

EHRHARTA LONGIFLORA SM. AND *PENNISETUM SETACEUM*
(FORSK.) CHIOV., TWO NEW ALIEN GRASSES
FOR MADEIRA ISLAND (PORTUGAL)

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ABSTRACT

The number of introduced, and possible introduced, taxa in the Madeira and Selvagens islands currently accounts for nearly 36% of the total flora of these archipelagos, including 53 Poaceae taxa (out of 141 Poaceae taxa), therefore constituting the family with the higher proportion of introduced taxa (38.4%). The genus *Ehrharta* Thunb. comprises about 35 species, with one species, *E. longiflora* Sm., recorded as introduced in Gran Canaria. The genus *Pennisetum* Rich. includes ca. 80 species of which a total of nine species are present in Macaronesia, with three: *P. clandestinum* Hochst. & Chiov., *P. purpureum* Schum. and *P. villosum* R. Br. ex Fresen, occurring in the Madeira archipelago. *Ehrharta longiflora* Sm. and *Pennisetum setaceum* (Forssk.) Chiov., are here recorded for the first time for the Madeira island, found in disturbed areas at low and medium altitudes. The finding of several mature and flowering/fructifying individuals of both species suggests a fully naturalized status. Naturalization, invasiveness and ecological impacts are discussed.

KEYWORDS: alien, *Ehrharta longiflora*, grasses, Madeira, *Pennisetum setaceum*.

EHRHARTA LONGIFLORA SM. Y *PENNISETUM SETACEUM* (FORSK.) CHIOV.,
DOS NUEVAS GRAMÍNEAS EXÓTICAS PARA LA ISLA DE MADEIRA (PORTUGAL)

RESUMEN

El número de taxones introducidos y posiblemente introducidos en los archipiélagos de Madeira y Salvajes supone aproximadamente un 36% de su flora total, incluyendo 53 taxa de poáceas (sobre un total de 141 taxa de poáceas), constituyendo, de esta manera, la familia botánica con mayor número de taxa introducidos (38,4%). El género *Ehrharta* Thunb. comprende unas 35 especies, con una especie, *E. longiflora* Sm., registrada como introducida en Gran Canaria. El género *Pennisetum* Rich. incluye cerca de 80 especies, de las cuales un total de nueve especies están presentes en Macaronesia, de las que tres (*P. clandestinum* Hochst. & Chiov., *P. purpureum* Schum. y *P. villosum* R. Br. ex Fresen), se encuentran en el archipiélago de Madeira. *Ehrharta longiflora* Sm. y *Pennisetum setaceum* (Forssk.) Chiov. se citan en este trabajo por primera vez para la isla de Madeira, donde han sido encontradas en áreas perturbadas a bajas y medias altitudes. El hallazgo de varios individuos maduros en estado de flor/fruto de ambas especies sugiere que están totalmente naturalizadas. El trabajo discute la naturalización, la capacidad invasora y los impactos ecológicos generados por las mismas.

PALABRAS CLAVE: especies exóticas, *Ehrharta longiflora*, gramíneas, Madeira, *Pennisetum setaceum*.

DOI: <https://doi.org/10.25145/j.SI.2020.03.08>

REVISTA SCIENTIA INSULARUM, 3; diciembre 2020, pp. 133-144; ISSN: e-2659-6644



1. INTRODUCTION

The archipelagos of Madeira and Selvagens include 1204 taxa of vascular plants, including 401 introduced taxa and 29 as possible introduced (Jardim and Menezes de Sequeira 2008). In what concerns the grass family, more than one third correspond to alien taxa, i.e. 54 out of 141 (Jardim and Menezes de Sequeira 2008), corresponding to almost 12% of the total number of introduced vascular plant taxa.

Pennisetum Rich. is a cosmopolitan tropical genus that includes about 80 species native from Africa (Fish *et al.* 2015). A total of 9 species of this genus are already reported in the Macaronesian archipelagos, 7 of them as aliens: *Pennisetum atrichum* Stapf ex Hubb. (Cabo Verde), *Pennisetum clandestinum* Hochst. ex Chiov. and *Pennisetum villosum* R. Br. ex Fresen. (Azores, Madeira archipelago and Canary Islands), *Pennisetum purpureum* Schumach. (Canary Islands and Madeira), *Pennisetum setaceum* (Forssk.) Chiov., *Pennisetum thunbergii* Kunth and *Pennisetum glaucum* (L.) R. Br. (Canary Islands) (Sánchez-Pinto *et al.* 2005; Jardim and Menezes de Sequeira 2008; Acebes Ginóves *et al.* 2009; Silva *et al.* 2010; Verloove 2013). There is also a reference to *Pennisetum macrourum* Trin. for the Canary Islands as cultivated and occurring spontaneous in one locality in Las Palmas (Reyes-Betancort *et al.* 1999).

The segregation of the genera *Pennisetum* and *Cenchrus* L. has always been controversial. Diagnostic morphological characters being the degree of fusion of bristles and their characteristics, and the presence of pedicellate spikelets, however none of these characters can fully differentiate them (Chemisquy *et al.* 2010). Although some authors still consider *Pennisetum* and *Cenchrus* as two separate genera (Fish *et al.* 2015), recent molecular studies suggest otherwise (Donadío *et al.* 2009). Chemisquy *et al.* (2010), also based on molecular data, propose the inclusion of both *Odontelytrum* Hack. and *Pennisetum* in the genus *Cenchrus*.

Pennisetum clandestinum, was included in a separate genus –*Kikuyuochloa* H. Scholz (Scholz, 2006), but included in *Cenchrus* by other authors (Verloove 2012; Veldkamp 2014). The taxonomic and nomenclatural criteria adopted here follow Jardim and Menezes de Sequeira (2008). *Pennisetum setaceum* native distribution ranges from North Africa to the Middle East (Fish *et al.* 2015). In Europe, it is

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present as alien species in the south of the Iberian Peninsula, Canary archipelago and Sicily (Valdés and Scholz 2009). In Portugal, *P. setaceum* is naturalized in Alto Alentejo (Bejarano *et al.* 2011), Algarve (Marchante *et al.* 2014), and Extremadura (Gullón 2017).

Pennisetum setaceum was introduced as ornamental plant in the Canary Islands in the 40's (Saavedra and Alcántara 2017) and found naturalized in different locations in the north of Tenerife in 1969 (Hansen 1970). It is currently present in all the islands of the archipelago, prevailing below 500 m a.s.l., affecting the coastal xerophytic scrub and the endemic communities dominated by *Euphorbia canariensis* L. and *E. balsamifera* Aiton (González-Rodríguez *et al.* 2010). *P. setaceum* also outcompetes native grasses (e.g. *Hyparrhenia hirta* (L.) Stapf, *Aristida adscensionis* (L.), and affects the native rupicolous flora (Elorza *et al.* 2004; González-Rodríguez *et al.* 2010; Anonymous 2014).

Due to its fast growth and high capacity to adapt to different habitat conditions (Elorza *et al.* 2004), *P. setaceum* was recently included on the List of Invasive Species of Union Concern (EU 2017). Previously, this species was also included in the Spanish Catalogue of Invasive Alien Species, what entails in the “prohibition generic possession, transport, trafficking and trade of live or dead specimens, their remains or propagules, including foreign trade” (Anonymous 2014). Despite the conservation concerns, *P. setaceum* continues to be cultivated in many regions as ornamental plant (Gullón *et al.* 2017).

The genus *Ehrharta* Thunb. includes about 35 species, naturally distributed from South Africa to Ethiopia and Yemen (Fish *et al.* 2015). Four species of this genus: *E. calycina* Sm., *E. delicatula* Stapf, *E. erecta* Lam. and *E. longiflora* Sm., are present in Europe and North Africa (Morocco and Tunisia) as alien species (Valdés and Scholz 2009). *E. longiflora* was reported for Gran Canaria as naturalized for the first time by Kunkel (1978), as probably escape from cultivation, in a medium altitude (650 m a.s.l.), moist and shady habitat. In fact, *E. longiflora* is a palatable species for cattle, known to have a high leaf production (Fish *et al.* 2015).

Here we present the first record of *E. longiflora* and *P. setaceum* for the archipelago of Madeira. Naturalization, invasiveness and ecological impacts of both species are also discussed.

2. MATERIAL AND METHODS

Collected specimens were stored in the herbarium of the University of Madeira and identified using descriptions and keys published by Kellogg (2015) and Fish *et al.* (2015). During fieldwork, 2018 and 2019, collection sites were briefly characterized including: the approximate number of individuals of both species, the dominant plant taxa, exposure, slope and altitude (Table 1). The distribution map (Figure 1) was produced using ArcGis online version E204CW. The two species occurred in disturbed areas highly exposed to the sun. Fully developed flowering and fructifying individuals of both species were found (Figures 2, 3, 4 and 5).





Figure 1. Distribution map of *Ehrharta longiflora* and *Pennisetum setaceum*.

| TABLE 1. DATA ON <i>EHRHARTA LONGIFLORA</i> AND <i>PENNISETUM SETACEUM</i> MADEIRA POPULATIONS | | | |
|--|---|---|---|
| | <i>EHRHARTA LONGIFLORA</i> | | <i>PENNISETUM SETACEUM</i> |
| Localities | Ponta do Pargo | Santa Cruz | São Martinho |
| Date of field work | May/June 2018 | August 2018/March 2019 | March 2019 |
| Number of individuals | <20 | >1000 | 1 |
| Dominant plant taxa | <i>P. clandestinum</i> with some individuals of <i>E. longiflora</i> | <i>P. setaceum</i> (in most of the cases) and shared with <i>P. clandestinum</i> , <i>Ageratina adenofora</i> and <i>Cardiospermum grandiflorum</i> | <i>Cenchrus ciliaris</i> , <i>Nicotiana glauca</i> , <i>Sinapidendron agustifolium</i> , <i>Parietaria</i> sp. and <i>Rumex</i> sp. |
| Altitude/ altitude range | 568 m | 50 to 200 m | 15 m |
| Slope | 30° | Between 0° and 90° | 90° |
| Exposure | N | S and O | S |
| Description | Ruderal disturbed area along a roadside, next to agricultural land. High exposition to the sun, but with some humidity. | Ruderal disturbed area near a brook. Roads, houses and gardens nearby. High exposition to the sun. | Rocky cliff near the ocean, next to a pedestrian path. No gardens nearby. |
| Collector Number/UMad | JF150 | LC181 | - |

3. RESULTS

3.1. *PENNISETUM SETACEUM* (FORSK.) CHIOV

Two populations of *Pennisetum setaceum* are here reported: one in St. Cruz (NE of Funchal) and another in Funchal, both at low altitude (Figure 1). Individuals of *Pennisetum setaceum* found in St. Cruz formed dense tufts, mostly on terrains near





Figure 2. *Pennisetum setaceum* individuals forming dense tufts on a terrain (St. Cruz).



Figure 3. *Pennisetum setaceum*, individuals in a basaltic walls (St. Cruz).

a road (Figure 2), but also in cliffs and basaltic walls (Figure 3) including on a margin of a small brook, corresponding to highly hemerobic areas close to roads, houses and gardens. *P. setaceum* was the dominant plant, although this dominance was shared, in some cases, with other alien plants such as *Pennisetum clandestinum*, *Ageratina adenophora* (Spreng.) R.M. King & H. Rob. and *Cardiospermum grandiflorum* Sw. *Cosentinia vellea* (Aiton) Tod. (Table 1), a rare native fern in Madeira island, was found in chasmophytic invaded habitats.



One individual of *Pennisetum setaceum* was found on a cliff near the ocean in Funchal (São Martinho), next to a pedestrian path and with no gardens nearby, on a community dominated by *Cenchrus ciliaris* L., *Nicotiana glauca* R.C. Graham and *Sinapidendron angustifolium* (DC.) Lowe (table 1). After the first visit, the specimen was eventually removed, and no other individuals were found in the surrounding area.

PORTUGAL, MADEIRA, Santa Cruz; near “Rua da Ribeira” street; on a terrain near houses and gardens; 32°41’23.07”N; 16°47’44.39”W; alt. ca. 50 m a.s.l., 06-VII-2018, Laura Cabral, LC181, UMad s/n;

Based on Cope (1994), Veldkamp (2014) and Clayton (1980), we suggest a new key for the identification of *Pennisetum* species presents on Madeira archipelago.

Pennisetum Rich. key to the Madeira archipelago species:

- 1- Culms mat-forming, inflorescence reduced to a cluster of 2-4 subsessile spikelets enclosed in the uppermost sheath, with long protruding filaments and stigmas, involucre bristles soft..... *P. clandestinum*
- 1'- Culms erect to geniculate at base, inflorescence exerted, with many spikelets, involucre bristles stiff or softly villous..... 2
- 2- Dwarf plant up to 20(-40) cm, with a broadly cylindrical to sub-globose inflorescence, spikelets 7-14 mm, bristles softly villous..... *P. villosum*
- 2'- Plants generally larger, with a narrowly cylindrical inflorescence, spikelets 4.5-7 mm, bristles stiff..... 3
- 3- Plant up to 6 m (reed like), leaf blades flat 16-150 × 0.4-4 cm with spinulose margins, peduncle pilose below the inflorescence, involucre with one bristle distinctly longer than the others..... *P. purpureum*
- 3'- Plants up to 2 m, leaf blades involute 30-100 × 0.1-0.37 mm, with scaberulous margins, peduncle glabrous below the inflorescence, involucre with a few bristles distinctly longer than the others..... *P. setaceum*

3.2. *EHRHARTA LONGIFLORA* SM.

One population of *E. longiflora* was found in Calheta (Ponta do Pargo) (figure 1) along a roadside close to agriculture fields occupying, so far, a very restricted area, dominated by *P. clandestinum* (table 1). This population included several mature individuals (figures 4 and 5) suggesting a fully, although localized, naturalization. In June, one month after the first visit, plants were subject to mowing, therefore no photographs of the naturalization site were taken.

PORTUGAL, MADEIRA, Calheta: Ponta do Pargo; along a roadside of “Estrada Regional 101”, next to agricultural land; 32°48’6.04”N; 17°14’27.47”W; alt. ca. 568 m a.s.l., 12-V-2018, João Ferreira, JF150, UMad s/n.



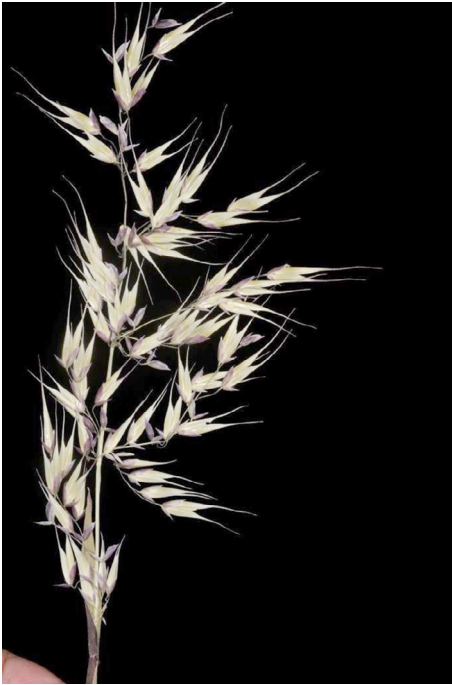


Figure 4. *Ehrharta longiflora*, panicle.



Figure 5. *Ehrharta longiflora*, detail of panicle.

4. DISCUSSION

Pennisetum setaceum was probably introduced in Madeira island as ornamental plant, considering that this species is used in many parts of the world for this purpose and is often found in nurseries (Salinas *et al.* 2011; Saavedra *et al.* 2014; GIDS 2015; Gullón *et al.* 2017). *P. setaceum* is a perennial C4 plant and, consequently, can withstand dryness and high temperatures, being widely used as garden plant (Rahlao *et al.* 2010). Sometimes, it is also used for the stabilization of soil and cliffs (Salinas *et al.* 2011). These characteristics, along with ecological adaptability, rapid growth and high seed production (100 seeds per plant), make it a species with high invasive potential (EPPO 2012).

So far *Pennisetum setaceum* has a relatively small area of distribution on Madeira island, but according to Dana *et al.* (2005) fruits are easily dispersed, by water, animals, people and even cars, being therefore highly probable that this alien grass will spread quickly to other areas. Salinas *et al.* (2011) also refer that fruits are easily dispersed and to the fact that fruits remain viable in the soil for 6 years or more, being also capable of sprouting from root fragments.



Pennisetum setaceum prevails on arid and semi-arid open areas (Reyes-Betancort *et al.* 1999; GISD 2015), and, therefore, Madeiran Mediterranean secondary grass communities (e.g. *Dactylo hylodes-Hyparrhenietum sinaicae*, *Cenchrus ciliaris-Hyparrhenietum sinaicae* and *Bromo-Oryzopsis miliacei*, as defined by Capelo *et al.* 2004) could be invaded by this grass. If this invasion occurs, it will possibly block successional processes, therefore affecting endemic communities such as *Euphorbietum piscatorie*. *P. setaceum* will also potentially affect chasmophytic plant communities (e.g. *Sedo nudi-Aeonietum glutinosi*).

Salinas *et al.* (2011) describe the elimination by competition, of native and endemic species, but also changes in soil carbon sequestration, that further affect succession. In the Canary Islands *P. setaceum* can reach altitudes above 1000 m a.s.l. (Reyes-Betancort *et al.* 1999; Salinas *et al.* 2011), but it seems to be limited to areas with an average annual rainfall of less than 1270 mm/m² (GISD 2015), not tolerating freezing temperatures (Devender 1997). These data suggest that the south coast and the east side of the island of Madeira are likely to be invaded and that most of the north coast and the mountain areas are less likely to be affected.

Due to the large amount of biomass accumulated, *P. setaceum* potentiates the risk of fires, which further increases its expansion (Salinas *et al.* 2011).

Ehrharta longiflora was probably introduced for cattle feeding (see Fish *et al.* 2015), since it was found naturalized near agricultural fields. The dispersion of *E. longiflora* mainly occurs locally and is wind mediated, but fruits may also be dispersed by animals (Frey 2005). This species is already recorded as naturalized in several countries of North Africa and Europe, including Spain (Valdés and Scholz 2009) and being reported as invasive in Australia, New Zealand and California (Frey 2005).

Ehrharta longiflora typically occurs in wet shady places (near rocks and shrubs), often near disturbed areas (e.g. gardens, roadsides), but is also found in hill slopes (Fish *et al.* 2015). Apparently, the invasion of this and other *Ehrharta* spp. is facilitated by moisture. Besides that, these species can tolerate extensive annual summers in Mediterranean climates due to their deep-roots (Frey 2005).

In Madeira, *E. longiflora* possibly will prevail in areas of medium altitude, such as occurs in the Canary Islands (Kunkel 1978), but its invasiveness is hard to predict due to the scarcity of available information. Irrigated disturbed areas could be at higher risk of invasion, but this species may disperse to areas of high conservation value, possibly including laurisilva clearings and margins.

As in the islands of El Hierro, La Gomera, Fuerteventura and Lanzarote, where the introduction of *P. setaceum* was later (in the 1990s) (García-Gallo *et al.* 1999) and where control is still approachable, monitorization of populations and quick intervention (eradication) seems to be the best strategies and should be applied for Madeira. According with García-Gallo *et al.* (1999) the removal of individuals, manually or using hoes, seems to be the most effective method of eradication of *P. setaceum* (and has been applied in many parts of the world). It is important to eliminate the floral parts first by carefully covering the inflorescences with plastic bags, and removing all root fragments and seeds that are present in the soil (García-Gallo *et al.* 1999). Chemical methods may be implemented in situations where



the complete removal of individuals is not possible (walls, asphalt) using systemic herbicides such as hexazinone or similar products, since glyphosate appears to be ineffective (Anonymous 2014).

Although both taxa may become troublesome invasive, *Pennisetum setaceum* constitutes a clear threat to Madeira ecosystems. *P. setaceum* is still in an initial phase of invasion and plants should be eradicated urgently, and its use as ornamental prohibited.

5. ACKNOWLEDGMENTS

The authors are grateful to the IFCN (*Instituto das Florestas e Conservação da Natureza, IP-RAM*) for the collecting permit (n.º 05/IFCN/2017 - Flo Mad).

6. AUTHORS' CONTRIBUTION

Introduction: L.C., J.F.

Field work: L.C., J.F., P.N., A.B.

Methodologies: L.C., J.F., P.N., A.B., M.S.

Results and Discussion: L.C. J.F., P.N., A.B., M.S.

Review and edition of the final draft: M.S.

RECIBIDO: septiembre de 2019; ACEPTADO: abril de 2020



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