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Research Article

First record of *Nassella neesiana* (Trin. & Rupr.) Barkworth (Poaceae) in Croatia

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Abstract

Chilean needle grass, *Nassella neesiana* belonging to the tribe *Stipeae* (Poaceae), native to South America was recorded for the first time in Croatia. It was found in ruderal vegetation on the island of Veli Brijun in the Brijuni National Park (Istria, NW Croatia). This species can cause negative impacts to native grasslands, outcompeting native grasses or can increase fire hazards in peri-urban areas. Considering the species has already naturalized in a number of European countries, and the fact that the territory of Northern Croatia has been evaluated as suitable for its eastward expansion, it is of great importance to monitor and control the spread of the species in the Adriatic and possibly promote an early eradication. Notes on the environment in which it was found and its invasive status in Croatia are discussed.

Key words: Adriatic, alien plants, Brijuni, vascular flora

Introduction

The genus *Nassella* Desv. belongs to the tribe *Stipeae* Dumort. (Poaceae) whose rank, status and delimitation has been controversial till today. At the moment, there is no overall agreement upon the circumscription within the tribe *Stipeae*, however, following the comprehensive recent studies on the subject, *Nassella* is treated at generic level (for detail synopsis, history and the delimitation of the genus *Nassella* see Barkworth 1990; Jacobs et al. 1995; Barkworth and Torres 2001). All the characteristics that unite the genus *Nassella* appear to represent derived states within the tribe *Stipeae* (Barkworth and Torres 2001). Morphological features that best distinguish *Nassella* from other genera of the tribe *Stipeae* are the strongly convolute lemma with the crown at the apex varying from inconspicuous to conspicuous; the reduced usually glabrous short palea, up to one third of the length of the lemma, almost always glabrous and without veins; the lemma epidermal pattern (Thomasson 1976, 1978, 1979; Barkworth 1990), and its ITS sequence data (Jacobs et al. 2000). The combination of the strongly convolute lemma and short glabrous palea are also the most useful field characters (Barkworth and Torres 2001). On the other hand, no

vegetative characteristics are known to distinguish *Nassella* from other stipoid grasses (Arriaga and Barkworth 2000). Currently the genus *Nasella* includes 116 species mostly native to Central and Southern America, although several representatives have the status of aggressive invasive alien plants outside their natural range (Verloove 2005).

According to Verloove (2005), Valdés and Scholz (2009) and Galasso et al. (2018) six species of the genus *Nassella* are recorded in Europe: *N. formicarum* (Delile) Barkworth, *N. hyalina* (Nees) Barkworth, *N. neesiana* (Trin. & Rupr.) Brakworth, *N. poeppigiana* (Trin. & Rupr.) Barkworth, *N. tenuissima* (Trin.) Barkworth and *N. trichotoma* (Nees) Arechav. The presence of *N. mucronata* (Kunth) R.W.Pohl in the European fora is questionable according to Verloove (2005).

The most common species found in the European flora is *N. neesiana* (= *Stipa neesiana* Trin. & Rupr.), which is native to Argentina, Bolivia, Brazil, Chile, Ecuador, Peru and Uruguay (Verloove 2005), and naturalized in Australia, New Zealand (Jacobs and Everett 1993; Bourdôt et al. 2012), South Africa (Gibbs Russell et al. 1991), Corse (Tison and de Foucault 2014) and Italy (Galasso et al. 2018).

According to the literature, the occurrence of *N. neesiana* has been, however, reported in several European countries. At present this species is recorded in Great Britain (Ryves et al. 1996), Corse in France (Tison and de Foucault 2014), Germany (Tison and de Foucault 2014; Buttler and Thieme 2018), Greece (Greuter and Raus 2004), Spain (Greuter and Raus 2004) and Italy (Celesti-Grapow et al. 2009; Galasso et al. 2018).

The taxonomical status of the genus *Nassella* has undergone many changes over time. The name was first used by Trinius (1830) for a subgenus of *Stipa* L. The name *Nassella* was used for the first time at generic level by Desvaux (1853). The rank of the taxon had later on been changed more than once by different authors (Spegazzini 1901, 1925; Elias 1942; Parodi 1944, 1947). Finally, Barkworth (1990) expanded *Nassella* from a genus of approximately nine species (Parodi 1947) to one of 79 species, including at present 116 species (Barkworth and Torres 2001). Moreover, most of the species of the genus were earlier described and listed as members of the genus *Stipa*. However, all the representatives originally listed within *Stipa* with their origin and distributions in the New World are at present treated as separate genera, like *Nasella* or *Jarava* Ruiz & Pav. (Verloove 2005). As for the species *N. neesiana*, in Europe it has been often confused taxonomically with *N. mucronata*. In most of the European countries with the occurrence of *Nassella*, both these species were reported. However, the biggest confusion seems due to the misapplication of the name *Stipa setigera* J. Presl (which is the heterotypic synonym of *N. mucronata*) to *N. neesiana* in Europe (Verloove 2005) probably due to Spegazzini's treatment of *Stipeae* in Argentina (Spegazzini 1901). Accordingly, all the

records of *N. mucronata* are doubtful for the majority of the European countries (Verloove 2005). The origin of *N. neesiana* in Europe is obscure, and according to Garcia (1946) the species might have been accidentally introduced as contaminant of cereals from Argentina. A number of French populations are assumed to originate from the former local wool industry import, while the others might have been introduced by railway traffic (Verloove 2005). *N. neesiana* was added to the Alert List within the European and Mediterranean Plant Protection Organization (EPPO) prioritization process for invasive alien plants, prior to which its spread and impact on the environment, agriculture and forestry were evaluated as from medium to high (Brunel et al. 2010).

None of the species of the genus *Nassella* have been reported for Croatia so far. Nevertheless, climate change scenarios have predicted Croatia, amongst other European countries, as a potentially suitable area for the expansion of *N. neesiana* eastwards (Bourdôt et al. 2012).

Materials and methods

In May and September 2018 and in May 2019 the vascular flora of Veli Brijun was investigated. Species identification and vascular flora nomenclature was done according to Nikolić (2018), while the terminology used for designation of the morphological features of *N. neesiana* is the one proposed by Barkworth (1990), Jacobs et al. (1995) and Barkworth and Torres (2001). Plant materials of *N. neesiana* were digitalized and deposited at ZAGR herbarium according to Bogdanović et al. (2016).

The island of Veli Brijun (5.72 km^2) is an uninhabited island in Istria (North-western Croatia). It is the largest island in the Brijuni islands archipelago, and also a part of the Brijuni National Park. The island itself lies about two km west of the mainland town of Fažana, from which it is separated by the Fažana Channel (Figure 1).

Results

The island of Veli Brijun belongs to the Mediterranean biogeographic region and to the Eu-Mediterranean zone of the Eastern Mediterranean province, with an average annual temperature of 13.9 °C and an average annual rainfall of 800 mm (Zaninović at al. 2008). It was characterized by the potential vegetation of the *Quercion ilicis* Br.-Bl. (1931) 1936 (Trinajstić 2008).

However, due to centuries of human influence, most holm oak forests were converted into degradation form of maquis, garrigues with limestone rock outcrops (Horvat 1949; Tomaselli 1981; Matić et al. 2011) and have only been preserved on small areas such as on Brijuni. Today, although the island is inhabited, the vegetation of Veli Brijun is under a strong pressure of grazing due to the presence of goats, mouflons and deers.

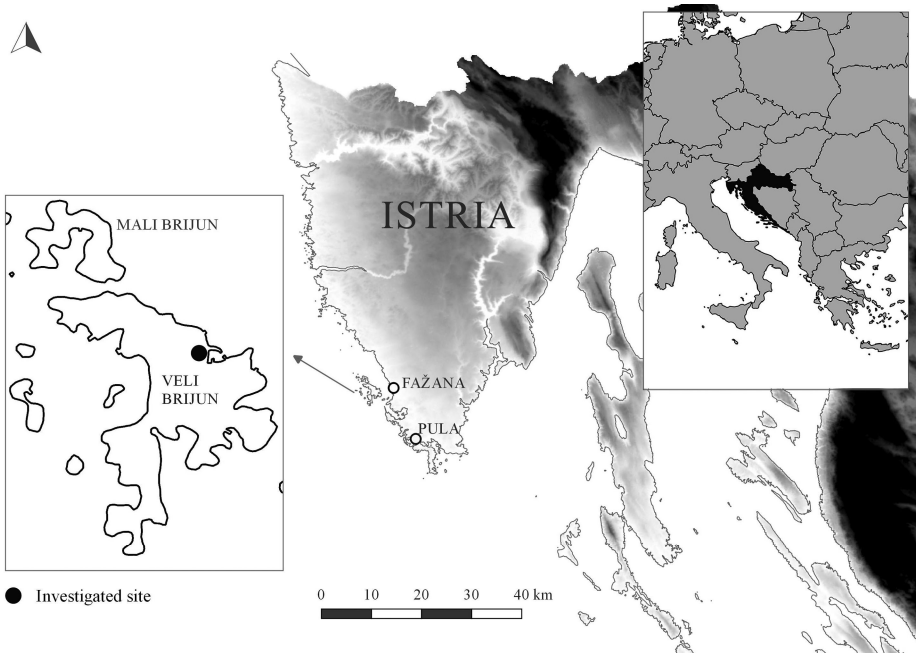

Figure 1. Geographical position of investigated area of Veli Brijun (Brijuni National Park) in Croatia.

During a floristic investigation of Veli Brijun in May 2018 we found ten individuals of *N. neesiana* at one locality (Figure 1). The plants were growing in ruderal vegetation within an Aleppo pine forest along the sea coast near the Hotel Karmen (GPS coordinates: 44°55′5.89″N; 13°46′4.87″E, ZAGR-47877, ZAGR-47978). The stand was characterized by *Rostraria cristata* (L.) Tzvelev, *Lolium perenne* L., *Trifolium campestre* Schreb., *Catapodium marinum* (L.) C.E.Hubb., *Piptatherum miliaceum* (L.) Coss., *Sherardia arvensis* L., *Stipa bromoides* (L.) P.Beauv., *Carex divulsa* Stokes and *Vulpia ligustica* (All.) Link and other species, together with *N. neesiana*. The locality was revisited at the end of September, and the whole vegetation was found browsed by herbivores living there, such as goats, deer, roe deer and mouflons. Evidently, the habitat is under heavy grazing pressure.

Since the representatives of the genus *Nassella* in Europe and especially in Croatia are not frequently seen and identified, the comparison was made considering all important characters of the taxa recorded within the European countries, in order to avoid misidentification. The morphological characters were retrieved from Barkworth and Torres (2001) and are reported in Table 1.

The morphological description of the collected specimens from Veli Brijun using the terminology of Barkworth (1990), Jacobs et al. (1995) and Barkworth and Torres (2001) are reported in the following section.

Morphological description

Nassella neesiana s. str. is a densely caespitose perennial, growing in tufts (Figure 2). Culms ca. 90 cm tall, erect, glabrous with pilose nodes (Figure 3a). Leaf sheats in most cases with scattered long white hairs, with membranous

Table 1. Morphological features of *Nassella* species occurring in the European flora. The information was retrieved from Barkworth and Torres (2001) and Verloove (2005). Leaf width refers to the diameter of strongly convolute leaves; Glume length encompasses the range for both glumes in species; Anthoecium includes the callus, lema body and crown, but not the awn; Lema vestiture is recorded as glabrous even if there are hairs on the lower portion of the mid-vein; Bolded values indicated in the brackets (*) refers to *N. neesiana* specimens from Veli Brijun.

Species	*N. formicarum*	*N. hyalina*	*N. neesiana* (*)	*N. poeppigiana*	*N. tenuissima*	*N. trichotoma*
Culm height (cm)	40–80	25–100	30–100 **(40)**	50–100	25–70	20–60
Panicle length (cm)	10–20	5–30	10–25 **(12)**	15–35	8–50	10–25
Ligule length (mm)	0.8–1.0	0.3–0.5	1–4 **(2)**	0.4–0.8	1–3	0.5–1.5
Leaf width (mm)	1.0–2.5	3.0–5.5	2.5–8.0 **(3.5)**	3–10	(0.4–0.5)	(0.3–0.6)
Glume length (mm)	9–13	5.5–11.5	14–21 **(18.5)**	9–17	5.0–10.5	6–8
Anthoecium length (mm)	4.5–6.5	3–4	7.0–11.5 **(10.5)**	5.8–8.5	1.8–3.6	1.5–3.0
Anthoecium shape	cylindrical-fusiform	cylindrical-fusiform	cylindrical	cylindrical	cylindrical	obovoid and ellipsoid, gibbous
Callus length (mm)	0.7–2.0	0.4–0.9	3.0–5.5 **(3.5)**	2.0–3.5	0.2–0.4	0.3–0.5
Lemma vestiture	glabrous	glabrous	glabrous	veins pubescent	glabrous	glabrous
Lemma surface	papillose all over or only above	papillose	papillose	papillose	papillose above	papillose
Crown length (mm)	0.4–0.5	0.4–1.0	0.5–1.0 **(0.5)**	0.5–0.7	0.1–0.2	cc 0.1
Awn length (cm)	6–9	2.0–4.5	6.0–9.5 **(9)**	5–9	4.5–10.0	2–3
Awn bends	2	0,1,2	2 **(2)**	1,2	1,2	1,2
Awn bristle	straight	slightly flexuous	straight	straight	flexuous	straight

ligules, 1.5–4 cm long. Inflorescence is a more or less contracted panicle, with age becoming more effuse, long up to 25 cm (Figure 3b). Spikelets one-flowered, disarticulating above the glumes. Glumes unequal, the lower one longer, up to 20 mm, five-nerved, the lower shorter, up to 15 mm (including awn up to 8 mm), three-nerved, purplish with hyaline apex and margins, nerves hairy. Anthoecium cylindrical up to 10 mm long, 1.2 mm in diameter. Lemma is hidden by the tuft of white hairs, constricted at the base and with denticulate hairs at apex (Figure 3c). Awn (60–) 80 (–95) mm long, column slightly shorter than bristle. Palea membranous, glabrous, 1–2.5 mm long. Caryopsis 4–5 mm. Morphological traits of specimens from Veli Brijun are in accordance with morphological variability of *N. neesiana* (see Table 1) known from literature.

Discussion

Nassella neesiana seems to be the most widespread of all naturalized taxa of this genus in Europe. According to Verloove (2005) this species inhabits very wide range of anthropogenic habitats such as road-verges, abandoned vineyards, urban parks, disturbed pastures, etc. Moreover, it is the only species of its genus with reported invasiveness in Europe (Verloove 2005). Although it is sometimes found in small populations, like in our case, *N. neesiana* is able to form dense stands and spread very fast (Bosc 1982). As for its ecology, the species is adapted to a wide range of climates and soil types, and it is tolerant to drought, fire and grazing, but however, limited by salinity and water logging. It grows in temperate regions with annual precipitation higher than 500 mm. In optimal conditions, it can produce more than 20.000 caryopsis, but also has (in addition to normal

Figure 2. Herbarium specimen of *Nassella neesiana* from Veli Brijun (ZAGR-47877).

flower caryopsis) hidden caryopsis at the node and bases of flower stems. However, the seedlings are usually outcompeted by other plants, becoming more competitive under drought or overgrazing (Brunel et al. 2010). Since *N. neesiana* is an ornamental plant, this could be the possible introduction pathway. Also, the caryopsis are easily spread by wind or water, as well they adhere to clothing and livestock, or can be dispersed on farm machinery or by contaminated seeds and fodder (Brunel et al. 2010). Regarding impacts on the environment, being a vigorous plant, *N. neesiana* can crowd out desirable pasture species, thus reducing pasture value and stock carrying capacity. Due to its high fibre content and low nutritive value, it forms indigestible balls in the stomach of the livestock, causing losses in production.

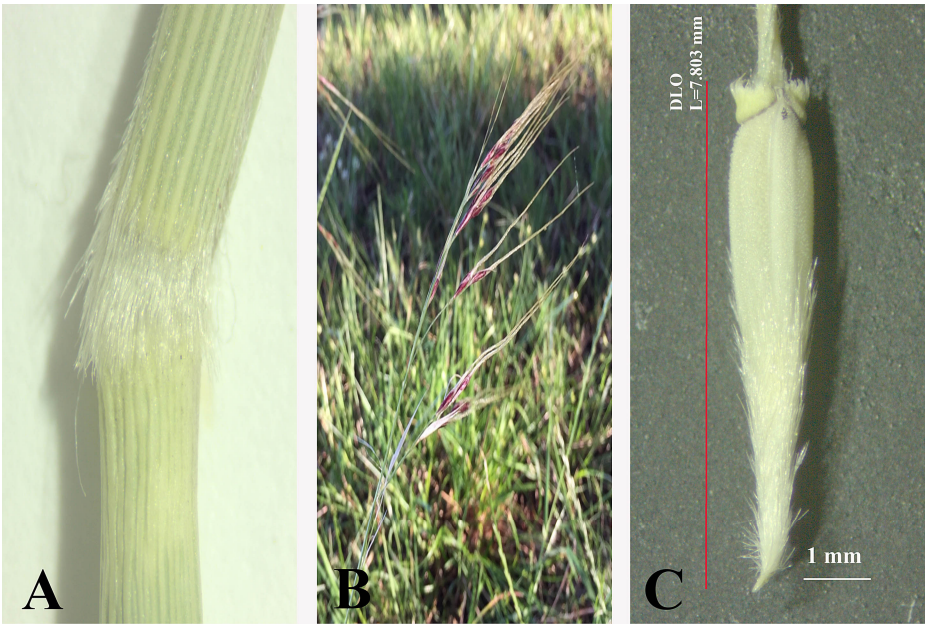

Figure 3. Morphological features of *Nassella neesiana* from Veli Brijun. A – hairy node, B – inflorescence, C – lemma with white hairs. Photographs by Sandro Bogdanović and Ivica Ljubičić.

The sharp caryopsis may also cause injuries and blindness to the livestock, or contaminate wool and devaluating its value (Brunel et al. 2010). The species can also cause environmental damage to native grasslands, outcompeting native grasses or can create a fire hazards in peri-urban areas (Brunel et al. 2010).

Since this is the first report of *N. neesiana* in Croatia, it is needed to monitor its spread, plan an early eradication and classify it according to the criteria applied for alien species (as proposed by Pyšek et al. 2004) and adjusted for Croatia according to the National alien flora of Croatia: proposals for standards in terminology, criteria and related database (Mitić et al. 2008). *N. nessiana* is classified as a casual alien species (category 2.1.2) that is implemented in the national database Flora Croatica (Nikolić 2018). Considering the species has already been naturalized in a number of European countries (Verloove 2005; Galasso et al. 2018), and the fact that the territory of northern Croatia has been evaluated as suitable for its eastward expansion (Bourdôt et al. 2012), it is of great importance to follow the spread of the species, or even establish some control programs aiming to reduce the amount of seed produced and eradicate it from the island. This could be done by grubbing out *Nassella* infestations before they flower and set seed, and to destroy them by burning. Judging by the invasive behavior of the species in Australia and New Zealand, and its breakthrough to Europe, the conclusion emerges that pastures, natural grasslands and river banks of temperate and Mediterranean European countries might be at risk (Bourdôt et al. 2012).

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