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Research Article

Senecio brasiliensis (Spreng.) Less. (Asteraceae), another potentially invasive alien species in Europe

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Abstract

Senecio brasiliensis (Spreng.) Less., native to South America (Brazil, Paraguay, Uruguay, Bolivia and Argentina), is reported for the first time as a naturalized alien species from Europe (near Porto; Portugal). The species' taxonomy and nomenclature were analysed based on literature data. Its ecology, habitat, biology and possible vector of introduction are discussed. As a necessary step towards a risk assessment, the suitability of European climates for the species' settlement was analysed. Fourteen countries with suitable climatic conditions appeared in all our models: Albania, Bosnia-Herzegovina, Bulgaria, Croatia, Cyprus, France, Greece, Italy, Macedonia, Montenegro, Portugal, Slovenia, Spain and the United Kingdom (England). Given the ecological characteristics of the species and the climatic features of the areas analysed, it is concluded that *S. brasiliensis* exhibits a great potential to become an invasive alien in Europe.

Key words: biological invasion, climatic matching, exotic species, introduced species, invasive species, Portugal, risk assessment

Introduction

Senecio L. (Asteraceae) was long thought to be one of the largest genera of flowering plants on earth with approximately 3,000 species (Jeffrey et al. 1977). Molecular phylogenetic studies, however, shed new light on the boundaries of the genus. The tribe Senecioneae was shown to be paraphyletic (Knox and Palmer 1995) and *Senecio* itself para- or polyphyletic (Knox and Palmer 1995; Pelser et al. 2002). Pelser et al. (2007) proposed a new delimitation of the genus based on DNA sequence data. In its new circumscription, *Senecio* still counts ca. 1,000 species with an almost worldwide distribution.

The genus exhibits enormous variation in life-history strategies (ranging from annual or perennial herbs to shrubs, vines, trees or epiphytes) and morphology, especially with respect to leaf shape, indumentum, inflorescence type and flower color (Barkley 1978). Although the genus is almost cosmopolitan obvious centres of diversity are discernible in southern Africa and—particularly—South America. Species of *Senecio* are found in aquatic to desert habitats, from low altitudes to alpine communities and from arctic regions to tropical areas.

Species of *Senecio* are of limited economic importance although some have been used as garden ornamentals. Rowley et al. (2000) cited 47 species that are grown in European gardens but most of these now belong to genera that are no longer part of *Senecio* s. str. A considerable number of species of *Senecio* are considered noxious agricultural or environmental weeds (e.g. Holm et al. 1979; Randall 2017) or are highly toxic to livestock. Seneciosis, a chronic hepatotoxicosis of livestock, is caused by the ingestion of species of *Senecio* (Hill 1960). In Europe, introduced species such as *Senecio inaequidens* DC. or *S. pterophorus* DC. are known as invasive species with detrimental impacts on native biodiversity (numerous references, e.g. Caño et al. 2007; Vilatersana et al. 2016).

In this paper, we provide details about the first European record of a naturalized population of *Senecio brasiliensis* (Spreng.) Less., a species native to South America that was found in highly disturbed habitats with many alien species near Porto (Portugal). We describe the environmental characteristics of the invaded locality and discuss the possible vector of introduction. The species is also illustrated. With the information gathered, we assess the invasion risk posed by this species to the European continent (eastwards up to the European Union's external borders). As the protocol used for this risk assessment includes a question on the species' amplitude and climatic matching, we also analysed its climatic range in the native area and the similarity of these areas as compared to Europe.

Materials and methods

Identification

The species was identified based on morphological characters using relevant literature sources (e.g. Cabrera 1957, 1985; Cabrera et al. 1999) and comparison with type specimen images deposited at herbaria G and P (herbarium acronyms follow Thiers 2020). Its taxonomic position within the genus *Senecio* was analysed, as were nomenclatural aspects. Its main diagnostic features, compared with closely similar or other relevant representatives of the genus, were investigated. Herbarium specimens were collected and deposited in the herbarium of Meise Botanic Garden, Belgium (BR). We further collected and documented geographic coordinates (latitude/longitude datum WGS 84), date of observation, habitat, accompanying species and climatic parameters (average annual rainfall; average, minimum and maximum mean temperature and minimum temperature of the coolest month).

Risk assessment

The species' invasion risk was assessed following the original scheme of Pheloung et al. (1999). This procedure was initially developed to screen the risk of weeds in Australia based on 49 questions dealing with the target species' distribution, eco-physiological characters and undesirable attributes. The method was shown to be also applicable in other parts of the world (e.g. Andreu and Vilà 2010; Verloove et al. 2018). Gordon et al. (2010) subsequently improved the definition of the criteria used to answer the questions. The resulting scores place a species in one out of three categories: accept (score < 1), evaluate (score 1–6) or reject (score > 6). Pheloung's system takes into account biological, ecological and historical aspects linked to the species, its distribution across a variety of climate types and the climatic matching between the native and alien range, among others (Gordon et al. 2010). It is generally accepted that a greater climatic similarity implies a less restrictive effect of the climate for the establishment of an alien species (e.g. Beans et al. 2012). However, it should be avoided, whenever possible, that the climate assessment is based merely on subjective evaluations (Gordon et al. 2010). Therefore, the degree to which there was a match between the species' climate range in its native area and European countries was first analysed. A matrix with 563 georeferenced records (geographical coordinates) of *S. brasiliensis* in its native area was built and used for climate match analyses. Records were extracted from Global Biodiversity Information Facility Database (GBIF.org 2020). Only records indicating geographical coordinates matching the locality provided in the original labels and showing no standardization problems according to the criteria for integrating information into the database were used. The records were distributed across Argentina, Bolivia, Brazil, Paraguay and Uruguay (Figure 1).

To inspect for critical climate matches between the native and the study area (European countries and member-countries of the European Union), the records of *S. brasiliensis* in their native area were used to build two models with Climatch 1.0 software (Australian Bureau of Rural Science, available at https://climatch.cp1.agriculture.gov.au/climatch.jsp).

Modelling strategy

The existence of potential climatic restrictions to the establishment of *Senecio brasiliensis* was analysed by inspecting the similarity between the source (native) and target (potential alien) area under study according to Crombie et al. (2008). The Euclidean algorithm was employed in order to calculate the match class. This algorithm uses a function that rounds down the distance values obtained in order to establish the corresponding match class. The input site with the metric that is closest to a given target location determines the level of match class or score (Crombie et al. 2008). The match score may vary

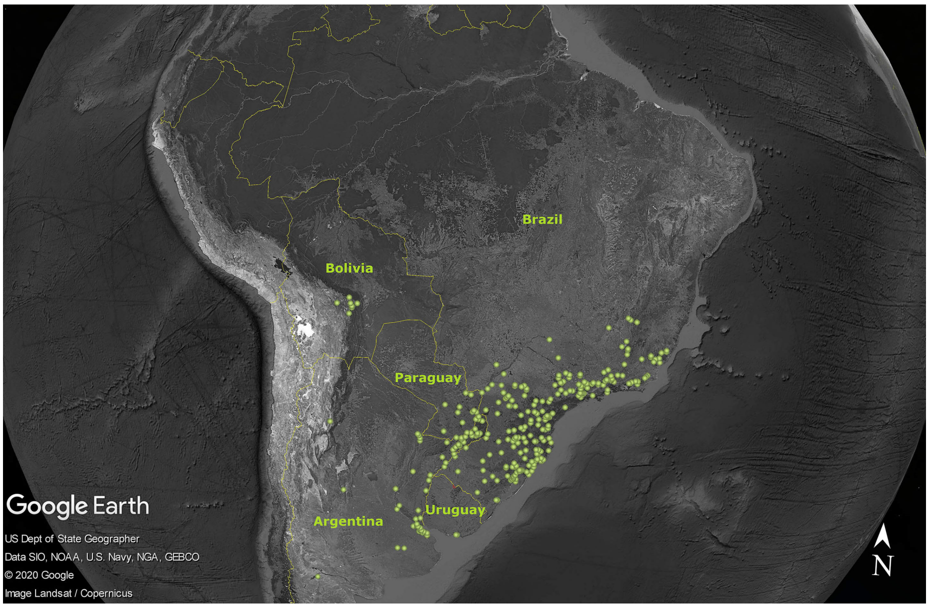

Figure 1. Geographical distribution of *Senecio brasiliensis* (Asteraceae) across its native distribution area (Source: Global Biodiversity Information Facility, www.gbif.org).

Table 1. Variables included in each model analysed. Mean values were used.

	Model 1	Model 2
Variables included	$T^a_{coldest\ quarter} + pp_{driest\ quarter}$	$T^a_{warmest\ quarter} + pp_{warmest\ quarter}$

from 0 (absence of match) to 10 (perfect match). A score ≥ 7 indicates no climate barrier for a successful establishment.

Climatic data of quarters instead of months were used since they provide a more realistic approach to the plant's lifespan. For a perennial, a quarter is generally a period to cope with key processes such as germination, establishment of juveniles and recruitment and, for established individuals, flowering and fruiting. The variables were selected according to their assumed importance for plant development (Table 1). Mean temperatures of the coldest quarter and mean rainfall of the driest quarter (model 1) and mean rainfall of the warmest quarter plus mean temperature of the warmest quarter (model 2) were selected for model building. Model 1 allows to inspect whether or not mean cold temperatures and shortage of rainfall could restrict the species' settlement. Model 2 allows inspecting whether or not European countries show areas with favourable combinations for rainfall and temperature during the warmest quarter, assuming that a Neotropical species will require a combination of favourable conditions of both parameters.

Our climate matching analysis followed a conservative approach by using world meteorological stations instead of interpolated samples and by choosing just one station within the nearest 50 km from each record. Although this approach reduces the number of stations selected in the native area, it has the advantage of reducing the noise effect derived from topographic positions, e.g. high mountains, large desert basins, etc. Besides,

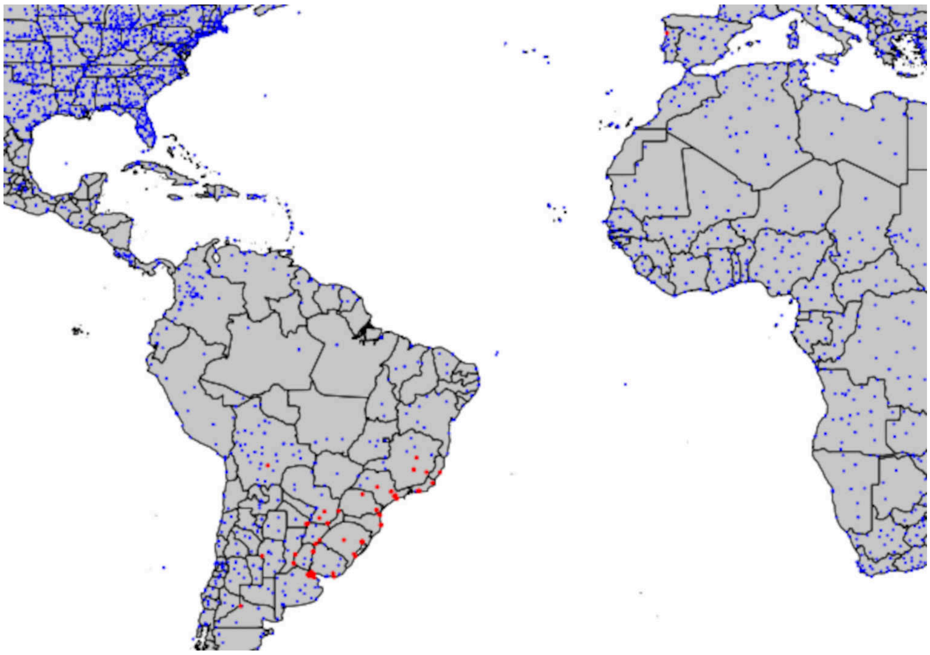

Figure 2. Source area showing the climatic stations matching the conditions imposed and their geographical distribution (n = 72, covered area = 1,187,059 km^2). Red dots correspond to stations located within a 50 km radius from the *Senecio brasiliensis* (Asteraceae) records harbouring one station. Blue dots refer to meteorological stations located outside the study area.

using real meteorological stations instead of sampled projections allowed including some of the smaller islands in the analysis (e.g. Malta, Balearic Isles, Ultraperipheral areas of Azores and Canary Islands) which, otherwise, would have been excluded. An original dataset was compiled from different sources as indicated in Crombie et al. (2008). Only meteorological stations located near to native South American and established non-native populations in Portugal were used. Consequently, the historical records as waifs (casuals) in the United States and the British Isles (see below) were not included in the analysis. Data of 72 meteorological stations covering an area of ca. 1,187,059 km^2 in the native and alien area (Figure 2) were compared to data gathered from 1,248 stations located across Europe covering an estimated area of ca. 4,943,225 km^2 (Figure 3).

For each model, the percentage of climatic suitability was calculated as the percentage of areas showing a score of ≥ 7. In addition, in order to adopt a conservative criterion, the percentage of localities with a match score = 6 was also calculated, as a threshold value for a potential settlement (Bomford et al. 2010; Lyons et al. 2020). The latter can also be of interest considering either a climate change or the potential suitability at smaller scales (e.g., habitat level).

Results and discussion

Taxonomy and nomenclature

***Senecio brasiliensis* (Spreng.) Less., Linnaea 6: 249. 1831**

≡ *Cineraria brasiliensis* Spreng., Neue Entdeck. Pflanzenk. 2: 142. 1820 [1821].

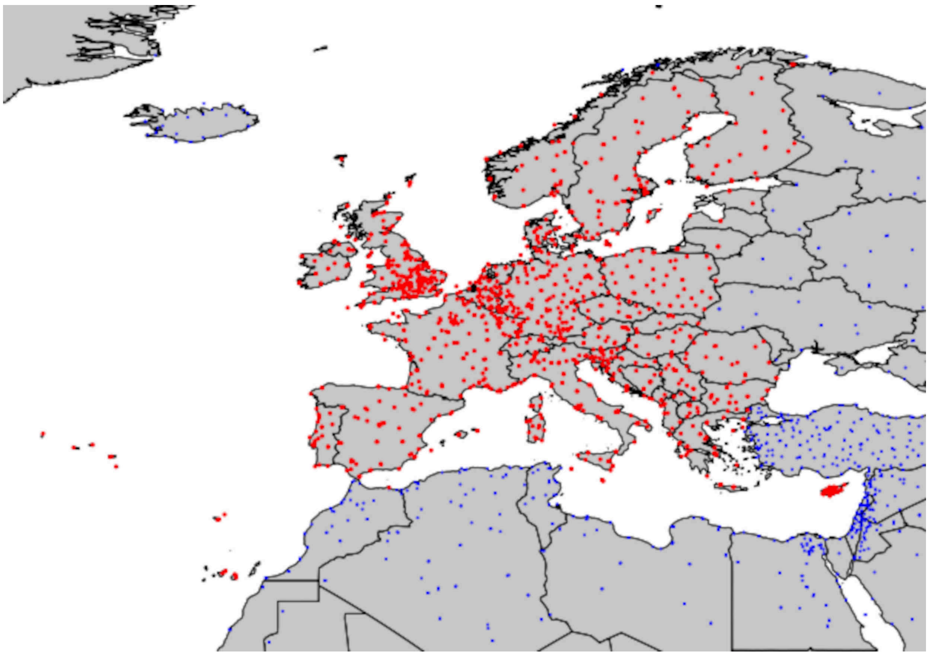

Figure 3. Target area for the climate match analysis showing (red dots) the distribution of the climatic samples (n = 1248, area coverage = 4,943,225 km^2). Blue dots refer to meteorological stations located outside the study area. For further description on the features of the climatic samples, see Crombie et al. (2008).

Type: *F. Sellow* s.n.; no date; Brazil, Rio Grande (holotype G-DC image available at: https://www.ville-ge.ch/musinfo/bd/cjb/chg/adetail.php?id=337961&lang=en); isotypes: MNHN-P-P01816895 (image available at: http://coldb.mnhn.fr/catalognumber/mnhn/p/p01816895) and MNHN-P-P01816896 (image available at: http://coldb.mnhn.fr/catalognumber/mnhn/p/p01816896)

= *Senecio cannabinifolius* Hook. & Arn., J. Bot. (Hooker) 3: 341. 1841.

= *Senecio megapotamicus* H. Buek. Gen. Sp. Synon. Cand. 2: 6. 1840.

= *Senecio tripartitus* DC., Prodr. 6: 418. 1837 [1838].

Erect glabrous herbaceous perennial, 100–200 cm tall, much-branched and densely leafy throughout. Leaves 6–12 cm long, alternate, sessile, deeply pinnatisect with 2–4 pairs of linear segments 25–50 mm long and +/– 2 mm wide, margins slightly serrate, upper surface green, lower surface much paler and slightly cobwebby. Inflorescence a terminal multi-flowered corymb; heads radiate, campanulate, 3.5–4 mm diam., glabrous; involucral bracts 16–20, 5 mm long, acute; bracteoles present (less numerous), shorter than bracts. Ray florets female, +/– 12 in number; 4–5 mm long, bright yellow. Disc florets bisexual, numerous, yellow. Cypselae densely pubescent, 1.2 mm long, brownish; pappus white, 5 mm long (adapted from Cabrera 1957, 1985; Cabrera et al. 1999). Diploid (2n = 20) (Waisman et al. 1984). See also Figure 4.

Herbarium specimen: Portugal: Matosinhos, Santa Cruz do Bispo, 41.213854; −8.681631, port area, 12 May 2017, *P. Alves* s.n. (BR 0000026784496V and BR 0000026784519V).

Senecio brasiliensis is part of *Senecio* s. str. (Pelser et al. 2007) and belongs to series *Corymbosi* (Cabrera) Cabrera, more precisely—based on the pinnatisect leaves that are not auriculate at base—to subseries *Brasilienses* (Cabrera) Cabrera & Freire (Cabrera et al. 1999). Key characters

Figure 4. View of a naturalized population of *Senecio brasiliensis* (Asteraceae) in Matosinhos (Porto, Portugal).

that immediately distinguish it from congeneric species in Europe, native or alien, are the very deeply pinnatisect leaves with linear segments that are green above and slightly cobwebby beneath. It is, however, an exceedingly variable species, especially with regard to leaf characters; based on width and indumentum of leaf segments and the presence or absence of teeth along margins, three varieties are usually accepted: *S. brasiliensis* var. *brasiliensis* (with entire leaf segment margins and cobwebby-hairy lower leaf surface), *S. brasiliensis* var. *incanus* Baker (similar to var. *brasiliensis* but with serrate leaf segment margins and densely hairy upper leaf surface) and *S. brasiliensis* var. *tripartitus* (DC.) Baker (similar to var. *incanus* but with more or less glabrous leaf surfaces; it also tends to have wider leaf segments, see Cabrera 1957). These varieties are probably of limited taxonomic value. The Portuguese plants combine the slightly but definitely cobwebby lower and glabrous upper leaf surface of var. *brasiliensis* with the slightly serrate leaf segment margins of var. *tripartitus*. Plants formerly found in North America were ascribed to the latter variety (as *S. cannabinifolius*; Barkley 2006).

Distribution and habitat

Senecio brasiliensis is native to Brazil, Paraguay, Uruguay, Argentina and Bolivia (Cabrera 1957, 1985; Cabrera et al. 1999) (Figure 1). It is a serious agricultural weed in Argentina, Brazil and Uruguay (e.g. Holm et al. 1979; Lorenzi 1991). It was formerly introduced accidentally to the United States (Florida) where it seems not to have persisted (Barkley 2006). In Europe, it was once recorded as a casual wool alien in the British Isles in the second half of the 19th century (Hayward and Druce 1919; Clement and Foster 1994).

A naturalized population of *Senecio brasiliensis* was found in the Matosinhos port area (Porto district, Santa Cruz do Bispo, Portugal, 41.213854; −8.681631) on 12 May 2017 (Figure 5). The area, located at 55 m above sea level, is classified as CSb, "Warm temperate climate with dry summer" (Kottek et al. 2006). Mean temperature and mean annual rainfall of the area are 14.3 °C and 1,217 mm respectively. January and February are the coldest months with average minimum temperature of 5.6 °C and 5.9 °C, respectively. Summers are warm with low precipitation levels. The least amount of rainfall is in July, with 15 mm, and the greatest amount of rainfall in January, with an average of 165 mm (see https://en.climate-data.org/europe/portugal/santa-cruz-do-bispo/santa-cruz-do-bispo-1045192/ for more detailed numeric information).

Seedlings, juvenile and adult flowering and fruit-bearing individuals were seen in the field. In 2017 around 10–20 individuals were counted. The individuals found in 2017 occurred in several habitat types, specifically hygrophilous woodlands dominated by *Salix atrocinerea*, in the fringe of *Eucalyptus globulus* and *Pinus pinaster* mixed plantations and in disturbed ground dominated by small shrubs, perennial grasses and forbs (e.g. the invasive aliens *Baccharis spicata* and *Cortaderia selloana* and native *Dittrichia viscosa*). The area and its surroundings were visited again in 2018 and 2020. In 2018, the hygrophilous woodland dominated by *Salix atrocinerea* was clear-cut and the number of individuals increased, reaching up to 50 specimens. In the central area of distribution, most specimens were found growing in disturbed grounds dominated by annuals (*Andryala integrifolia*, *Bromus diandrus* and *Erigeron sumatrensis*), perennials (*Pteridium aquilinum* and *Holcus lanatus*), scattered *Salix atrocinerea* and *Eucalyptus globulus* with shrubby habit. Several individuals had the lower cauline leaves dried-up, probably indicating that they were

Figure 5. Aerial view of Matosinhos port area (Porto, Portugal) depicting *Senecio brasiliensis* (Asteraceae) colonised sites (black and yellow bullets).

growing in more exposed circumstances, with direct sun all day. The individuals detected in 2017 under the shadow of trees did not appear to have any signs of hydric stress. It is interesting to highlight that when soil water level becomes unfavourable, the species behaves as monocarpic (Karam et al. 2002). Further, in the intervening years, several other nuclei were found in similar habitats in the same area (Figure 5). The two most distant locations were separated by 1,026 m. This may suggest that the species is more abundant than initially though, locally well-established and probably also occurring in localities that are impossible to prospect (private lands). The habitats occupied by *Senecio brasiliensis* in Portugal

Table 2. Number and percentage of climatic suitability and near-suitability areas obtained with each model.

	Model 1	Model 2	Countries appearing in both models
Percentage and number [n] of suitable areas [score ≥ 7]	29.7% [370]	25.1% [313]	
Percentage and number [n] of limit areas [score = 6]	17.8% [222]	15.7% [196]	
Number and names of European countries with at least one suitable [score ≥ 7] locality	18 Albania, Belgium, Bosnia-Herzegovina, Bulgaria, Croatia, Cyprus, France, Greece, Ireland, Italy, Macedonia, Malta, Montenegro, Netherlands, Portugal, Slovenia, Spain, United Kingdom	19 Albania, Germany, Bosnia-Herzegovina, Bulgaria, Croatia, Cyprus, France, Greece, Hungary, Italy, Macedonia, Montenegro, Portugal, Slovenia, Slovak Republic, Spain, United Kingdom (England), Romania, Serbia.	14 Albania, Bosnia-Herzegovina, Bulgaria, Croatia, Cyprus, France, Greece, Italy, Macedonia, Montenegro, Portugal, Slovenia, Spain, United Kingdom (England)

are similar to those occupied in its native area (arable or pasture fields, roadsides, vacant lots, exposed river and lake margins, etc.).

Potential introduction pathway

Since *Senecio brasiliensis* is so far recorded as naturalized from nowhere else in Europe, it would appear to have been accidentally introduced into Portugal, perhaps directly from South America, although the possibility that it might be established elsewhere in the world cannot be ruled out. For species that are easily transported over long distances by human assistance, it can be difficult to establish the true country of origin. The most plausible hypothesis is that it entered through the shipments that arrive daily at the Leixões harbour. One of the materials presently with more demand by the Portuguese pulp industry are logs of eucalyptus imported from Brazil and Uruguay. As the seeds of this species have a very effective wind dispersing capacity, it is likely that it arrived amidst imported wood material. This hypothesis is corroborated by the fact that another species (*Baccharis spicata*), with similar dispersion characteristics and originating from the same region in South America, was recently found in the same location (Verloove et al. 2018). Interestingly, *S. brasiliensis* was discovered during a mapping action directed for *Baccharis spicata* in the neighbouring areas of the port. The latter was detected some years earlier in the very same area and was also assessed to be potentially invasive, though less so than *S. brasiliensis* (Verloove et al. 2018). Yet, it has shown to be very prolific and has expanded significantly in Portugal since its initial discovery. It was recently included in the Portuguese list of invasive prohibited species (Decreto-Lei n.º 92/2019 2019). A similar or even worse behavior can be expected for *S. brasiliensis*.

Climatic matching

Our climatic matching analysis showed that in Europe over 25% of the area shows climatic conditions that are compatible with those needed by the species (Table 2). These areas are distributed across 18 and 19 European countries respectively, depending on the model. Fourteen countries appeared

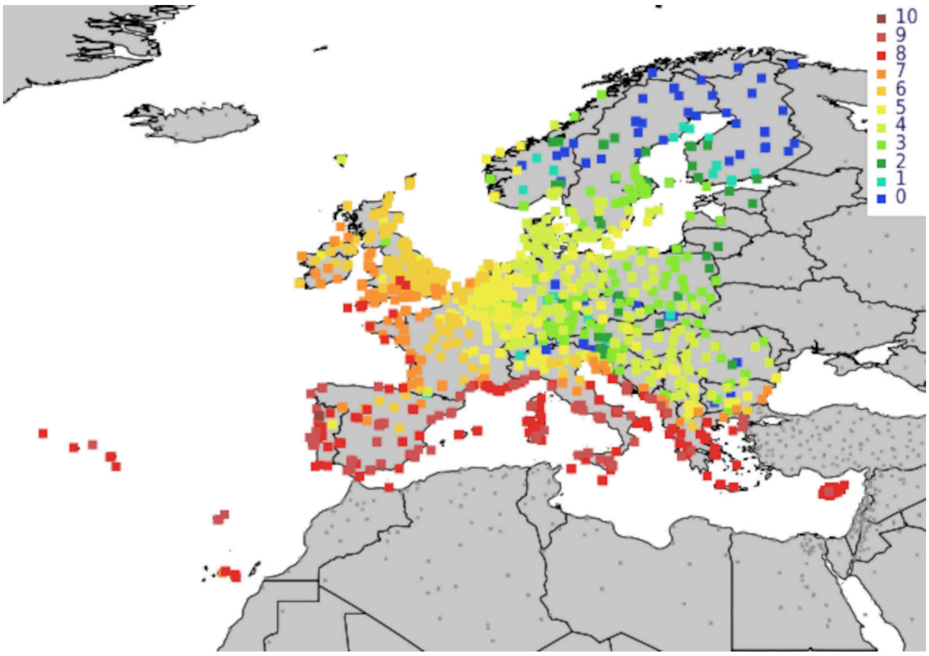

Figure 6. Climate match map showing the suitability of analysed regions for the establishment of *Senecio brasiliensis* (Asteraceae) for model 1 (mean temperature of coldest quarter and mean rainfall of driest quarter). Areas with a score ≥ 7 are considered suitable. Areas with a score = 6 are near-suitable.

to harbour favourable areas (i.e., with a score > 7) in both models (Table 2): Albania, Bosnia-Herzegovina, Bulgaria, Croatia, Cyprus, France, Greece, Italy, Macedonia, Montenegro, Portugal, Slovenia, Spain and the United Kingdom (England). All of them are considered to have areas under "Warm temperate climates" (−3 °C < $T_{\text{monthly mean temperatures of the coldest month}}$ < +18 °C), i.e. "C" type-climate in Köppen-Geiger's system, which is the type of climate represented across vast areas of the species' native distribution (Kottek et al. 2006). Besides, the representation of near-suitable areas (i.e., with a score = 6) was not negligible, with 17.8% (222 stations) in model 1 (Figure 6) and 15.7% (196 stations) of sampled stations in model 2 (Figure 7), which can be of interest under scenarios of future climate change. The conduction of a specific analysis at finer resolutions, such as at local or at habitat level, would be desirable in such cases.

Due to the scale of the analysis, it must be highlighted that, at habitat or quadrat scale, locations with favourable microclimatic and edaphic conditions can result in an increased range of suitable areas. Hence, this suggests that the findings should be considered as conservative at a European scale.

Weed risk assessment

After the analysis of the climatic match, a risk assessment was conducted (see Supplementary material Appendix 1). The analysis showed that *Senecio brasiliensis* must be considered as a species with high risk, since it reached a score of 18, the critical threshold for considering a species as potentially invasive being a score > 6. All except two of the 49 questions were answered (13 about biogeography, 12 about undesirable attributes and 24 about

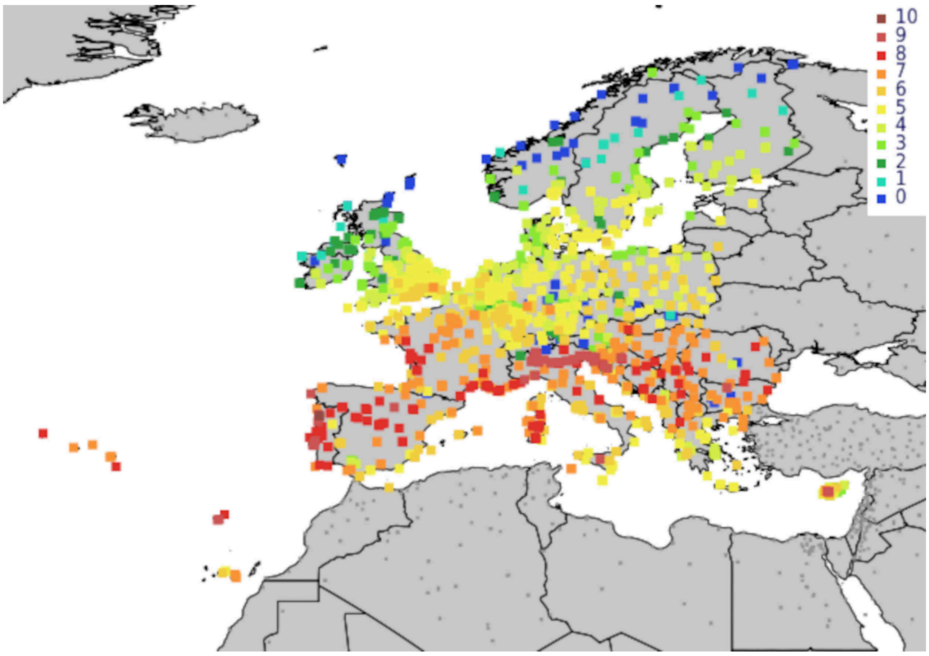

Figure 7. Climate match map showing the suitability of analysed regions for the establishment of *Senecio brasiliensis* for model 2 (mean rainfall of warmest quarter and mean temperature of warmest quarter). Areas with a score ≥ 7 are considered suitable. Areas with a score = 6 are near-suitable.

biology/ecology). The high score of 18 pt. was caused by the presence of a number of key characteristics related to the invasion process and impact. Some outstanding aspects contributing to such a high score were climate similarity between native and potentially alien range, weedy behaviour of the species in agricultural, forestry, pastures and ruderal sites (Hashimoto 1977; Kissman and Groth 1993; Marzocca 1994; Lorenzi 2000; Carneiro and Irgang 2005; De Carvalho 2013; De Egea et al. 2016), its repeated history of introductions (Hayward and Druce 1919; Clement and Foster 1994; Barkley 2006) or the existence of important co-generic weeds (Lafuma et al. 2003; Heger and Böhmer 2005; López-García and Maillet 2005; Caño et al. 2008; Vilatersana et al. 2016). Other important traits also contributed to the final score. Some of these traits were explicit, e.g. its competition through allelopathy (Cruz-Silva et al. 2009) or unpalatability and toxicity to both grazing and non-grazing animals, since a wide range of animal taxonomic groups can be affected (Méndez et al. 1990; Ribeiro et al. 2009; Poncio 2010). Important also is that toxicity can be observed either by direct consumption of *S. brasiliensis* in the field (Riet-Correa et al. 1993; Pessoa et al. 2013; Sandini et al. 2013, 2015; Panziera et al. 2018) or indirectly, as contaminant of silages or hays (Biffi et al. 2018). Moreover, it was found to be toxic to humans due to the potential carcinogenic and mutagenic effects of Pyrrolizidine alkaloids (Méndez and Riet Correa 2008; Spinosa et al. 2008). The latter potential risk merits specific studies for in case the species comes into the trophic chain, by being inadvertently harvested as weed contaminant (Karam et al. 2011). *S. brasiliensis* was also found to host recognised pests and pathogens (de Oliveira et al. 2003) and to potentially cause a negative impact on native *Senecio* species through hybridization (López et al. 2008).

WRA are key for the management of natural resources since they provide useful information as a primary step to help building models for decision taking (Dana et al. 2019). Several countries such as Spain (Ministerio de Agricultura, Alimentación y Medio Ambiente 2013) and regions such as the European Union (European Commission 2018) have imposed risk assessments as a mandatory previous step to adopt legislative and regulatory measures.

Once it has been introduced, *Senecio brasiliensis* may rapidly naturalize thanks to traits also encountered in other weedy Asteraceae, such as herbaceous or short-live perennial *Senecio* species. Some further examples of adaptive traits observed are wind dispersal, independence of specialist pollinators and the capability to grow even on infertile soils (Cabrera and Klein 1975; Matzenbacher 1998; Solera et al. 2007; Teles 2008; Achinelli et al. 2014). Hence, *S. brasiliensis* can naturalize and then spread, even inadvertently, as other weeds do. This should lead to adopt preventive measures that—although they are not generally put into practice—should be common usage in agricultural preventive measures for weed management strategies to reduce its spread. One of them includes cleaning of wheels and lower parts of combines, tractors, etc. prior and after use, as an attempt to prevent spread onto other locations and analyses of hays, silages and harvested seed.

Overall, the species showed most of the critical characteristics related to invasiveness, while the climatic conditions of the native area were found to be significantly similar to those present across a considerable area of Europe. Therefore, *Senecio brasiliensis* must be considered as a species with high risk of becoming invasive and provoking nuisance to human activities. Consequently, urgent measures should be taken. At this stage, these measures should consist in a thorough prospection of the region to detect other potential patches and sustained eradication campaigns at plot level using appropriate herbicides that should be applied before fruit set.

Conclusions

Since *Senecio brasiliensis* is classified as a species showing high risk, special attention should be paid to this species and effective control measures implemented by the Portuguese and European responsible Administrations. The results of climatic matching further indicate that, in Europe, large areas show climate types that are suitable for the species.

Acknowledgements

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Supplementary material

The following supplementary material is available for this article:

Appendix 1. Weed Risk Assessment following Pheloung et al. (1999).

Appendix 2. References to Appendix 1.

This material is available as part of online article from:
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