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Artículos científicos

Epilobium brachycarpum C. Presl in Europe: forty years later

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Summary

After *Epilobium brachycarpum* C. Presl was first cited in Madrid (Spain) in 1983, the species has multiplied and extended countrywide in the last 40 years. Subsequent new citations indicate its presence in other European countries in western part of the continent. Based on published information and new records from Spain, its expansion in the Iberian Peninsula and Europe in general is summarized.

Keywords: Aliens; invasive flora; globalisation; neophytes; xenophytes.

Resumen

Desde que *Epilobium brachycarpum* C. Presl se citó por primera vez en Madrid (España) en 1983, la especie se ha multiplicado y extendido a lo largo del país durante los últimos 40 años. Nuevas citas indican su presencia en otros países europeos en la parte occidental del continente. A partir de información publicada y nuevos registros en España, se resume su expansión en la Península y Europa en general.

Palabras clave: Exóticas; flora invasora; globalización; neófitos; xenófitos.

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INTRODUCTION

Epilobium brachycarpum C. Presl is an annual willowherb that reaches a height of up to 1.50 m, highly ramified with alternating leaves, either linear or linear-elliptical, with open-paniculate inflorescence, short pedunculate fruits, either linear or linear-elliptic (Solomon, 1982; Nieto, 1997; Hoch, 2012). The species is native to North America and is present in states in central west areas of the USA, and provinces to the south of Canada, from British Columbia to Quebec (USDA, NRCS, 2019). Although its presence south of the US fronter has been occasionally rejected, it has been mentioned in several Mexican states: Durango, Guerrero, Mexico FD, Michoacán, Morelos, Puebla, Oaxaca and Tlaxcala (Munz, 1960; GBIF, 2020 a).

Its presence in Europe has been documented for 40 years with the first record in Madrid (Spain) (Izco, 1983), sub *E. paniculatum* Nutt. Many publications mentioned the presence of the species in

the Iberian Peninsula, in Spain: Pujadas (1986); Rivas Martínez & Cantó (1991), Gavilán et al. (1993), Mateo et al., (1996), Nieto (1997), Martín et al. (2000), Mateo & Pisco (2002), Cardero et al. (2004), Gabriel et al. (2005), Oltra & Conca (2006), Royo (2006), Sanz et al. (2006), Lázaro (2008), Blanca et al. (2009), Castro et al. (2009); Delgado & Paz (2009), García Muñoz (2009), Romero (2009), Acedo (2011), Anonymous (2012), Aymerich (2012), López Tirado (2013), Vázquez & Palacios (2013), Elvira et al. (2014), Lázaro (2012), López Tirado & Jiménez (2014), Rodríguez García et al. (2014), Sánchez & Otero (2014), Salvador (2015), Sánchez Gullón & Verloove (2015), Asturnatura (2016), Márquez et al. (2016), Rodríguez Torres (2016), García Cardo (2018), Mateo (2018), Gestí & Villar (2019), León & Ascaso (2020); it has been also mentioned in Vizcaya (Anonymous, 2012), but it has not been possible to confirm this citation. In Portugal, it is present in the districts of Aveiro, Bragança, Castelo Branco, Guarda and Viseu, all of which lie north of this country (Almeida & Freitas, 2012; Alves & Aguiar, 2012; Marchante et al. 2014).

The first citation in the rest of the European continent is French (Magnanon, 1995), followed in France by other mentions: Provost (1998), Lamaison & Deschatres (2003), Bardet et al. (2008), Bedouet (2009), Verloov & Lambinon (2009), Madre & Mayrand (2018). The distribution of *E. brachycarpum* in France in 10 x 10 km grids, is available in INPN.MNHN (2015). The first citation in Germany appeared at the end of the 20th century, in Palatinate (Lang & Wolff, 1991), followed by many others in different Landers: Lenker (2001), Jung (2002), Hand (2003), Bönsel & Ottich (2005), Höcker & Hetzel (2006), Emrich (2008), Gregor et al. (2013). *Epilobium brachycarpum* is also present in others European continental countries: Czech Republic (Salák & Hadinec, 2017; Kaplan et al. 2018); Italy (Alessandrini, 2016; Alessandrini & Ardenghi, 2018); Belgium (Remacle, 2014a, 2014b; Verloove et al. 2019). The species has also been identified in Great Britain: in Essex (Adams, 2010) and Suffolk (Sanford, 2016) (Fig. 2).

Records in South America of the presence of *E. brachycarpum* as alien can be found in Chile, province of Biobio (Macaya & Faúndez, 1998), and in Argentina's provinces of Córdoba, Chubut, Neuquen and Río Negro (Flora Argentina, 2018). Given its unstoppable expansion, the species has even appeared in New Zealand (Handler, 2009).

Epilobium paniculatum Nutt. is a later synonym of *E. brachycarpum* C. Presl but has been frequently used for years. Accordingly, the proposal put forward by Hoch & Raven (1981) of rejecting the name *E. brachycarpum* as *nomen rejiciendum* and maintaining *E. paniculatum* as a conserved name, was not accepted (Brummitt, 1984). The many specific synonyms of the taxon are listed in *Epilobium brachycarpum* C. Presl in GBIF (2020 b).

Forty years after *E. brachycarpum*'s first quote in Europe, the article aims to show its expansion on this continent and the diversity of habitats it colonizes.

MATERIAL AND METHODS

The materials corresponding to the new localities in Spain are deposited in the SANT Herbarium. Only printed sources of information have been consulted. In addition to bibliographic quotations, other data have been analized from the Global Biodiversity Information Facility (GBIF, 2020 b) and the Biodiversity Foundation-Royal Botanical Garden of Madrid (ANTHOS, 2012). For the transposition of the presences of the species in Spain at the provincial level and in Portugal at

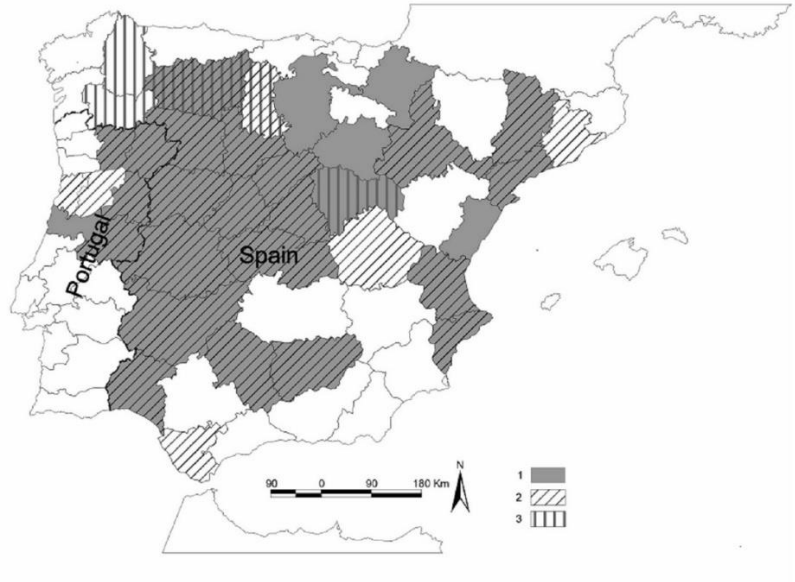
the district level, Google maps has been used. In all cases, the entries *Epilobium paniculatum* Nutt., *E. paniculatum* Nutt. ex Torr. & A Gay. y *E. brachycarpum* C. Presl have been analyzed. The Extend of Occurrence (EOO) of *Epilobium brachycarpum* in the Iberian Peninsula has been done by taking the capitals of Spanish provinces and the capitals of Portuguese districts as polygon angles. Similarly, the calculation of EOO in Europe has been performed by taking the capitals of each country as polygon angles, except for France, where the western vertex has been positioned in La Rochelle to encompass, at least in part, the French populations on the Atlantic coast. To calculate the EOO in the Iberian Peninsula and the rest of Europe, Maps & Directions (2018) has been employed.

RESULTS

The number of papers mentioning *E. brachycarpum* as a neophyte in Spain have grown decade after decade since its first indication in Madrid: 1980 (2), 1990 (4), 2000 (13) and 2010 (16). Portuguese publications are from the 2010s. The Spanish provinces and the Portuguese districts where the species have been mentioned can be seen in Figure 1. Written previous mentions of *Epilobium brachycarpum* indicate its presence in 25 Spanish continental provinces.

The new records correspond to the province of Guadalajara, in central Spain, and the provinces of Orense and Lugo in the extreme northwest of the Iberian Peninsula. In Guadalajara, the species is common in fallow areas and disturbed soils by the preparatory work for the expansion of the capital. In the province of Lugo, the species is distributed into two different areas: to the south by road N-120, from the eastern border with Orense province to near Monforte de Lemos, following the River Sil Valley; to the north by road N-VI (Madrid-La Coruña) on both the southern slope of the Piedrafita del Cebreiro Pass (province of León) and the northern slope (province of Lugo). In the province of Orense, the species is present along the road N-120, from Carballeda de Valdeorras to Petín. In Orense and Lugo, it is present along roads and often around petrol stations. Soils have a limous or limo-clayey texture. Other new findings come from the provinces, where the species was already known, of Palencia, León and Zamora, and correspond to railway stations (Figure 1).

Figure 1. Distribution of *Eplobium brachycarpum* in continental Spain (provinces) and Portugal (districts). 1: Previously web cited administrative entities. 2: Previously published cited administrative entities 3: Newly cited provinces



According to the models of Rivas-Martínez et al. (2004 a, b), the bioclimate viewpoint, the Guadalajara locality is subject to Supramediterranean thermotype climates, in the Biogeographic Mediterranean Region, Western Mediterranean Sub-Region, Mediterranean Central Iberian Province and Castilian Sub-Province. Those from the localities of Orense and south of Lugo are subject to Submediterranean bioclimates in the Biogeographic Eurosiberian Region, Atlantic European Sub-Region and Cantabroatlantic Province, while the citations from the Piedrafita of Cebreiro Pass are subject to Supratemperate Supramediterranean climates in the Biogreographic Eurosiberian Region, Atlantic European Sub-Region and Orocantabrian Province.

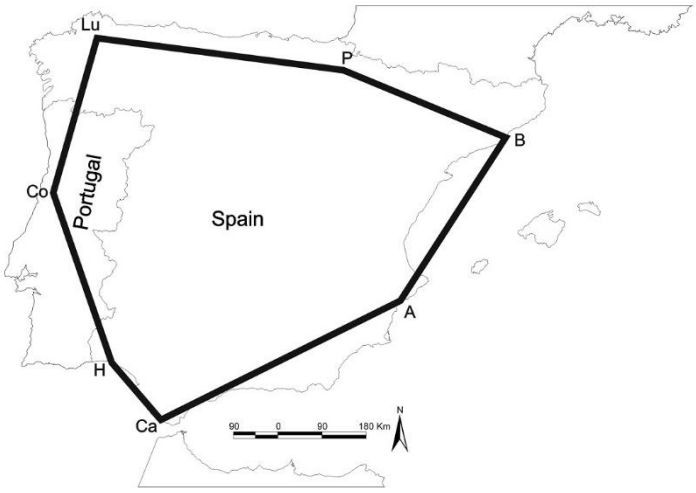
DISCUSSION

Information on the presence of *E. brachycarpum* in the Iberian Peninsula is expanded on the web. According to ANTHOS map (2020) it is present in the provinces of Avila, Badajoz, Cáceres, Castellón de la Plana, León, Lérida, Lugo, Madrid, Salamanca, Segovia, Tarragona, Valencia, Valladolid and Zaragoza. However, the point of Lugo province does not correspond to the associated information; on the contrary, the mentioned locality 'Campo' belongs to the Municipality of Ponferrada, province of León, with coordinates 42°32′15″N 6°33′40″W. Also, from herbarium samples, GBIF (2020 b) indicates the presence of the species in numerous Spanish provinces: Alicante, Ávila, Badajoz, Burgos, Cáceres, Cantabria, Córdoba, Guadalajara, Huelva, Jaén, León, Lerida, Lugo, Madrid, Navarra, Palencia, Salamanca, Segovia, Soria, Toledo, Valencia, Valladolid, Zamora, Zaragoza. The point that indicates on the map the presence of the especies in the province of Lugo is also a typo, since the associated data also correspond to the locality of Campo (León), as in ANTHOS. It is the same for the point indicating the presence of the species in Cantabria, since the associated information states that the locality is Pozuelo de Alarcón (Madrid), with coordinates 40°26′27″N 3°48′53″W. GBIF (*loc. cit.*) also indicates the presence of the species

in the Portuguese districts of Bragança, Castelo Branco, Coimbra, Guarda and Viseu. These same Portuguese districts are also indicated in Araujo et al. (2019).

In the last forty years, the species has rapidly expanded in the Iberian Peninsula. Currently, in mainland Spain it is present in 34 provinces out of a total of 47, or 73%, and in Portugal it is present in 4 continental districts over a total of 18 (22%). The Iberian EOO has an approximate area of *c.* 450,000 km^2 (Fig. 2).

Figure 2. Extent of Occurrence for *Epilobium brachycarpum* in the Iberian Peninsula
A: Alicante. B: Barcelona. Ca: Cádiz. Co: Coimbra. Lu: Lugo. P: Pamplona. H: Huelva



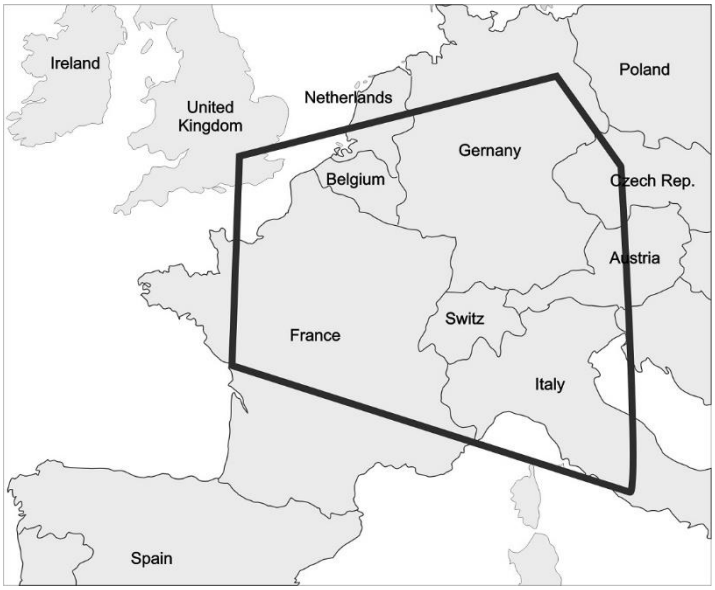
The global distribution of the panicled wilowherb in the Iberian Peninsula according to the proposal of Rivas-Martínez et al. (2004 a, b), extends across most of the Mediterranean Region, Western Mediterranean Subregion, in the chorological provinces Mediterranean West Iberian (Luso-Extremaduran and Carpetano-Leonese Sectors), Betican, Mediterranean Central Iberian (Castilian, Oroiberian and Low Aragonese Sectors), Balearic-Catalan-Provençal (Valencian-Catalonian Sector); in the Eurosiberian Region, Atlanic-Central European Subregion in the chorological province Atlantic-European (Cantabro-Atlantic and Orocantabrian Provinces) and in the Alpine-Caucasian Subregion, Céveno-Pyrenean Province (Central-Pyrenean Sector). From a bioclimatic point of view, *Epilobium bachycarpum* in the Iberian Peninsula is present in the termotypes Thermomediterranean, Mesomediterranean, Supramediterranean, and Mesotemperate Submediterranean; as far as the ombrotypes are concerned, it is present in the Temperate oceanic Submediterranean and Mediterranean pluviseasonal oceanicones.

The wide distribution of *Epilobium brachycarpum* is determined by its annual condition, its dispersion either by air (anemochory) or adhering to different damp or wettened objects, or on rough surfaces of different vectors as trains and motor vehicles given their alignment by means of railway lines and roads; on other occasions, dispersion is linked to people or animals (zoochory) if we bear in mind its presence in agricultural settings. The species shows a long-distance dispersion

of 1-several km/year (Gregor et al. 2013), that is longincua or in long-distance, sense Font Quer (1963). Its wide dispersion is also based by its wide ecological valence.

As Gregor et al. (2013) point out, the species shows great expansive potential in Europe favored by the genetic diversity of the populations, sourced from at least one triple introduction (Nierbauer et al. 2016). The European EOO –excluded the Iberian Peninsula- cover a surface area of *c*. 980,000 km^2 with the species being present in six countries; France, Germany, Belgium, Italy, the Czech Republic and Great Britain (see Fig. 3).

Figure 3. Extent of Occurrence for *Epilobium brachycarpum* in Europe, excluding the Iberian Peninsula



This species' ecology is broad in North America in wet environments of the USA (Moise et al. 2002; Riefner & Boy, 2007; Hoch, 2019), also in Mexico (Munz, 1960), or in dry environments (Kaplan et al. 2018; Hoch, 2019). In the Iberian Peninsula, findings suggest seasonally wet environments, but they are clearly dry in general. In any case, Iberian populations probably have a different origin than other European populations - in rainy environments during the summer - as their ecology differs because they occupy environments that face severe summer drought conditions (Alves & Aguiar, 2012; Vazquez & Palacios, 2013; López Tirado & Jiménez Conejo, 2014). However, mentions being made to the presence of *E. brachycarpun* in wet environments are not lacking, such as banks of reservoires, lagoons and temporal watercourses (Anonymous, 2012; López Tirado & Jiménez Conejo, 2014), even if they are subject to severe summer drought, which suggests certain humidity requirements of the species during the germination period.

According to López Tirado & Jiménez Conejo (2014), currently in Spain the flora accompying this species is diverse: *Dittrichia viscosa, Verbena officinalis, Daucus carota, Eryngium campestre, Heliotropium europaeum* or *Chrozophora tinctoria*, plants that characterise classes like *Artemisietea vulgaris, Onopordetea acanthi, Plantaginetea majoris* or *Stellarietea mediae*, according

to the phytosociological classification by Rivas-Martínez et al. (2002). In dry environments, the species comes with *Chenopodium opulifolum, Conyza canadensis, Chondrilla juncea, Hirchsfeldia incana* and *Heliotropium europaeum* as part of nitrophilous communities with summer and autumn optimum of the association *Epilobio brachycarpi-Chenopodietum opulifolii* Rivas-Martínez, Navarro et Cantó, the alliance *Chenopodion muralis*, the order *Chenopodietalia muralis,* and the class *Stellarietea mediae* (Rivas-Martínez et al. 2002). In other cases, it can be found on dry semi-natural meadow lands of the class *Festuco-Brometea* or on annual grasslands of the class *Thero-Brachypodietea* (Anonymous, 2012).

In relation to its European extra-Iberian presence, the accompanying species of *E. brachycarpum* are *Erigeron annuus*, *Picris hieracioides, Senecio inaequidans, Conyza canadensis, Daucus carota, Lotus tenuis, Tripleurospermum inodorum, Solidagpo canadensis,* in a community belonging to *Dauco-Melilotion* (Weiss & Gutte, 2007). According to Gregor et al. (2013), in Germany it is accompanied by *Erigeron canadensis, Lactuca serriola, Tripleurospermum perforatum, Daucus carota, Taraxacum* sect. *Ruderalia* and *Aira spicaventi* as part of the association *Erigeronto canadensis-Lactucetum serriolae* Lohmayer et Oberdorfer 1957, and the alliance *Sisymbrion officinalis* Tx. et al. in Tx. 1950, the order *Sisymbrietalia* J. Tx. in Lohmayer et al. 1968. Remacle (2014a) provides a long list of the flora that accompanies *E. brachycarpum* in the city of Treves (Germany), of which a large part is characteristic of the alliance *Dauco carotae-Melilotion albi* and the order *Onopordetalia acanthi: Crepis foetida, Echium vulgare, Hypericum perforatum, Inula conyzae, Melilotus albus, Senecio inaequidens* (http://www.omnibota.com/View/Flora_group.php?Type=2&Groupe=69).

Generaly speaking, in Europe the species forms part of communities of different phytosociological classes: *Stellarietea mediae, Artemisietea vulgaris, Molinio-Arrhenatheretea, Bidentetea tripartitae, Isoeto-Nanojuncetea* and *Polygono-Poetea annuae*, mainly of the first.

CONCLUSIONS

Epilobium brachycarpum has been introduced to Europe repeatedly over the past forty years. Since these introductions it has expanded through the west of the continent, as has been documented by numerous collections referred to in numerous publications. From its previous behaviour his expansion in Europe is not over, always linked to anthropic environments. As far as mainland Spain and Portugal are concerned, there do not appear to be any limits to colonize the rainy strip of the northern peninsular or the southern territories with Mediterranean climate.

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