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Original article

Cortaderia selloana invasion across a Mediterranean coastal strip

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ABSTRACT

The invasive success of *Cortaderia selloana*, an alien perennial grass introduced from South America, was assessed by comparing plant and population performance in ruderal and non-ruderal habitats across a Mediterranean coastal strip. The main habitat differentiation criterion was the absence or presence of visible signs of recent disturbances. Plant functional group richness (i.e. number of plant groups classified as grasses, herbs, shrubs, vines and trees), total plant cover and percentage of bare ground was calculated in each habitat. In addition, soil samples were randomly taken in order to analyse total soil C, total N, $CaCO_3$, pH and soil texture. *Cortaderia selloana* populations were characterized by calculating total density, proportion of juvenile plants, plant volume, number of panicles and reproductive effort (i.e. number of panicles/plant volume) and fecundity per unit area (number of panicles per ha).

We compared whether population characteristics and plant performance were associated with biotic and abiotic habitat factors. We expected a better performance of *C. selloana* in ruderal habitats than in non-ruderal habitats. As expected, ruderal habitats had larger and denser *C. selloana* populations and recruitment was very high (the proportion of juvenile plants was more than 50%). In consequence, in ruderal habitats, on average, plants were smaller, produced fewer panicles, and had a lower reproductive effort. The high percentage of bare ground, low pH and low functional group richness were the best explanatory variables associated to *C. selloana* invasion success.

1. Introduction

The increasing number of intentional or accidental human introductions of species that is occurring around the world is threatening the conservation of biodiversity through direct and indirect impacts on native species and the modification of ecosystem functions (Vitousek, 1994; Enserink, 1999; Mack and Lonsdale, 2001; Cole and Landres, 2004).

Invasion success not only depends on the characteristics of alien species but also on invasibility, the ecosystem's intrinsic capacity to favour species' survival independently of their introduction rates (Lonsdale, 1999). Invasibility depends both on

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abiotic and biotic factors (Rejmánek et al., 2005). Yet it is not always clear which ecosystem characteristics favour or hinder the invasion of a particular alien species because performance of a species depends on multiple ecological factors (Hobbs and Humphries, 1995). Soil nutrient pulses and suitable climatic conditions are reported to favour ecosystem invasibility (Rejmánek, 1989; Hobbs and Huenneke, 1992; Bastl et al., 1997; Davis et al., 2000). Ecosystem invasibility may increase as there are more resources available to invaders (Davis et al., 2000) and decrease with environmental harness (Davis et al., 1999; Higgins et al., 1999). In addition, disturbances can promote invasions either through a reduction of plant competition, an increase in the availability of specific resources or an increase of the entrance of invader propagules (Hobbs, 1989; Hobbs and Humphries, 1995).

Ruderal habitats, defined as disturbed areas are highly invaded (Lincoln et al., 1998). For example, in the alien flora of the Czech Republic 62.8% of invasions occur in human-made habitats while 11.0% have been recorded in seminatural habitats (Pysek et al., 2003; Chytrý et al., 2005). Similarly, in Spain from 637 naturalised plant species (13% total flora), most of them (44.67%) are found in ruderal and disturbed habitats (Vilà et al., 2001, 2007). Ruderal habitats are characterized by receiving a high propagule pressure and frequent disturbances, which increase their susceptibility to plant invader establishment with respect to unaltered habitats (Tyser and Worley, 1992). Given these differences in the degree of invasion between ruderal and non-ruderal habitats, we focused the present study on finding ecological factors associated to invasions in ruderal habitats.

Ruderal habitats are a common element in the Mediterranean landscape because of widespread modification by humans (Naveh and Vernet, 1991). Most of the alien species that have been intentionally or accidentally introduced are able to successfully invade ruderal habitats (Le Floc'h, 1991). *Cortaderia selloana* (Pampas grass) is an invasive plant species native to South America now invading old fields, riverine and marshland areas worldwide. We assessed *C. selloana* invasion in ruderal and non-ruderal habitats spread along the Catalan Mediterranean coastal strip (NE Spain) by comparing if population characteristics and plant performance were associated to biotic and abiotic ecological factors differing between ruderal and non-ruderal habitats. We expected a better *C. selloana* performance in ruderal habitats than in non-ruderal habitats.

2. Materials and methods

2.1. Field survey

From mid August to mid September 2004, at the stage of plant flowering, we conducted a survey of 27 introduced populations of *C. selloana* in a Mediterranean coastal strip in Catalonia (NE Spain). Coordinates and altitude above sea level of each population were measured with a GPS. Mean annual temperature ranged from 15 to 17 °C and mean annual rainfall varied from 400 to 700 mm. The habitat was classified "a priori" as ruderal or non-ruderal. The main habitat differentiation criterion was the visual identification of signs of anthropogenic disturbance in ruderal habitats. Ruderal habitats had trampled areas and waste deposits while non-ruderal habitats were mainly old fields, grasslands, woodlands and marshes without signs of recent disturbances (Table 1).

Populations were less than 35 km from the seashore and they were at least 1 km apart; the same distance chosen in a previous study that used herbarium records to determine the expansion history of *C. selloana* in California (Lambrinos, 2001). A population was identified as a group of 5 or more plants present in an area where *C. selloana* could really spread in any direction. Populations situated in road sides or agricultural field margins were not included in our survey because they could only spread linearly.

Vegetation characteristics of each invaded site were estimated by the point-intercept method conducted in one 50-m line transect in the centre of each population. We identified all functional groups (i.e. grasses, herbs, shrubs, vines and trees) found every 50 cm. Plant functional group richness (i.e. number of functional groups), total plant cover and percentage of bare ground was calculated in each site. In each site we randomly took 5 soil samples of the first 20 cm mineral soil with a 6 cm diameter drill. Soil samples of each site were pooled after air-drying on flat trays in the laboratory and we

Table 1 – *Cortaderia selloana* populations surveyed in a Mediterranean coastal strip of Catalonia (NE Spain)

Code	Location	UTM coordinates		Altitude (m.a.s.l.)	Habitat
		X	Y		
1	Roses	510750	4679323	0	Non-ruderal
2	Rubina	512231	4679854	1	Non-ruderal
3	Dos Rius	507650	4671121	0	Non-ruderal
4	Empuriabrava	509682	4676255	0	Non-ruderal
5	Malgrat de Mar	477828	4611642	32	Ruderal
6	Blanes	482492	4614647	20	Ruderal
7	Blanes-Lloret	482928	4614957	20	Ruderal
8	Lloret	484952	4615929	23	Ruderal
9	Lloret-Tossa	489996	4617685	103	Ruderal
10	Sta. Maria de Lloret	492372	4618622	131	Ruderal
11	Tossa	484781	4620686	163	Ruderal
12	Mollet	434621	4599996	85	Ruderal
13	Parets	436127	4601152	73	Non-ruderal
14	Matadepera	419200	4605353	405	Non-ruderal
15	Terrassa (Sta. Margarita)	419189	4599821	239	Ruderal
16	Terrassa (Les Fonts)	420590	4599318	242	Ruderal
17	Sant Boi	420436	4577016	23	Ruderal
18	Regarons	419718	4570752	3	Non-ruderal
19	Castelldefels	419587	4569946	0	Non-ruderal
20	Filipines	420647	4570227	3	Non-ruderal
21	Mallola de Dalt	418715	4569935	0	Non-ruderal
22	Gavà Mar	417996	4569770	0	Non-ruderal
23	Viladecans	418189	4570365	0	Non-ruderal
24	Toro Bravo	421225	4570632	5	Non-ruderal
25	UAB	424524	4594041	171	Ruderal
26	Calafell	379153	4560457	350	Non-ruderal
27	Vinaròs	287582	4485612	6	Non-ruderal