

To Hildemar Wolfgang Scholz, in memoriam

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## *Trisetum tamonanteae* (Poaceae, Aveninae), a new species from Fuerteventura, Canary Islands, Spain

### Abstract

Marrero Rodríguez A. & Scholz S.: *Trisetum tamonanteae* (Poaceae, Aveninae), a new species from Fuerteventura, Canary Islands, Spain. – Willdenowia 43: 45–57. June 2013. – Online ISSN 1868-6397; © 2013 BGBM Berlin-Dahlem.

Stable URL: <http://dx.doi.org/10.3372/wi.43.43105>

A new species of *Trisetum* Pers. (Poaceae, Aveneae), *T. tamonanteae* Marrero Rodr. & S. Scholz, from Fuerteventura, Canary Islands, Spain, is described. We discuss its affinities to related taxa, and provide information about its habitat and ecology, noting its possible ability to reproduce vegetatively by pseudoviviparism, as well as the conservation status of its populations. This is the first reference to *Trisetum* s. str. for the Canary Islands and the whole of Macaronesia.

### Resumen

Se describe una nueva especie del género *Trisetum* Pers. (Poaceae, Aveneae), *T. tamonanteae* Marrero Rodr. & S. Scholz, para Fuerteventura, Islas Canarias, España. Se comentan las relaciones taxonómicas con otras especies próximas, se hace un breve comentario sobre su hábitat y ecología señalando la posible capacidad de la especie a la reproducción vegetativa por pseudoviviparismo, y el estado de conservación de las poblaciones. Esto constituye la primera referencia de *Trisetum* s. str. para las Islas Canarias y para el conjunto de Macaronesia.

Additional key words: *Gramineae*, taxonomy, Macaronesia, habitat, ecology, pseudoviviparism

## Introduction

The genus *Trisetum* Pers. (Poaceae, Aveneae, Aveninae) currently includes 70–80 species distributed through the high mountains of temperate and cold regions of both hemispheres (Clayton & Renvoize 1986; Finot & al. 2006).

It is included in subtribe *Aveninae* s.l., which comprises 23 genera with more than 360 species (Clayton &

Renvoize 1986; Soreng & al. 2003; Finot & al. 2006). Within the subtribe, Clayton & Renvoize (op. cit.) postulate three evolutionary lineages, represented by the genera *Helictrotrichon* Besser ex Schult. & Schult. f., *Deschampsia* P. Beauv. and *Trisetum*, respectively. According to these authors, *Trisetum* is the ancestral group from which *Dielsiochloa* Pilg., *Grappheporum* Desv., *Koeleria* Pers., *Peyritschia* E. Fourn., *Rostraria* Trin., *Sphenopholis* Scribn., *Trisetaria* Forssk., *Ventenata* Koe-

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ler, and other more recently described genera such as *Leptophylochloa* C. E. Calderón ex Nicora and *Raimundochloa* A. M. Molina (Finot & al. 2006) evolved.

Soreng & al. (2003) restricted the subtribe *Aveninae* to the *Trisetum* and *Helictotrichon* lineages only, congruent with the results of the phylogenetic analyses of Catalán & al. (1997) using sequences of the cpDNA gene *ndhF*. Newly defined in this sense, the subtribe *Aveninae* appears as a monophyletic group (Soreng & Davis 2000). However, as shown by other authors (Döring & al. 2007; Soreng & al. 2007; Quintanar & al. 2007, 2010; Saarela & al. 2010), the issue is more complex: for example in the *trnT-F* (cpDNA) and ITS (DNA nuclear ribosomal) data analysis (Quintanar & al. 2007), shows little consistency between the subtribes *Aveninae* and *Koeleriinae*, where *Trisetum/Trisetaria* species are distributed in one or another group, independent of the perennial or annual character.

Some authors have considered *Trisetum* in a broad taxonomic sense, but with different criteria depending on the diagnostic characters used or on the nomenclatural interpretation. In some cases, it has been treated as *Trisetaria* s.l., including *Trisetum* and species of the genus *Rostraria* (Paunero 1950); on other occasions, it has been treated as *Trisetum* s.l., including diverse genera such as *Acrospelion* Schult., *Parvotrisetum* Chrték, *Rupestrina* Prov., *Sennenia* Sennen, *Trisetaria*, or *Trisetarium* Poir., depending on authors (Jonsell 1980; Watson & Dallwitz 1992).

However, more analytical criteria have frequently been used for taxonomic circumscription, either (1) considering new studies that provide new diagnostic characters (e.g. Koch 1979 or Finot & al. 2006, who emphasize the importance of such characters as lodicule shape, the consistence of endosperm, or the morphology of the lemmas), or (2) segregating as independent genera annual and perennial species: *Helictotrichon/Avena*, *Koeleria/Rostraria* or *Trisetum/Trisetaria* (Holub 1974; Tzevlev 1989; Valdés & Scholz 2009).

In this paper we consider the genus *Trisetum* in its strict sense, as it has been recognized by several authors (Pignatti 1982; Clayton & Renvoize 1986; Soreng & al. 2003; Finot & al. 2005a, b; Wu & Phillips 2006; Valdés & Scholz 2009). According to this treatment, *Trisetum* includes perennial, caespitose or rhizomatose species characterized by subisomorphic glumes, the lower one 1(–3)-nerved, the upper one 3(–5)-nerved; lemmas 2-lobed (bifid or with two setae) with the awn inserted in the centre or the upper third of the back; palea gaping from the lemma; bilobate lodicules, and androecium with three stamens (Clayton & Renvoize 1986).

Recent studies and reviews have been conducted for the American (Soreng & al. 2003; Finot & al. 2005 a, b) and Chinese (Wu & Phillips 2006) circumscriptions of *Trisetum*. However, the information for European, western Asian, and African species is much more sparse, and often anachronistic, thereby impeding a revision of the

whole genus. In Europe, between 17 and 22 species have been recognized (Jonsell 1980), seven of which are part of the Spanish flora (Paunero 1950; Jonsell 1980; García Rollán 1996): *T. baregense* Laffitte & Miégev., *T. distichophyllum* (Vill.) P. Beauv., *T. flavescens* (L.) P. Beauv., *T. glaciale* (Bory) Boiss., *T. hispidum* Lange, *T. spicatum* (L.) K. Rich. and *T. velutinum* Boiss. Valdes & Scholz (2009) in the Euro+Med Plantbase include 24 species, of which six species and two subspecies occur in the Iberian Peninsula, with *T. baregense* as *T. flavescens* subsp. *baregense*.

In northwestern Africa, Maire (1953) recorded only one perennial *Trisetum* species (split up into seven varieties and four forms), whereas at present only three subspecies are accepted for this area: *T. flavescens* subsp. *africanum* (H. Lindb.) Dobignard, *T. flavescens* subsp. *griseovirens* (Murb.) Dobignard, and *T. flavescens* subsp. *macratherum* (Maire & Trab.) Dobignard (Dobignard 2004; African flowering plants database 2009). The latter was considered by Romero Zarco (2002) to be synonymous with the typical subspecies; thus that author accepted only two subspecific taxa in northwestern Africa.

During our extensive fieldwork in the Jandía-mountains of Fuerteventura (Canary Islands), from the Viera y Clavijo Botanical Garden (LPA) along with other projects, we frequently collected a species of *Poaceae* that belongs to the *Trisetum/Trisetaria* group but which did not fit into any of the species known to date from that archipelago.

Following a detailed study of (1) the taxa of this group known from northwestern Africa and the Iberian Peninsula, (2) different species of more or less related genera (*Koeleria*, *Rostraria* and *Trisetaria*), (3) herbarium material available in Internet portals such as Aluka (<http://www.aluka.org>, now served through JSTOR, <http://www.jstor.org>), and (4) the available bibliography of the genus *Trisetum*, and after having compared all the taxa considered with the plants collected in Jandía, we came to the conclusion that the latter represent an undescribed new species, which we describe here. We consulted the floras or checklists of the Macaronesian archipelagos (Cope 1994; Sánchez Pinto & al. 2005; Silva & al. 2005; Acebes Ginovés & al. 2009) and confirmed that our new species constitutes the first report of the genus *Trisetum* s.str. for the flora of the Canary Islands and the whole of Macaronesia. Although Valdes & Scholz (2009) point to *Trisetum flavescens* subsp. *flavescens* as native to Terceira in the Azores, Silva & al. (2005) did not include it in their list.

## Material and methods

We used specimens collected in the wild, as well as cultivated material also derived from the wild. These specimens, which include the type material (holotype and paratypes), are deposited in the herbarium LPA (Jardín Botánico Canario Viera y Clavijo-Unidad Aso-

ciada CSIC). Isotypes and paratypes will be deposited in several other herbaria. The type material has served as a reference for the iconography. For comparison, additional material from several herbaria (LPA, MA, VAL) was studied. This includes: *Koeleria splendens* C. Presl., *Trisetaria aurea* (Ten.) Pignatti, *T. canariensis* (Parl. ex Webb & Berthel.) Pignatti, *T. dufourei* (Boiss.) E. Paunero, *T. koelerioides* (Borrm. & Hack.) Melderis, *T. loeflingiana* (L.) Paunero, *T. panicea* (Lam.) Paunero, *Trisetum baregense*, *T. distichophyllum*, *T. flavescens* subsp. *flavescens*, *T. flavescens* subsp. *africanum*, *T. flavescens* subsp. *griseovirens*, *T. glaciale*, *T. triflorum* (Bigelow) Á. Löve & D. Löve subsp. *molle* (Kunth) Á. Löve & D. Löve (= *Trisetum spicatum* (L.) K. Richt. subsp. *molle* (Kunth) Piper), and *T. velutinum* Boiss. (Appendix 1). The study was completed with online material from other herbaria (B, G, MPU, P, S, STU), which includes several types: *Helictotrichon namaquense* Schweick., *H. elongatum* (Hochst. ex A. Rich.) C. E. Hubb., *Trisetum (Helictotrichon) lachnanthum* Hochst., *T. flavescens* subsp. *flavescens*, *T. flavescens* subsp. *africanum*, *T. flavescens* subsp. *griseovirens*, *T. flavescens* var. *clausonis* Maire, *T. macratherum* and *T. longiaristum* A. Rich. (Appendix 2). The micro-morphological observations were made with an Olympus-Tokyo 259571 and a Zeiss Stemi 2000c, with compact camera Zeiss Axio-Cam ICc3. For the phytosociological nomenclature we followed that proposed for Spain and Portugal by Rivas Martínez & al. (2001, 2002), revised for Fuerteventura by Rodríguez Delgado & al. (2005b).

***Trisetum tamonanteae* Marrero Rodr. & S. Scholz, sp. nov.**

Holotypus: Spain, Islas Canarias, Fuerteventura, Pájara, Jandía, Pico de La Zarza, N, borde superior de los escarpes, UTM 28RES631085, 800 m, 11 Jun 1987, A. Marrero (LPA 24804; isotypus: B). – Fig. 1, 2.

Paratypi: Spain, Islas Canarias, Fuerteventura, Pájara, Jandía, Pico de La Zarza, N-NO, cantiles superiores, UTM 28RES631085, 780–800 m, en fisuras y poyatas del borde del escarpe, 30 Mar 1989, A. Marrero (LPA 24805, 24806); *ibid.*, Pico de La Zarza, N-NO, cornisa superior, UTM 28RES6308, 780 m, en fisuras y poyatas del borde del acantilado, Jun–Jul 1993, S. Scholz (LPA 24820); *ibid.*, entre el Pico de La Zarza y el Pico del Mocán, N-NO, UTM 28RES632086, 770 m, taliscas y poyatas de los escarpes en la escotadura, 8 Apr 2000, A. Marrero & S. Scholz (LPA 24807, 24808).

Duplicates of two of the paratypes (LPA 24805 and LPA 24807) will be deposited in other herbaria, including K and MA.

**Description** — *Plants chamaephytic*, perennial, densely tufted. *Culms* simple or more rarely branched towards base, erect, thin, (5–)15–25(–30) cm tall, with a tendency to root at basal nodes, glabrous or generally with

a few reflexed hairs beneath nodes, entirely covered by leaf sheaths; nodes glabrous or with some hairs. *Leaves* scattered over whole length of culm, 2-ranked or distichous only in juvenile culms; *leaf sheath* striate, densely pubescent-pilose, with fine hairs c. 0.5 mm long and a few cilia 0.5–1 mm long in distal portion; *ligule* white hyaline, triangular-truncate, very short, glabrous or with some hairs dorsally, margin lacerate-fimbriate; *leaf blade* narrowly linear, flat, (2.5–)3.5–10(–14) cm long, 2.8–4.5(–6) mm wide, ± rigid, velutinous-pubescent on both surfaces, with hairs 0.2–0.3 mm long, midrib somewhat prominent on dorsal surface towards proximal portion of blade and distal portion of sheath, apex subulate. *Inflorescence* very little exerted, ± congested, ovoid, sometimes lobate, 3–7(–9) cm long, with a finely silky-hairy rachilla; *spikelets* generally not longer than superior glume, 4–5.5 mm long, (2 or)3- or 4(or 5)-flowered, with upper flower normally not developed; *callus* broadly ovate-elliptic, with short hairs; *glumes* subequal, glabrous or with few hairs generally scattered dorsally, nerves scabrid, margin hyaline; inferior glume narrowly lanceolate, 3.4–4.5 mm long, 1- or 2-nerved, with scabrous edges, apex acute; superior glume oblanceolate, 4.3–5.5(–6) mm long, reaching or surpassing length of spikelet, 3-nerved, edges broadly scabrous, apex acute or ± mucronate; *lemma* oblong-ob lanceolate, (2.6–)3–3.8 mm long, glabrous or with some hairs dorsally, translucent-scabrid, apex bifid and generally without setae, slightly fimbriate, but sometimes with 2 setae 0.2–0.6 mm long, awn inserted dorsally on distal 1/3 or 1/4 portion of lemma, straight, somewhat curved, or geniculate, 1.8–4.5 mm long; *palea* linear, somewhat wider towards apex, 2.3–3 mm long, shorter than lemma, hyaline, bicarinate, with scabrid-hairy nerves, with edges folded, marginal band scabrid-hairy on external side, apex bifid; *lodicules* bilobate to bidentate, (0.3–)0.5–0.6 mm long, as long as or slightly surpassing ovary, lobes unequal; *stamens* 3, anthers linear, 0.8–1.6(–1.8) mm long; *ovary* obovoid or obpyriform, 0.3–0.5 mm long, glabrous, stigmatic branches much branched, 0.6–1.4 mm long. *Caryopsis* free, brown-yellowish, narrowly oblong-fusiform, (1.6–)1.8–2(–2.2) mm long, somewhat translucent. *Flowering* from March to June; *fruiting* from April to July.

**Distribution** — Local endemic of the upper Jandía mountains, Fuerteventura, distributed along c. 1.5 km of the ridge between Pico de la Zarza and Pico del Mocán, and in a small area around Pico del Fraile, roughly 3 km west of the first locality.

**Etymology** — We dedicate this species to Tamonante, daughter of Tibiabin. According to the chronicles, the two women were priestesses and advisors of the rulers of the pre-European people of Fuerteventura when the island was conquered on the early 15th century.



Fig. 1. Holotype of *Trisetum tamonanteae* – A. Marrero (LPA 24804).

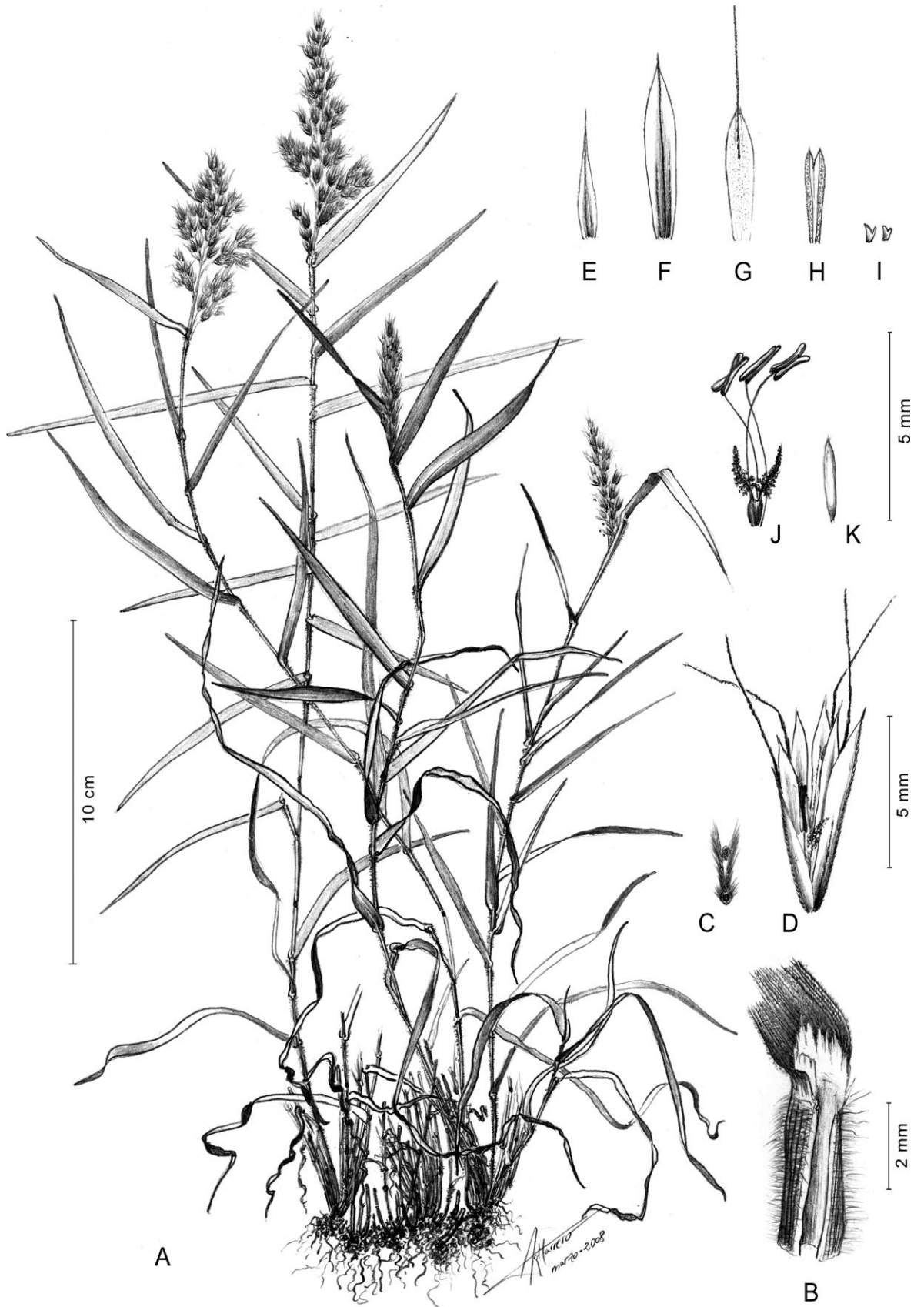


Fig. 2. *Trisetum tamonanteae* – A: habit of plant; B: part of a leaf with ligule; C: rachilla; D: spikelet; E: lower glume; F: upper glume; G: lemma; H: palea; I: lodicules; J: stamens and pistil; K: caryopsis. – Drawn by Á. Marrero, based on type material (holotype and paratypes) deposited at LPA.

## Taxonomic remarks

The most important features of *Trisetum tamonanteae* are size of the plant, short flowering culms, leaves not concentrated at the base of the culms, internodes covered by the leaf sheaths, upper culm leaves with well-developed blades generally reaching or surpassing the panicle, subexserted panicle, and small anthers (Table 1).

*Trisetum tamonanteae* differs from the European species *T. argenteum* Roem. & Schult., *T. distichophyllum*, *T. macrotrichum* Hack., and *T. velutinum* because these species present a glaucous-velutinous indumentum and both basal and culm leaves that are clearly 2-ranked. By having short culms with nodes completely covered by the leaf-sheaths, *T. tamonanteae* differs from the above mentioned species, as well as from most other European species (*T. agrostideum* Fr., *T. alpestre* P. Beauv., *T. baregense*, *T. burnoufii* Req. ex Parl., *T. flavescens*, *T. fuscum* Schult., *T. hispidum*, *T. laconicum* Boiss. & Orph., *T. macrotrichum* Hack., *T. rigidum* Roem. & Schult. *T. sibiricum* Rupr., and *T. tenuiforme* Jonsell). Moreover, the small anther size clearly differentiates *T. tamonanteae* from all the above mentioned species and from the remaining European species (*T. bertolonii* Jonsell, *T. flavescens*, *T. glaciale*, and *T. gracile* (Moris) Boiss.), with the exception of *T. agrostideum* (Laest.) Fries and *T. spicatum*, which have larger florets and also present other differentiating features.

*Trisetum tamonanteae* is also clearly distinct from the taxa occurring in northwestern Africa. These are members of the *T. flavescens*-complex, which all present their leaves more aggregated towards the base, have longer flowering culms, in which the internodes are not covered by the leaf-sheaths, and larger glumes, apart from other, individually differentiating features of each taxon.

The morphological features of *Trisetum tamonanteae* approach *T. spicatum* (L.) K. Richt. This is a very variable species, for which many subspecies, varieties, and forms have been described. However, they can be aggregated mainly in three or four subspecies: subsp. *spicatum*, which inhabits the arctic and subarctic regions of Europe; subsp. *ovatipaniculatum* Hultén ex Jonsell, from the high mountains of Central Europe and the Pyrenees; subsp. *pilosiglume* (Fernald) Hultén, found in Greenland and North America, where it reaches as far north as Alaska; and subsp. *tibeticum* (P. C. Kuo & Z. L. Wu) Dickoré, found in temperate China (Tibet). However, *T. spicatum* s.l. differs from *T. tamonanteae* by its stoloniferous habit, its villous-hairy or glabrescent indumentum, and the size of its floral bracts, especially the longer lemma, among other characters.

*Trisetum tamonanteae* grows in close vicinity to large populations of *Trisetaria canariensis* (Parl. ex Webb & Berthel.) Pignatti (= *T. panicea* (Lam.) Paunero var. *canariensis* (Parl. ex Webb & Berthel.) Maire & Weiller). This is an annual species that tends to occur in narrow rock platforms with sufficient soil, but not in cliff crev-

ices and fissures. Furthermore, its villous and glabrescent leaf indumentum (always velutinous in *T. tamonanteae*), the shape of its floral bracts, and its most graceful and geniculate habit and branched culms differentiate it from *T. tamonanteae*.

There are other annual species in the Canary Islands, such as *Trisetaria pumila* (Desf.) Maire and *T. lapalmae* H. Scholz. Both are small and very graceful, with smaller spikelets and floral bracts, and little-branched and erect culms. In addition, *T. pumila* is usually treated as *Rostraria pumila* (Desf.) Tzvelev. Other annual species cited for the Canary Islands, such as *T. panicea* (Lam.) Paunero s.l., *T. aurea* (Ten.) Pignatti and *T. dufourei* (Boiss.) Paunero, refer to different material of *T. canariensis*, whereas references to *T. loeflingiana* (L.) Paunero correspond to *T. lapalmae*. In any case all these species have other different features that distinguish them from *Trisetum tamonanteae*.

## Habitat and ecology

*Trisetum tamonanteae* grows in fissures and cracks of north-facing cliffs in the highest parts of the Jandía massif between 700 and 800 m. This massif represents the strongly eroded remains of a once much higher Miocene volcanic edifice (Coello & al. 1992; Ancochea & al. 1996; Mangas Viñuela 1997; Carracedo & al. 2005). Today, the highest peak is Pico de la Zarza, at 807 m. The inaccessible escarpment of the upper part of the northern and northwestern side of Jandía is the result of gigantic landslides that occurred in the middle or the end of the Miocene.

In the upper part of the Jandía mountains, precipitation is estimated at 200 mm per year (Marzol 1988), although no direct measurements have ever been undertaken. The bioclimate is xeric, with lower thermomediterranean xeric bioclimatic belts and lower or upper semiarid bioclimatic belts present (Rodríguez Delgado & al. 2005a). However, the highest parts are strongly influenced by the trade-wind clouds, especially during the spring and summer months, thus creating a fresh and humid microclimate, which is very different from the generally arid climate of Fuerteventura. Small patches of vegetation related to the laurel-forest vegetation of the central and western Canary Islands have long been known to be present in the most inaccessible places of this zone (Kunkel 1977; Marrero Rodríguez 1989; Rodríguez Delgado 2000; Rodríguez Delgado & al. 2005b, 2006). However, only recently has the vegetation been studied in detail, resulting in the description of several new associations (Martín Osorio & al. 2011). *Trisetum tamonanteae* is a local component of the most rocky situations of two of them: *Bupleuro handiense-Maytenetum canariensis* Martín Osorio, Wildpret de la Torre & S. Scholz and *Echio handiense-Visneetum mocanerae* Martín Osorio, Wildpret de la Torre & S. Scholz, often growing together

Table 1. Relevant morphological characters of *Trisetum tamonanteae* and related species.

	<i>T. baregense</i>	<i>T. distichophyllum</i>	<i>T. flavescens</i> subsp. <i>africanum</i>	<i>T. flavescens</i> subsp. <i>griseovirens</i>	<i>T. flavescens</i> subsp. <i>macratherrum</i>	<i>T. glaciale</i>	<i>T. hispidum</i>	<i>T. spicatum</i>	<i>T. tamonanteae</i>	<i>T. velutinum</i>
Plant habit	densely tufted	stoloniferous	densely tufted	densely tufted	densely tufted	stoloniferous	densely tufted	tufted to stoloniferous	densely tufted	stoloniferous
Plant height [cm]	1.5–4.0	20–30	20–40	20–40	20–75	5–25	2.5–8.0	10–45	1.5–3.0	30–40
Internode to leaf sheath ratio	> 1	> 1	> 1	> 1	> 1	> 1	> 1	≤ 1	≤ 1	> 1
Leaf sheath indumentum	villous	pubescent	(not recorded)	villous	villous-pubescent	velutinous-villous	velutinous-villous	velutinous-villous	villous	velutinous-villous
Leaf blade surface and indumentum	flat, villous to glabrescent	flat or convolute, puberulous	flat, pubescent	involute, ventral surface pubescent	flat, pubescent	flat, stiffly densely villous	flat, velutinous-villous	flat, pubescent	flat, velutinous	convolute, tomentose-villous
Panicle shape	exserted, narrowly oblong-lanceolate, open, very lax	exserted, ovate, lax	exserted, narrowly ovoid-cylindric, dense	exserted, narrowly oblong-lanceolate, ± dense	exserted, narrowly ovoid-cylindric, ± dense	exserted, linear or oblong, lobate, dense	exserted, linear or oblong, lobate, dense	exserted to subexserted, cylindrical-ovoid, contracted	subexserted, ovoid, ± lobate, ± dense	exserted, cylindrical, lax
Panicle length [cm]	3–7	2–4	4–6	(not recorded)	6–15(–20)	1–4	6–12	2–5	3–7(–9)	4–12
Spikelet length [mm]	4.2–5.5	(not recorded)	5–8	6.5–7	up to 7	3–5	4–6	3.9–6.6(–7.5)	4–5.5	5–8
Number of flowers per spikelet	2 or 3	2–4	2 or 3	2 or 3(or 4)	2	1 or 2	2 or 3	2 or 3	3 or 4	1 or 2(or 3)
Glumes relative size	equal or subequal	subequal	unequal or subequal	unequal or subequal	unequal or subequal	subequal	subequal	subequal	unequal or subequal	unequal or subequal
Lower glume length [mm]	2.4–3.1	(not recorded)	3–4	3.5–4	3.5–5	(not recorded)	2.7–3.5	3.7–5.5(–6.5)	3.4–4.5	3.3–5(–6)
Upper glume length [mm]	3.2–4.1	7–7.5(–8.5)	6–8	(4.5–)5.2–6.5	c 7.5	3–5	(3–)3.5–5	4.5–6(–7)	4.3–5.5(–6)	(4–)4.3–7
Lemma shape	(not recorded)	lanceolate	(not recorded)	(not recorded)	oblong-lanceolate	ovate	lanceolate-oblong	lanceolate	oblong-oblong-ecolate	ovate
Lemma length [mm]	3.5–4.5	(5.5–)6.5–8	3.5–4	(3.7–)4–6.5	5–7	(3–)3.5–4.5	3–3.8(–4)	(3.5–)4–5.3	3–3.8	5–6
Anther length [mm]	1.5–2	1.8–3	1.5–3	1.5–3	1.5–1.75	1.5–2.75	2–2.5	(0.6–)1–1.2	0.8–1.6	2–2.5

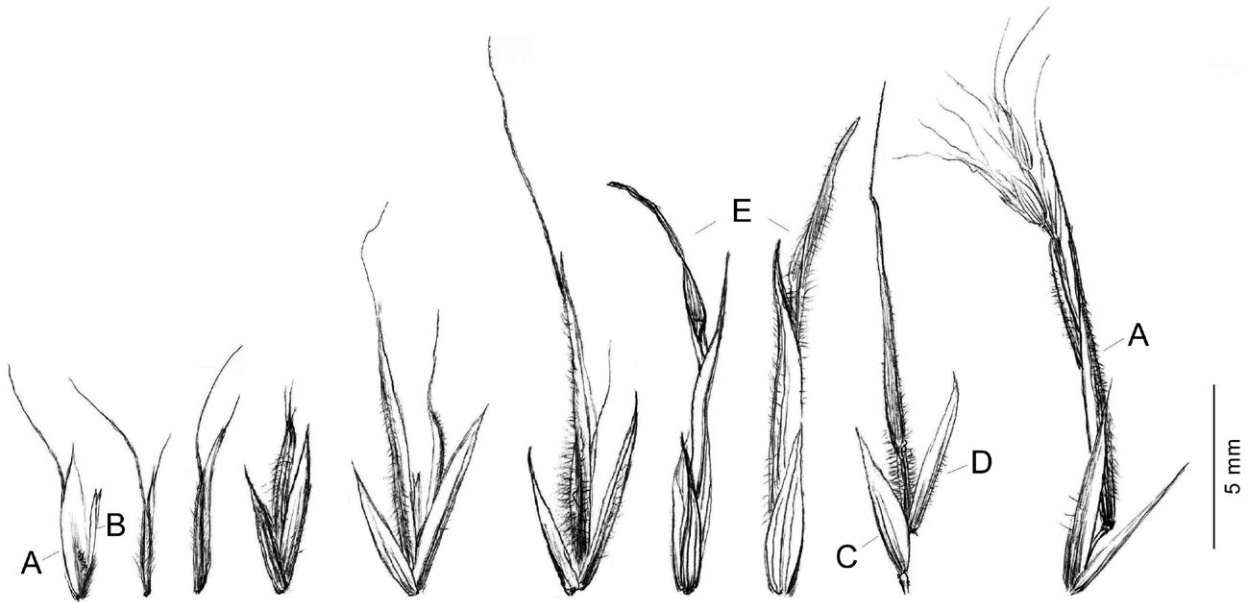


Fig. 3. *Trisetum tamonanteae* – different stages of development of possible vegetative propagules. – A: lemma; B: palea; C: lower glume; D: upper glume; E: lemmas already transformed into true leaves. – Drawn by Á. Marrero, based on various material deposited at LPA.

with the relatively recently described *Lolium saxatile* H. Scholz & S. Scholz. The importance of the upper Jandía mountains as a centre of endemism and diversity has been pointed out by several authors (e.g. Kunkel 1980; Marrero Rodríguez 1991; Bramwell & Bramwell 2001; Scholz & Scholz 2005; Martín Esquivel 2010). The finding of *T. tamonanteae* confirms this role, adding a new local endemic to others like *Argyranthemum winteri* Svent., *Carduus bourgeaui* Kazmi, *Echium handiense* Svent., and *Ononis christii* Bolle (Rodríguez Delgado & al. 2005b) and emphasizing the need for more effective protection for these highly endangered species.

The transformation of floral bracts into true leaves has been observed in *Trisetum tamonanteae* following the guidelines spelled out by Pierce & al. (2003) for the formation of propagules by pseudoviviparism (Fig. 3, 4). This has been noted especially in the distal spikelets of inflorescences, and this becomes more marked, affecting the whole of the inflorescence, when the plants bloom in especially humid climatic conditions. These situations are common in the habitat where the species grows, as a result of the already mentioned trade-wind clouds, which provide a very wet, windy microenvironment in a rocky area of poor soil.

In the *Poaceae* pseudoviviparism has been recorded for at least 41 species in 13 genera (Pierce & al. 2003). It has been described for genera such as *Dactylis* L., *Deschampsia* P. Beauv., *Digitaria* Haller, *Festuca* L., *Poa* L., and *Polypogon* Desf., among others (Vega & Rúgolo de Agrasar 2006). The pseudoviviparism mechanism is generally associated with boreal or alpine species exposed to strong stress in nutrient-poor habitats (Elmqvist & Cox 1996; Pierce & al. 2003). The possible tendency to vegetative propagation by pseudoviviparism in *T. tamonanteae*



Fig. 4. *Trisetum tamonanteae* – panicle with a proliferated spikelet (‘‘plantlet’’), as a possible pseudoviviparous mechanism. – Paratype: A. Marrero (LPA 24805).



*teae*, if it is confirmed as an alternative to sexual reproduction, would be remarkable and somewhat surprising.

### Conservation status

The whole known distribution area of the species is included within the Jandía Natural Park (Law 3/1998). We observed only one population of the new species, situated in the high cliffs between Pico de la Zarza and Pico del Mocán. Most individuals concentrate in the north-facing cliffs of the first peak. Some scattered individuals were found in the Pico del Fraile area, roughly 3 km west of the first locality. According to IUCN-criteria (IUCN 2001), the new species has to be considered Critically Endangered (CR) according to criteria B2ab(iii); D. It has only very few population nuclei in an extent of occurrence of around 3 km<sup>2</sup> and an area of occupancy of 2 km<sup>2</sup>, which is actually much smaller, only about 2 ha. The rugged terrain in which the species occurs makes it difficult to estimate accurately the number of mature individuals, which may be only a few hundred. The main threat to the species is grazing by herbivorous animals. As in most parts of Fuerteventura, this whole area has been used since ancient times as pasture land, and free-roaming goats and sheep are still abundant despite Jandía being protected as a natural park. These animals, as well as introduced rabbits, prevent the potential vegetation from extending to more accessible places. However, results of a few fencing trials on the southern slopes of Pico de la Zarza have shown promising vegetation recovery.

### Acknowledgements

We thank the curators of the herbaria MA (Real Jardín Botánico de Madrid) and VAL (Jardín Botánico de la Universidad de Valencia), Dr Mauricio Velayos and Dr Jesús Riera, respectively, for their collaboration. We also want to express our thanks for online data of several taxa available through Internet portals such as Aluka (<http://www.aluka.org>, now served through JSTOR, <http://www.jstor.org>); API (African Plants initiative), a project of the Andrew W. Mellon Foundation); and the herbaria of the Botanischer Garten und Botanisches Museum Berlin-Dahlem, Freie Universität Berlin (B), Conservatoire et Jardin botaniques de la Ville de Genève (G), Université Montpellier II (MPU), Muséum National d'Histoire Naturelle, Paris (P), Swedish Museum of Natural History, Stockholm (S), and Staatliches Museum für Naturkunde, Stuttgart (STU). For critical reviews of earlier drafts of this paper we also thank Dr Juli Caujapé Castells (JB-CVC-CSIC), Dr Robert Soreng (National Museum of Natural History, Washington, DC, i.e. US), and another anonymous reviewer. Finally we thank Nicholas Turland (B) for his constructive and critical comments that have greatly improved this paper.

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## Appendix 1 – Additional herbarium material examined.

- Koeleria splendens* C. Presl. — SPAIN: Castellón, Ares del Maestrat (40°26'N, 00°08'W), 820 m, *S. Castroviejo & al. 15016* (MA 628910).
- Trisetaria aurea* (Ten.) Pignatti. — GREECE: Péloponnèse, Argolide, Epidaurus, à proximité du parking pour autocars, Mai 1996, *G. van Buggenhout* (MA 628174). — ITALY: SICILY: Auf Sandboden bei Messina, Apr 1906, *G. Zodda* (MA 292742). — SPAIN: BALEARIC ISLANDS: Mallorca, Son Serra, 12 Apr 1977, *J. Duvigneaud 77 E 133* (MA 357473).
- Trisetaria canariensis* (Parl. ex Webb & Berthel.) Pignatti. — SPAIN: CANARY ISLANDS: LA GOMERA: Vallehermoso, Alojera, laderas por debajo de los riscos de Tejeleche, UTM 28RBS7016, 200–250 m, 5 May 2001, *A. Marrero* (LPA 24791); GRAN CANARIA: Tejeda, Mesa del Junquillo, base del risco sobre la presa del Parralillo, UTM 28RDR309960, 640 m, 13 Mar 2002, *A. Marrero* (LPA 24792, 24793); La Aldea de San Nicolás, Macizo de Gugüi, Amurgar hacia Peñón Bermejo, UTM 28RDR1894, 670 m, 12 Apr 2002, *A. Marrero* (LPA 24794); La Aldea de San Nicolás, Macizo de Gugüi, degollada de Vallehermoso, UTM 28RDR1994, 600 m, 3 May 2002, *A. Marrero* (LPA 24795); Valleseco, Lomo de Carpinteras, UTM 28RDS426040, 940 m, 2 May 2004, *A. Marrero* (LPA 24796, 24797); Pinos de Garda, 13 May 1954, *M. Jordán de Urries* (MA 171417). — FUERTEVENTURA: Pájara, Jandía, degollada de Cofete, UTM 28RES6007, 350 m, 1 May 1999, *S. Scholz* (LPA 24775); Pájara, Jandía, Pico del Fraile, UTM 28RES5907, 550 m, 1 May 1999, *S. Scholz* (LPA 24776); Pájara, Jandía, Pico de La Zarza, en laderas próximas al S-SE, UTM 28RES635083, 650–700 m, 8 Apr 2000, *A. Marrero & S. Scholz* (LPA 24777, 24778, 24779); Pájara, Jandía, barranco de Esquinzo, UTM 28RES6508, 350 m, Jan 2006, *S. Scholz* (ex horto El Esquinzo) (LPA 24800, 24801). — LANZAROTE: Haría, Valle de Malpaso, barranco del Elvira Sánchez, UTM 28RFT440235, 450 m, 18 May 1991, *A. Marrero & A. Carrasco* (LPA 24771, 24772); Teguisse, Tao, Lomo Camacho, UTM 28RFT3312, 300 m, 30 Mar 1989, *V. Montelongo* (LPA 24773); Haría, Famara, parte alta, 26 Mar 1989, *A. Marrero & V. Montelongo* (LPA 24774).
- Trisetaria dufourei* (Boiss.) Paunero. — PORTUGAL: Baixo Alentejo, entre Ferreira y Beringel, 24 Apr 1968, *E. Paunero 6087* (MA 187983). — SPAIN: Huelva, Mazagón, 2 May 1996, *J. Devesa & T. Ruiz 13/96* (MA 629020); Cádiz, Chiclana, Pinar del Hierro, 27 Apr 1983, *M. Ladero & C. Valle* (MA 454698); Huelva, Almonte, Reserva Biológica de Doñana, Sabinar de Ojillo, UTM 29SQA29, *S. Castroviejo & E. Valdés-Barmejo 3979 EV* (MA 292712).
- Trisetaria koelerioides* (Borrm. & Hack.) Melderis. — ISRAEL: Sharon Plain, Herzlia, 1 May 1928, *N. Feinbrun* (MA 292771).
- Trisetaria loeflingiana* (L.) Paunero. — SPAIN: Soria, Puerto de el Madero, 1100 m, 29 May 1977, *A. Segura Zubizarreta 15222* (VAL 103450, VAB 973056); Teruel, Tortajada, UTM 30TXK6372, 960 m, 12 Jun 1988, *G. Mateo 350* (VAL 58930, VAB 882041). — TURKMENISTAN: Turcomania (SSR Turkmenia) occidentalis, prope stationem Dzhebel, prope lacum Molla-Kara, 20 Apr 1979, *N. Belianina & T. Sofeikova* (VAL 117824).
- Trisetaria panicea* (Lam.) Paunero. — SPAIN: Córdoba, Pozoblanco, 13 May 1980, *E. Galiano & A. Ramos* (VAL 117825); Valencia, Sierra de Corbera, May 1945, *J. Borja 208* (VAL 117823); Valencia, Barig, campos arenosos por el Pla de Suros, 250 m, Jun 1975, *G. Mateo* (VAL 114028, VAB 75374); Alicante, Xàbia, Marina Alta, Jovades, UTM 31SBC5395, 40 m, 24 May 1997, *J. Segarra Moragues* (VAL 106655, VAB 82311).
- Trisetum baregense* Laffitte & Miégev. — FRANCE: Hautes-Pyrénées, im “Cirque de Gavarnie” auf grasigen Plätzen, c. 1600 m, Jul 1902, *A. Bordère* (MA 292753); Basses-Pyrénées, Eaux-Bonnes, rochers du col de Tortes, 1600 m, 8 Aug 1899, *H. Coste* (MA 7981).
- Trisetum distichophyllum* (Vill.) P. Beauv. — AUSTRIA: Tyrol, Alpes de Stubai, Vallée de Gschnitz, près du sentier de Gschnitz au Innsbrucker Hütte, au sud de Kalkwand, 2000 m, 19 Aug 1985, *D. Podlech 42147* (MA 366781, VAL 11898). — FRANCE: Basses-Alpes, Aurent, près d’Annot, dans les montagnes, 7 Jul 1887, *E. Reverchon & A. Dervez* (MA 8001). — GERMANY: Oberbayern, Berchtesgadener Alpen, Wimbachtal, bei der Kirche, 1400 m, 9 Aug 1963, *W. Lipper* (MA 183047). — ITALY: Bolzano, Tyrol meridional, Grödnertal (= Val Gardena), dolomites, Dantercepies, hauteur de Wolkenstein (= Selva di Val Gardena), 2150 m, 17 Aug 1986, *G. van Buggenhout* (VAL 016595).
- Trisetum flavescens* (L.) P. Beauv. — SPAIN: Teruel, Puerto Mingalvo, Mas de Gasque, UTM 30TYK1561, 1450 m, 18 Jul 1986, *A. Aguilera 545-AAP & X. García Flor* (VAL 14741).
- Trisetum flavescens* subsp. *africanum* (H. Lindb.) Dobignard. — MOROCCO: Alto Atlas: Jbel Siroua, cerca de Amassine, entre Anzal (Anezal) y Askaoun (30°46'37"N, 7°38'20"W), 2600 m, 30 Jun 1997, *J. Güemes & al. JGH-1440* (MA 561081, VAL 41023); Col Tizi-Melloul (30°46'48"N, 7°36'41"W), 2425 m, 27 Jun 1997, *C. Aedo & al. CA 4381* (MA 593200 pro parte, VAL 41438 pro parte).
- Trisetum flavescens* (L.) P. Beauv. subsp. *flavescens*. — MOROCCO: 72 km S from Marrakech, Oukaïmeden (31°13'N, 07°52'W), 2700 m, 3 Jul 1987, *S. L. Jury & al. 8876* (MA 391863).

*Trisetum flavescens* subsp. *griseovirens* (Murb.) Dobignard. — MOROCCO: Alto Atlas, desfiladero entre Amesker y Amejgag, pr. Amesker, al N de El Kelâades-Mgouna (31°29'N, 6°14'W), 1880 m, 4 Jul 1997, F. Muñoz Garmendia & al. 5387MG (MA 595045); Col Tizi-Melloul (30°46'48"N, 07°36'41"W), 2425 m, 27 Jun 1997, C. Aedo & al. CA 4381 (MA 593200 pro parte, VAL 41438 pro parte).

*Trisetum glaciale* (Bory) Boiss. — SPAIN: Granada, pico Veleta, 3350 m, 12 Jul 1986, C. Aedo (MA 609494).

*Trisetum spicatum* subsp. *molle* (Kunth) Piper. — GREENLAND: the head of Kangerdluarssuk (60°52'N, 45°52'W), 5 m, 14 Jul 1975, J. Feilberg (MA 446948).

*Trisetum velutinum* Boiss. — SPAIN: Málaga, Sierra de la Tejada, subida por Canillas del Aceituno, 1170 m, 19 Aug 1977, G. López (MA 208666); Málaga, Sierra Tejada, subida por Canillas del Aceituno, 15 Jul 1981, C. Romero Zarco (MA 357463); Granada, Sierra Nevada (hoya la Mora), 28 Jul 1967, A. Segura Zubizarreta 10644 (MA 357440); Alicante, Vall de Gallinera, S de la Safor, UTM 30SYJ3904, 900 m, M. Signes & J. X. Soler 7265-JXS (MA 590372); Valencia, Barig, 400 m, Jun 1980, S. Manzanet [?] & G. Mateo (VAL 114030, VAB 80813).

*Trisetum* cf. *velutinum* Boiss. — SPAIN: Granada, Monachil, Sierra Nevada, Dornajo, UTM 30SVG6108, 2050 m, 30 Sep 1975, J. Fernández Ca-

sas 963B (MA 346038); Sierra Nevada, Trevenque, Canal de Huenes, UTM 30SVG50, 20 Jul 1974, A. Charpin & J. Fernández Casas (MA 227043).

## Appendix 2 – Specimens examined via Internet portals.

*Helictotrichon namaquense* Schweick. SOUTH AFRICA: [illegible] bei Ezelsfontein, 4000–4800', 8 Nov 1830, J. Drège 2526 (P 00434805 syntype of *Trisetum barbatum* var. *minus* Nees).

*Trisetum flavescens* subsp. *africanum* (H. Lindb.) Dobignard. — ALGERIA: Kob-roumier, 30 May 1855, T. Clauson (MPU 009618, P00083440 holotype of *T. flavescens* var. *clausonis* Maire); Kob-roumier, 30 May 1855, T. Clauson 1346 (MPU 003030). — MOROCCO: Atlas medium, Ras-el-Ma prope pag. Azrou, 1600 m, 24 Jun 1926, H. Lindberg 4270 (MPU 009618).

*Trisetum flavescens* (L.) P. Beauv. subsp. *flavescens*. — ALGERIA: Ben-Chicao, Mai 1885, L. Trabut (MPU 001454); Teniet-el-Had, L. Trabut (MPU 001455); Djurdjura, Tizi-Djaboub, 22 Jun 1885, L. Trabut (MPU 001456).

*Trisetum flavescens* subsp. *griseovirens* (H. Lindb.) Dobignard. — MOROCCO: Reraya, 1900 m, 23 Jul 1923, R. de Letardière (MPU 001458).