

## *Brachypodium phoenicoides* (Poaceae), a (not so) new alien in Belgium

Filip VERLOOVE<sup>1</sup> & Rutger BARENDSE<sup>2</sup>

<sup>1</sup> Agentschap Plantentuin Meise, Nieuwelaan 38, 1860 Meise [filip.verloove@plantentuinmeise.be]

<sup>2</sup> Plantenwerkgroep Genk, Reinpadstraat 170, 3600 Genk [rutger.barendse@telenet.be]

**Illustrations:** Rutger Barendse

**ABSTRACT.** – *Brachypodium phoenicoides* (Poaceae), a (not so) new alien in Belgium. A large, apparently well-established population of *Brachypodium phoenicoides*, a predominantly western Mediterranean species, was discovered on a spoil tip slope in Winterslag-Genk (province of Limburg, Belgium) in 2016. A subsequent revision of herbarium collections stored at Meise Botanic Garden showed that this species was already collected in 1946 in coastal dunes in De Panne. This xerophilous species has been slowly expanding northwards in the past decades in Europe, possibly favored by the ‘Global Warming’. Distinguishing features between *B. phoenicoides* and the very similar native species *B. pinnatum* s.l. (incl. *B. rupestre*) are discussed and illustrated.

**RÉSUMÉ.** – *Brachypodium phoenicoides* (Poaceae), une adventice nouvelle (ou pas?) en Belgique. Une population apparemment bien établie de *Brachypodium phoenicoides*, une espèce indigène dans la région méditerranéenne occidentale, a été découverte sur la pente d’un terril de charbonnage à Winterslag-Genk (province du Limbourg, Belgique) en 2016. Une révision ultérieure de l’herbier du Jardin Botanique de Meise a démontré la présence de cette espèce, déjà en 1946, dans les dunes côtières de La Panne. Il semble que cette espèce méridionale se répand progressivement vers le nord en Europe, peut-être sous l’influence du changement climatique. La distinction entre *B. phoenicoides* et l’espèce indigène très semblable *B. pinnatum* s.l. (incl. *B. rupestre*) est discutée et illustrée.

**SAMENVATTING.** – *Brachypodium phoenicoides* (Poaceae) in België, minder nieuw dan gedacht? In 2016 werd op de flank van een terril van de voormalige steenkoolmijn van Winterslag-Genk (provincie Limburg, België) een grote, schijnbaar goed gevestigde populatie ontdekt van *Brachypodium phoenicoides*, een soort uit het westelijke Middellandse Zeegebied. Uit een revisie van de collecties van het herbarium van Plantentuin Meise bleek vervolgens dat deze soort al in 1946 in de duinen van De Panne werd ingezameld. Dit warmteminnend gras blijkt in meerdere landen in Europa in trage opmars, mogelijk ten gevolge van ‘Global Warming’. Het onderscheid tussen *B. phoenicoides* en de er erg op gelijkende inheemse soort *B. pinnatum* s.l. (incl. *B. rupestre*) wordt besproken en de soort wordt ook afgebeeld.

### Introduction

In July 2016 one of us (RB) discovered a large population of a species of *Brachypodium* P. Beauv. on the slopes of a spoil tip of the former coal mining site of Winterslag (Genk, province of Limburg). These plants were tentatively ascribed to *B. pinnatum* (L.) P. Beauv. s.l. [incl. *B. rupestre* (Host.) Roem. & Schult.], although they somehow differed from plants of that species occurring in chalk and limestone grasslands elsewhere in Belgium. A specimen was collected and sent to the first author (FV) for closer examination. At that time, apart from the fact

that the plant was indeed atypical for *B. pinnatum*, a better name could not be proposed using western European floras. In July 2017 we both visited the locality, accompanied by our Dutch colleague Sipke Gonggrijp. It then became clear that this species of *Brachypodium* could not be our native *B. pinnatum*: compared with the latter, these plants had a different colour (slightly glaucous), were rather growing in tufts and had leaves that appeared to be inrolled and tough. On closer examination spikelets had much shorter awns, ligules were very short and leaves prominently ribbed. All these features are characteristic for *B. phoenicoides* (L.) P. Beauv. ex Roem. & Schult., a



**Figure 1.** *Brachypodium phoenicoides* in Genk, July 2016. Spikelets are either awnless or very shortly awned.



**Figure 2.** *Brachypodium phoenicoides* in Genk, March 2017. The ribs on the upper leaf surface are very distinct and the ligule very short to almost absent. Leaves are flat at first but readily become convolute.

more southern species of the *B. pinnatum* complex (Smith 1980, Schippmann 1991, Conert 1998, Jäger & Werner 2005, Tison & de Foucault 2014).

To our knowledge *B. phoenicoides* was until then never recorded from Belgium. However, while examining specimens of *B. pinnatum* in the Belgian herbarium of Botanic Garden Meise (BR) – emphasizing those collected outside the known native distribution of that species – it became clear that *B. phoenicoides* was already collected in 1946 in coastal dunes in De Panne.

Although probably still overlooked on many occasions, *B. phoenicoides* has been increasingly recorded outside its native distribution range and is slowly migrating further north. As it looks well established in its newly discovered locality and may have been overlooked elsewhere, we present this species in this paper and compare it with *B. pinnatum*. Special attention is also paid to this species' occurrence in its secondary distribution range.

**Identification of *Brachypodium phoenicoides*** (Fig. 1-2)

*Brachypodium phoenicoides* is a member of the *B. pinnatum* complex. It was long considered a mere variety (var. *phoenicoides* (L.) Fiori) or subspecies (subsp. *phoenicoides* (L.) Nyman) of *B. pinnatum*. However, Saint-Yves (1934) demonstrated, based on leaf cross sections, that both are distinct species. Molecular studies have confirmed these findings (Catalán *et al.* 1995). Apart from leaf anatomy, which is by far the most conclusive charac-

ter, *B. phoenicoides* is set apart as follows: rhizomes are much shorter and, as a consequence, plants rather grow in clumps; lemma awns tend to be much shorter or lemmas often are merely mucronate; ligules tend to be much shorter and are at most 1 mm long; leaves are more convolute and are often more or less pungent and tough, at least when dry; the overall appearance of the plant is often slightly glaucous, not yellowish-green.

The differences between the introduced *B. phoenicoides* and the native *B. pinnatum* (incl. *B. rupestre*) are summarized in Table 1. Both species also differ ecologically. *Brachypodium phoenicoides* is a xerophilous species (typically growing in maquis and garrigue, although it is also often found in more ruderal habitats), whereas *B. pinnatum* and *B. rupestre* are mesic species (Schippmann 1991) that thrive best in Mesobromion grasslands (Rodwell 1992).

**Two records of *Brachypodium phoenicoides* in Belgium**

In July 1946 Norbert Cnops made a collection of a specimen of *Brachypodium* in the Westhoek coastal dunes in De Panne (province of West Flanders). He identified this as *B. pinnatum* subsp. *phoenicoides* and this identification was subsequently confirmed by J.E. De Langhe: “It is phoenicoides! The spikelets could have been a bit longer but the leaves are very typical. Linked with *Brach. pinnatum* through intermediate forms.” [Translated by the authors.] We confirm this identity.

**Table 1.** Main morphological features distinguishing *B. phoenicoides* and *B. pinnatum/rupestre*.

<i>B. phoenicoides</i>	<i>B. pinnatum</i> / <i>B. rupestre</i>
Leaf surface very distinctly and evenly ribbed, ribs rectangular in cross-section.	Leaf surface indistinctly ribbed, ribs rounded in cross-section.
Leaves flat to convolute when fresh, convolute and tough when dry.	Leaves usually flat and flaccid, sometimes becoming convolute when dry.
Lemma awns absent or up to 2.5 mm long.	Lemmas always awned, awn usually at least 2.5 mm long.
Ligule very short, up to ca. 1 mm but often less.	Ligules longer, usually up to ca. 2.5 mm long.
Plant slightly bluish green.	Plant bright green to yellowish-green.
Rhizomes short, plant often growing in clumps.	Rhizomes longer, up to 300 cm long (de Kroon & Kwant 1987).



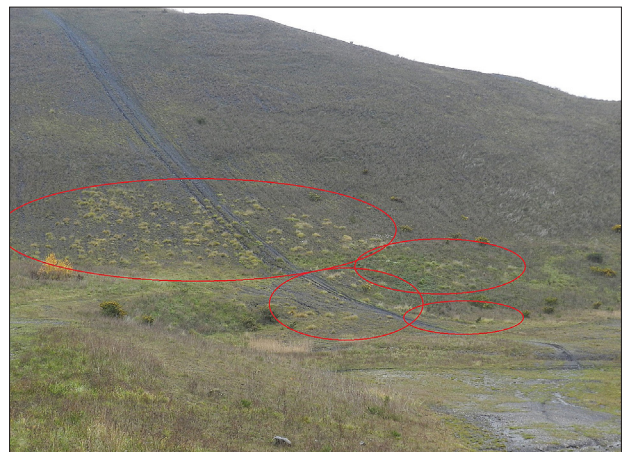
To our knowledge this record remained unpublished. As a result there are no further details about this finding. The specimen was collected in the IFBL square C0.56.41. This area was dramatically altered in the 1970s. The coastal dunes where the species was probably found in 1946 are now the site of a residential allotment (pers. comm. M. Leten 31 July 2017). There are no recent records of any species of *Brachypodium* from that particular area (e.g. Florabank, Waarnemingen.be). Most likely – if the species was ever able to establish after its introduction – its population was destroyed in the 1970s. We can only guess about the potential vectors of introduction for *B. phoenicoides* in De Panne. Interestingly, however, this part of the Westhoek coastal dunes was the one that was the most affected by the construction of the Atlantic Wall during World War II. Also during World War I many alien plant species from southern Europe were unintentionally introduced there (Magnel 1921, pers. comm. M. Leten July 2017). In the absence of other, more plausible introduction vectors, a fortuitous introduction as an ‘army alien’ appears to be the most likely.

In July 2016, a massive population of *B. phoenicoides* was discovered on the west-facing slope of a spoil tip of the former coal mining site in Winterslag-Genk (province of Limburg; IFBL square D7.31.43). The main part of the population occupies an area of ca. 3,000-4,000 m<sup>2</sup> and several smaller satellite patches are found higher up and on the top of the slope, as well as on an adjacent southwest-facing slope of the spoil tip (Fig. 3-4). The species is obviously well established in this locality and in a naturalization process.

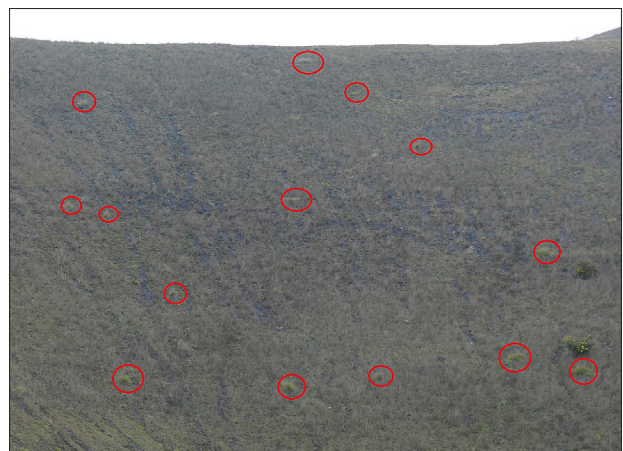
The origin of this species in Genk is uncertain. For various reasons (erosion control on the steep slopes, environmental remediation, speeding up of the natural recolonization process) the spoil tips were remodeled and sown after abandonment of the mining activities in Limburg (Vangronsveld 1995, Vanoppen & Gora 2004). For this purpose hydro-seeding was applied, a technique that uses a slurry of seeds and mulch. The seed composition consisted of 20-25, mostly native species, herbaceous as well as shrubs and trees (see Vanoppen & Gora 2004 for a complete list). Among the herbaceous species grasses were predominant and belonged to the genera *Festuca*, *Agrostis*, *Arrhenatherum* and *Lolium*. No species of *Brachypodium* were included in the seed mixtures. However, seed mixtures probably also were contaminated with seed of other species (not listed in the hydro-seeding mixture), most of them with showy flowers such as *Coreopsis lanceolata* L. and *Linum austriacum* L. Also elsewhere in the coal mining area in Limburg southern alien species appeared after the remodeling and sowing events. These may have been unintentionally introduced, such as *Achillea nobilis* L., *Calamintha nepeta* (L.) Savi subsp. *nepeta*, *Carlina vulgaris* L., *Linum tenuifolium* L., *Odontites luteus* (L.) Clairv. and *Spartium junceum* L. Some species may also have been introduced via railway traffic or nearby port and other industrial activities (Vanoppen & Gora 2004).

The spoil tip in Winterslag still contained sufficient amounts of coal and was therefore further exploited between 1996 and 2006 (Brouwers 2011). It is unclear whether or not it was sown again afterwards, but the whole area dramatically changed during this new exploitation. It is exactly on the steep slope of the newly obtained spoil tip that *B. phoenicoides* has now been found. It grows along with other thermophilous southern European species that are not found on other spoil tips in the Limburg coal mining area (*Salvia officinalis* L., *Saponaria ocyroides* L. and *Thymus vulgaris* L.). The most significant one, however, is *Plantago sempervirens* Crantz, a species with a distribution and ecological requirements very similar to that of *B. phoenicoides*. It had not been recorded before in Belgium, and was also discovered in 2016. In 2017, 10-20 individuals were counted.

Taking this into consideration, we conclude that the vector of introduction of *B. phoenicoides* (and *Plantago sempervirens*) remains speculative although it is most likely that both species were introduced during or – more likely – shortly after the last exploitation of 2006. Google



**Figure 3.** General view of the habitat of *Brachypodium phoenicoides* in Genk: main population on the west-facing slope.



**Figure 4.** General view of the habitat of *Brachypodium phoenicoides* in Genk: satellite populations on the southwest-facing slope.

Earth images of 2007 show a spoil tip that looked quite different compared with its current shape. No vegetation was discernible where *B. phoenicoides* is now found. On Google Earth images from 2016 the population is clearly visible. Given the size of the current population it seems to colonize the site in a fast way.

#### Herbarium:

- De Panne, Westhoek (IFBL C0.56.41), dunes, 21.07.1946, *N. Cnops* 46.216 (BR 1216013).
- Genk, Winterslag (IFBL D7.31.43), coal mining spoil heap, very common, 16.07.2017, *F. Verloove* 12914 (BR).

#### Distribution

*Brachypodium phoenicoides* is chiefly distributed in the western Mediterranean area. Its main distribution center is located in southwestern Europe, especially in the Iberian Peninsula (Portugal and Spain), and it is not rare in southern France. It is further found in North Africa, in particular in the northernmost parts of Morocco, Algeria and Tunisia. It also occurs on the Balearic Islands (Ibiza with Formentera, Mallorca and Menorca), Corsica, Sardinia and Sicily (Valdés & Scholz 2009). Further to the East it becomes much less frequent and only occurs sporadically in Italy (Lucchese 1990), Croatia and Albania. Previous claims from Greece (e.g. Smith 1980) turned out to be erroneous (Schippmann 1991).

The northern limits of the species' native distribution range are in France. In the valley of river Rhône it reaches the Lyon area (Nétien 1982), whereas on the Atlantic coast it is found up to Charente-Maritime (De Litardière 1935; as "Charente-Inférieure"). In the Haute-Savoie department two populations are considered native although the species was not recorded there before 1975 (Jordan 2017). In the same department it further grows in several localities in the Lac Lemman area where it is thought to be an introduction. For all these locations its native vs. introduced status has been the subject of discussion.

In the last decades *B. phoenicoides* has further spread northwards across the European continent. In Switzerland it was first recorded in 2003 in La Sarraz (Vaud department) where dense populations were seen at the railway station. It was subsequently seen in several additional localities in the Lausanne area as well (Bornand & Hoffer-Massard 2004). At present this species is widely naturalized north of the Lac Lemman, roughly between Lausanne, Fribourg and Yverdon (pers. comm. F. Hoffer-Massard November 2017). Although these localities are close to those in Haute-Savoie in France, the species is confined to railway infrastructure and is considered non-native.

In Germany *B. phoenicoides* was first collected in 1981 in an abandoned quarry in Ebersberg in Bayern (Schippmann 1991). The species is naturalized there and soon afterwards it has also been discovered along railway sidings about 40 km further to the East (Conert 1998). According to Jäger & Werner (2005) it is now naturalized in southeastern Bayern (Freilassing, Garching/Alz, Ebersberg).

Interestingly, *B. phoenicoides* was also grown from seeds in a garden in Habsheim in the 1980s (northeastern France, Haut-Rhin department; coll. *V. Rastetter* in BR!, Soc. Ech. Pl. Vasc. N° 13780). It adapted very well to the local, much less favorable climate ("Espèce méridionale, qui s'est bien acclimatée à Habsheim!").

Outside the Mediterranean basin *B. phoenicoides* is rarely observed. Records in Macaronesia are either considered alien (Canary Islands: Fuerteventura; Scholz *et al.* 2004) or dubious (Madeira; Press *et al.* 1994: "Reported from Madeira without further data"). In North America the species is established in coastal sand dunes in California (Sonoma County), at least since 1974 (Barkworth 2007).

The established population that was recently detected in Genk seems to be the northernmost worldwide.

#### Conclusion

The migration and naturalization of thermophilous species considerably north of their native distribution range is often associated with Global Warming (e.g. Bakkenes *et al.* 2002, Neilson *et al.* 2005, Midgley *et al.* 2007). It is tempting to suggest that *B. phoenicoides* migrated to Belgium as a result of climate change. However, given that the species' northern distribution limits are slowly shifting (most likely as a result of a changing climate), it is unlikely that the occurrence of this species in Belgium is directly linked to this phenomenon. There is indeed a considerable distance between the northernmost naturalized populations on the European continent (in southeastern Germany) and those currently found in Belgium. This seems to point to an introduction by man, intentionally or unintentionally. The fact, however, that *B. phoenicoides* thrives very well so far north of its native range is remarkable. In Genk it is found on a climatologically favorable, southwest-facing, sunny slope, on stony substrate and this probably enabled the species to establish itself. It will be interesting to see whether or not the species will be able to spread to other suitable habitats in the area in the near future.

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