capillaris* can also usually be readily distinguished from *A. gigantea* by its shorter size, culms being 10–75(–90) cm tall, and thinner blades of culm leaves (0.6–)1.0–4.0(–5.0) mm wide as opened out which are sometimes inrolled (Figure 1) (vs. culms 40–100(–120) cm tall, blades of culm leaves (2–)3–8 mm wide, always flat in *A. gigantea*) although there are smaller variants of *A. gigantea* with thinner leaves which can superficially resemble *A. capillaris*. In these cases of ambiguity, the ligule will always settle the identity (also see notes and key in Sylvester et al. 2020b).

Agrostis stolonifera L., a species not known from southern Africa, but which is native in temperate Eurasia and northern Africa reaching as far south as Chad, and which is widely introduced elsewhere (POWO 2020, and references therein), also bears similarities to *A. capillaris*. *Agrostis stolonifera* is primarily differentiated from *A. capillaris* by the ligule of tillers 1–3 mm long and culm leaves 2.0–6.5 mm long, always distinctly longer than broad. The habit also differs, with *A. stolonifera* usually extensively stoloniferous with stolons 5–100(–200) cm long [these often not collected as part of herbarium specimens], rhizomes usually absent (vs. extensively rhizomatous, sometimes also stoloniferous, in *A. capillaris*). Cope and Gray (2009) and Harvey (2007) differentiate *A. stolonifera* from *A. capillaris* and *A. gigantea* mainly based on panicle characteristics, e.g. Cope and Gray (2009) state *A. stolonifera* has primary panicle branches often bearing branchlets more-or-less from the extreme base but sometimes bare in the lower $\frac{1}{4}$ – $\frac{1}{3}$, panicle tightly closed after flowering (vs. primary panicle branches bare of branchlets at least in the lower half, panicle open or only partially contracted after flowering in *A. capillaris* and *A. gigantea*). However, in the case of *A. capillaris*, panicle contraction after flowering is seen as a somewhat ambiguous differentiating character as it can vary from contracted to open both before and after anthesis. Thus, the form of the ligule is found to be a much more reliable distinguishing character for differentiating these species (also see updated description and key in Sylvester et al. 2020b).

***Festuca rubra* L., Sp. Pl. 1: 74 (1753). *Festuca ovina* var. *rubra* (L.) Sm., Engl. Fl. 1: 139 (1824). *Festuca duriuscula* var. *rubra* (L.) Alph. Wood, Amer. Bot. Fl. 2: 399 (1871), nom. illeg. hom. Type: SWEDEN [Hab. in Europa sterilibus siccis]. In paludosis prati regii Upsalia, sin coll. s.n. (lectotype, designated by Jarvis et al. 1987: 301: GB [not seen]) (Figures 3, 4).**

Many heterotypic synonyms (POWO 2020).

Distribution: Native range is sub-arctic and temperate Northern Hemisphere (Figure 4). The native range of *F. rubra* s.l. is noted to extend into northern Africa by POWO (2020), although the subspecies or varieties of *F. rubra* described from high-elevation Morocco and Algeria have been re-assigned to other species of *Festuca* (Dobignard 2010). Thus, it is unclear whether *F. rubra* occurs naturally, or has been introduced, in northern Africa: Dobignard and Chatelain (2010: 296) note ‘?’ for Morocco and the Madeira islands. Our collection from South Africa is therefore possibly the first verified specimen from the African continent. It does, however, occur on sub-Antarctic Marion Island (one of South Africa’s two islands in the Prince Edward Islands group), where it is recorded as a major invasive species (Greve et al. 2017). *Festuca rubra* has also been introduced to Australia, New Zealand, and South and Central America (POWO 2020, and references therein) where it has become naturalised, but is not considered invasive.

New record: SOUTH AFRICA. Eastern Cape: Tiffindell Ski Area, next to ski lift, S30.650718 E27.925683, 2781 m alt., alpine grassland (specifically, Mucina and Rutherford 2006’s Lesotho Highland Basalt Grassland vegetation unit in the Grassland Biome), annually burnt, appears to be seeded with alien species, 11 Feb. 2020, S.P. Sylvester et al. 3455 (NU, PRE, US).

Common vernacular names: red fescue (Canada, UK, USA); strong creeping red fescue (UK).

Notes: *Festuca rubra* is generally not considered invasive in the areas where it has been introduced and naturalised (except for Marion Island), and is not included in the IUCN Global Invasive Species Database (<http://www.iucngisd.org/gisd/>). It was found to be locally common and is likely to have been sown in a seed mixture for maintenance of the Tiffindell ski slopes, which has subsequently spread into nearby alpine grassland (see notes under *Agrostis capillaris* above).

Traditional circumscription of infraspecific taxa within *F. rubra* has been brought into question (Saikkonen et al. 2019); although our specimen keys fairly solidly to *F. rubra* subsp. *rubra* in the treatments by Hubbard (1984), Cope and Gray (2009), and Darbyshire and Pavlickf (2007), we prefer to present the new record at the species rank here.

Similar species: *Festuca rubra* is quite distinct and differs from other *Festuca* s.l. taxa in the FSA region by having the combination of: rhizomes present, very slender, extensively creeping, tillers extravaginal, with cataphylls present (Figure 3B) (vs. extensive creeping rhizomes absent, tillers intravaginal, cataphylls absent in *F. africana* (Hack.) Clayton [= *Pseudobromus silvaticus* K. Schum.], *F. arundinacea* Schreb. [= *Lolium*

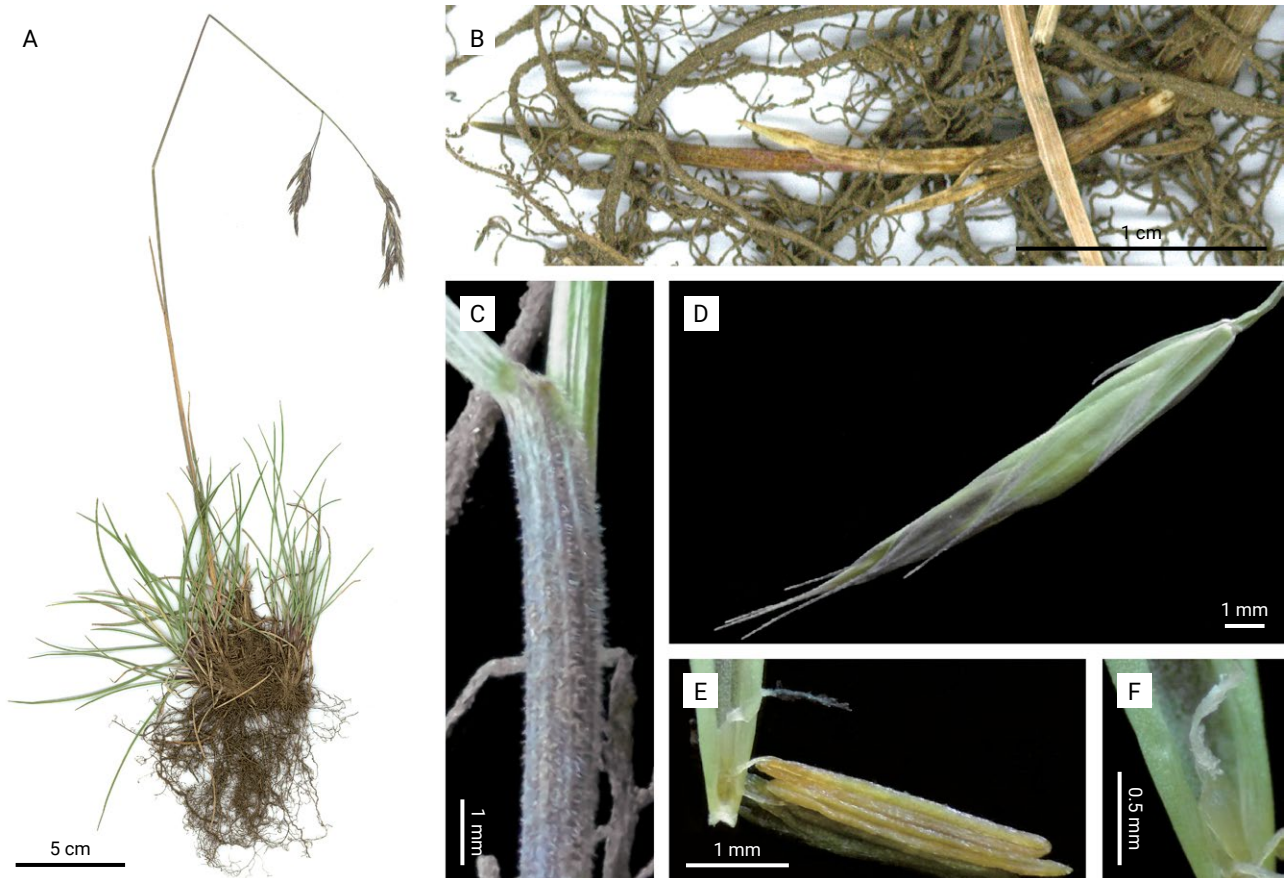


Figure 3. *Festuca rubra*; A, whole plant; B, lateral-tending rhizome covered in cataphylls; C, leaf sheath and junction with blade of a tiller showing strigose hairs; D, spikelet; E, base of palea with lemma removed to reveal the ovary and stamens; F, close-up of glabrous ovary apex. Images A and B of *S.P. Sylvester et al. 3455* (US), C–F of *S.P. Sylvester et al. 3455* (PRE).

arundinaceum (Schreb.) Darbysh.), *F. caprina* Nees, *F. costata* Nees, *F. killickii* Kenn.-O'Byrne, *F. vulpioides* Steud.); basal sheaths entire or splitting into narrow parallel threads (vs. coarsely fibrous in *F. costata*), usually

strigose-hairy (Figure 3C), rarely glabrous (vs. glabrous or scabrous in most; white velvet-hairy in *F. scabra* Vahl); ligules 0.1–0.5 mm long (vs. > 1 mm long in most apart from *F. caprina*, *F. dracomontana* H.P.Linder,

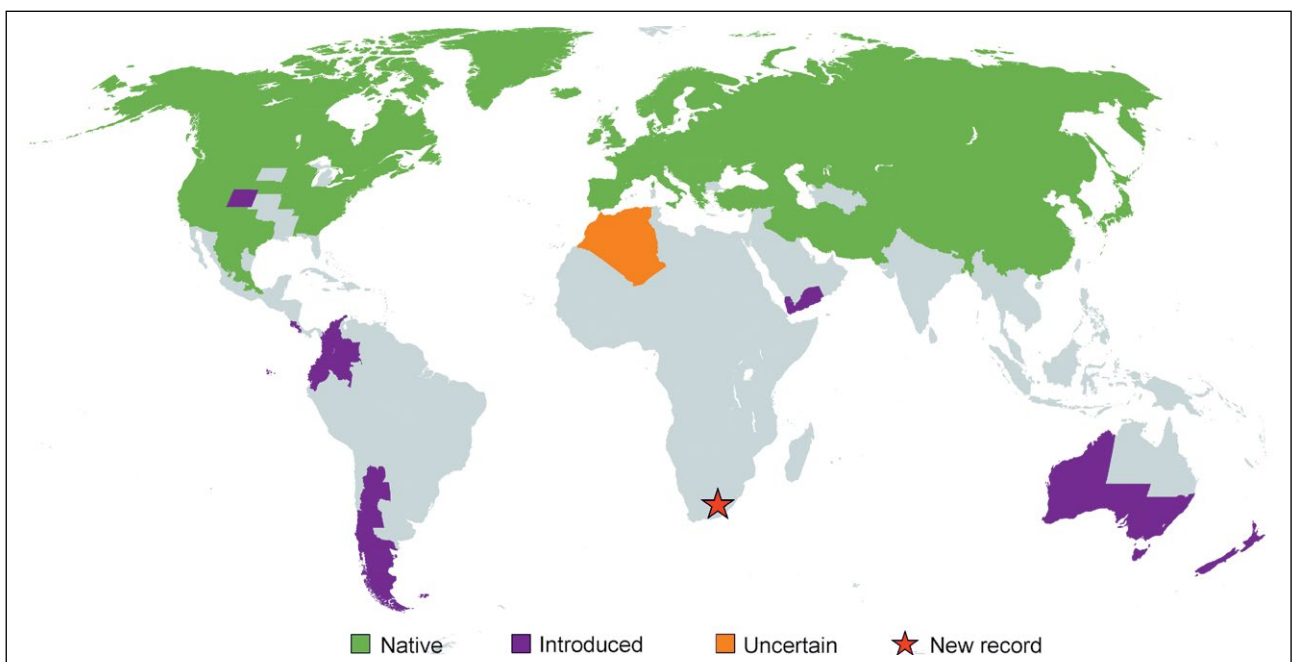


Figure 4. *Festuca rubra* global distribution map, with country- or regional-level shading, taken and modified from POWO (2020).

F. drakensbergensis Sylvester, Soreng & M.D.P.V. Sylvester [Sylvester et al. 2020a], *F. exaristata* E.B. Alexeev, *F. vulpioides*); collars non-auriculate (vs. auriculate in *F. arundinacea* [= *Lolium arundinaceum*], *F. dracomontana*, *F. vulpioides*); blades narrow, conduplicate or rolled, 0.3–1.5(–2.5) mm wide in diameter (vs. flat or relatively broad, [2–]3–15 mm wide in diameter in most [rarely narrower in *F. scabra*] apart from *F. caprina*, *F. drakensbergensis*, *F. exaristata*); panicles open or contracted (vs. very open, candelabrum-shaped, in *F. longipes* Stapf, open or contracted in other taxa); spikelets 3- to 10-flowered (vs. 1-flowered in *F. africana* [= *Pseudobromus silvaticus*]; sometimes 2-flowered in other taxa); awns (0.1–)0.4–4.5 mm long (Figure 3D) (vs. 10–20 mm long in *F. africana*); anthers 1.8–4.5 mm long (Figure 3E) (vs. 0.8–1.8 mm long in *F. drakensbergensis*, *F. exaristata*, and rarely *F. killickii*); ovary apex glabrous (Figure 3F) (vs. hairy in most taxa apart from *F. exaristata*, *F. arundinacea* [= *Lolium arundinaceum*]; incompletely known in *F. africana* [= *Pseudobromus silvaticus*]).

Jarava plumosa (Spreng.) S.W.L.Jacobs & J.Everett, *Te-lopea* 7(3): 301 (1997). *Calamagrostis plumosa* Spreng., *Syst. Veg.*, ed. 16 [Sprengel] 1: 253 (1824). *Arundo plumosa* (Spreng.) Schult., *Mant.* 3 (Schultes & Schultes f.) 604 (1827). *Stipa papposa* Nees, *Fl. Bras. Enum. Pl.* 2(1): 377 (1829). *Stipa papposa* Delile, *Ind. Sem.*

Hort. Monsp. 7 (1849). *Stipa delilei* Steud., *Syn. Pl. Glumac.* 1(2): 126 (1854). *Achnatherum papposum* (Nees) Barkworth, *Phytologia* 74(1): 11 (1993). Type: [URUGUAY] MONTEVIDEO. *F. Sellow s.n.* (holotype: B [not seen]; isotypes: US00141669 [image!]) ex herb. Berol., HAL0106794 [image!] ex herb. Berol.) (Figures 5, 6).

= *Stipa tenuiflora* Phil., *Linnaea* 33(3-4): 281. 1864. Type: CHILE. Prov. Colchagua: prope Llico, Dec. 1861, *L. Landbeck s.n.* (holotype: not located; isotypes: BAA00002961 [image!], SGO000000750 [image!]).

= *Stipa papposa* fo. *major* Speg., *Anales Mus. Nac. Montevideo* 100. 1901. Type: not designated.

= *Stipa papposa* fo. *minor* Speg., *Anales Mus. Nac. Montevideo* 100. 1901. Type: not designated.

Distribution: For the entire African continent, *J. plumosa* was previously known from a single population on the University of Cape Town (UCT) campus collected in 1963 and 1980 (Gibbs Russell et al. 1990; Fish et al. 2015). Our collection in the Eastern Cape extends the species range c. 950 km eastward. It is also feasible to say that the species has likely established in adjacent Lesotho, which was less than 100 m away on the opposite bank of the Telle River. *Jarava plumosa* has its native range in austral South America, covering central and eastern Argentina, Chile, Uruguay, to as far north

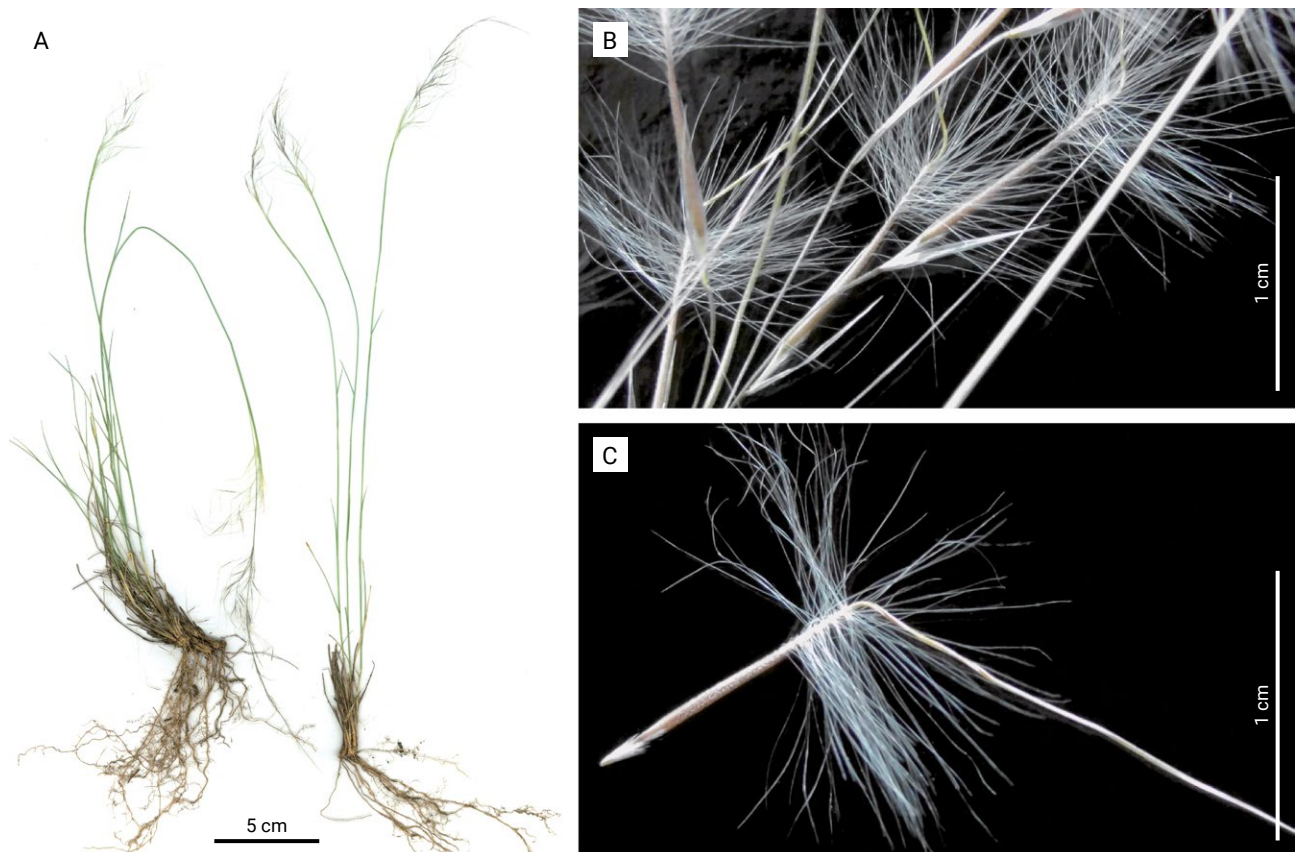


Figure 5. *Jarava plumosa*; A, whole plant; B, inflorescence close-up; C, floret. Image A of R.J. Soreng et al. ZA-30 (US), B and C of R.J. Soreng et al. ZA-30 (PRE).

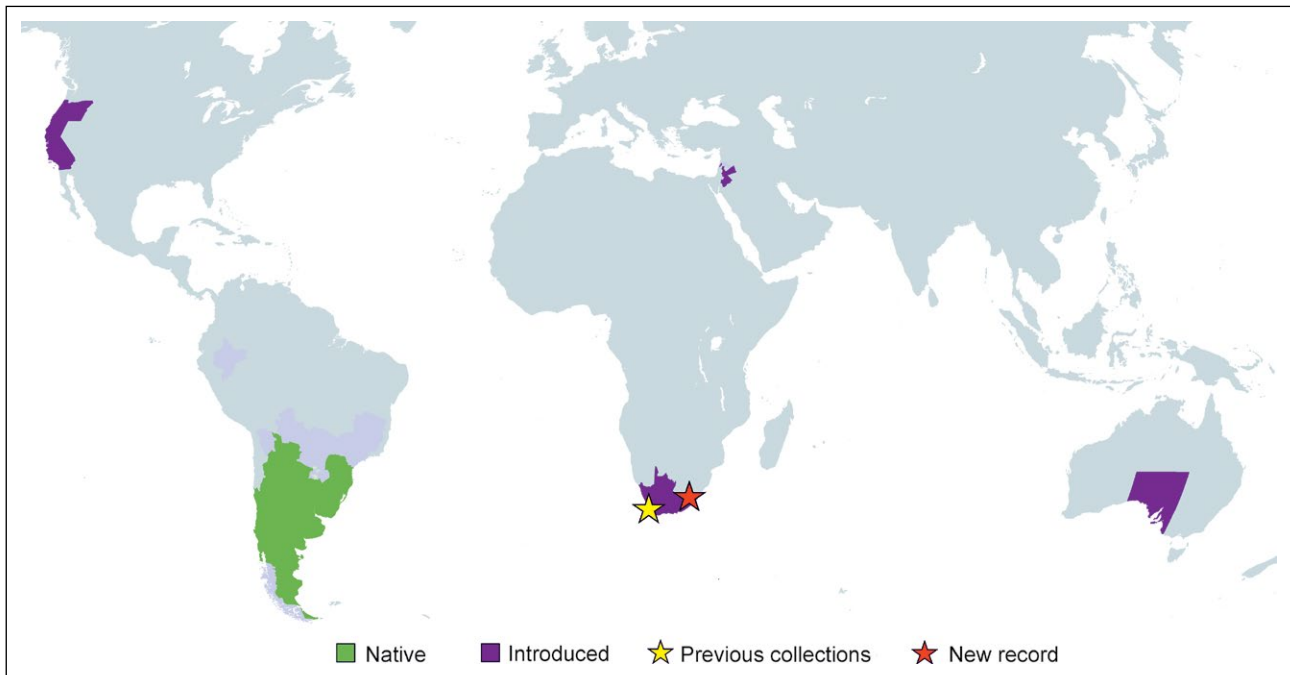


Figure 6. *Jarava plumosa* global distribution map, with country- or regional-level shading, taken and modified from POWO (2020).

as southern Brazil (Zuloaga et al. 2008; Longhi-Wagner 2015; Figure 6). The species has also been documented as becoming naturalised in Adelaide, Australia (Gardner et al. 1996; Wilson 2009), as well as California, USA (Arriaga 2007), and Palestine (Danin 2004).

New record: SOUTH AFRICA. **Eastern Cape:** by Telle river on road to Lundean's Nek, near village of Bebeza [or 'Emqheyen' in <https://earth.google.com/>], S30.518347 E27.649831, 1460 m alt., under *Eucalyptus* trees by roadside, 9 Feb. 2020, R.J. Soreng et al. ZA-30 (NU, PRE, US, QWA).

Common vernacular names: *flechilla mansa*, *flechilla* (Argentina).

Notes: Gardner et al. (1996) noted the vigorous nature of *Jarava plumosa* and how, despite efforts to remove the plant since as far back as 1968, it continued to establish at the Botanic Gardens of Adelaide and was subsequently found in the South Parklands bordering Adelaide. The first record of *J. plumosa* outside of its natural range comes from South Africa, from collections made in the UCT campus in 1963 and 1980 (Gibbs Russell et al. 1990). Our discovery of an abundant population of *J. plumosa* by the side of the Telle River, Eastern Cape, South Africa, points to the likelihood that this species has a wider distribution than previously realised, and has been overlooked. The species exhibits certain traits pointing to its potential to become invasive, such as the apical pappus highly adapted to anemochory, and long awns that easily attach to clothing, fur etc. to aid in zoochory. Closely related species in the genera *Nassella* (Trin.) É.Desv. and *Stipa* L. exhibit similar traits, and have successfully become naturalised in many parts of

the world, with a few – e.g. *Nassella neesiana* (Trin. & Rupr.) Barkworth, *N. tenuissima* (Trin.) Barkworth, *N. trichotoma* (Nees) Hack. & Arechav – that are known invasives causing ecological havoc in many parts of the world, including South Africa (Visser et al. 2017; Mapaura et al. 2020; IUCN Global Invasive Species Database, <http://www.iucngisd.org/>).

Similar species: In southern Africa, *J. plumosa* could be mistaken for *Stipagrostis anomala* De Winter, which also has a pappus-like plume of long hairs, 4–8 mm long, emerging from the apex of the lemma and/or lower part of the awn. *Jarava plumosa* can be differentiated from *S. anomala* by the pappus-like hairs being found on the apex of the lemma and base of the awn (vs. hairs restricted to just base of awn in *S. anomala*), callus being obtuse (vs. pungent), and a perennial habit (vs. annual) (Figure 5B–C).

Conclusions

Three new non-native grass species are added to the flora of the DMC and the FSA: two (*Agrostis capillaris* and *Festuca rubra*) in the alpine sub-centre, and one (*Jarava plumosa*) in the montane sub-centre. Although still apparently highly localised, the unique alpine habitat in southern Africa – with the closest ecological comparison in South Africa and FSA being the Prince Edward Islands – suggests that *F. rubra* in particular could become a species of concern, and should be monitored with the intention of eradication while still localised. Similarly, the presence of the potentially highly invasive species *J. plumosa* in the highly degraded and stressed

xeric rain-shadow region of Telle Bridge requires further population assessment to determine abundance and distribution. All three of these grasses should be looked out for across the DMC for additional undetected populations.

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