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Spartina patens as a weed in Galician saltmarshes (NW Iberian Peninsula)

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Abstract

Spartina patens (Gramineae) is an American coastal grass which grows in a wide range of coastal habitats in its native area. After it was discovered in some Galician wetlands two years ago, we undertook a regional survey whose preliminary results reveal that this grass is actually a rather common species in Southwestern Galicia, being present in several coastal habitats also. Nevertheless, it is in saltmarshes where it seems to compete more successfully, invading rush communities that have been traditionally harvested for cattle bedding. In many estuaries, it tends to form dense monospecific stands and could become a serious threat to high marsh plant diversity. In order to evaluate the impact of *S. patens* as an invasive weed in saltmarshes, we have performed a transect study, which seems to indicate that *S. patens* establishes preferentially in the upper marsh (but reaching higher coverages in the uppermost part of its altitudinal rank), where it has a significant negative effect on species diversity as well as on total cover of other species.

Introduction

Spartina patens (Ait.) Muhl. (Gramineae) is a perennial rhizomatous grass that grows in a wide range of coastal habitats. It has long been known to be present along Western Mediterranean coasts, but had not been recorded on the northern Iberian coast up to the present (Bueno, 1997; Campos & Herrera, 1997). On the other hand, former records exist from other parts of the Iberian Peninsula between the Mediterranean Spanish–French and Atlantic Spanish–Northern Portuguese borderlines.

There is no agreement on the origin of this taxon on the Atlantic coasts of Europe, since it has traditionally been reported as *S. versicolor* Fabre and considered as a native Mediterranean species (Fabre, 1849; Tutin, 1980; Van der Maarel & Van der Maarel, 1996). It has also been known as *S. patens* (Aiton) Muhlenberg, previously described as original from the Atlantic coasts of North America. Nevertheless, since the early days, many authors have considered them to be the same single species (Cosson & Durieu, 1867; Fernald, 1929; Mobberley, 1956; Hultén, 1958, and other people later), introduced from America to the Mediterranean Sea (see Hultén, 1958: 287, Figure 268, for distribution map). While the North American populations are very variable (Silander & Antonovics, 1979), the European ones always show a very reduced flowering (Fabre, 1849; Pignatti, 1982; our own data) and their morphology resembles that of the American variety *S. patens* var. *monogyna* (Curtis) Fernald (Hultén, 1958). Nevertheless, in his review of the genus, Mobberley (1956) regarded all the infraspecific taxa as synonyms of *S. patens*, not recognizing any consistent differences among the North American populations or between them and the European ones.

It is probable that the plant was introduced first to various ports around the Mediterranean, as it was used as packing material in ships boxes and crates. So, it might have been established locally from this material and eventually spread out along the coast (Silander, *in litt.*). Saint-Yves (1932) also supports this theory, since the Gulf Stream itself would not have been enough to transport the plants so far.

Being a strong rhizomatous invasive species (Daehler & Strong, 1996), the presence of *S. patens*

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in NW Iberian saltmarshes could represent a considerable impact on the native plant communities. Looking to these precedents, this work intends to present initial data concerning the distribution of *S. patens* in Galicia, its frequency and its preferred habitats. The preliminary results of this regional survey lead us to select a representative site on the SW Galician coasts to undertake a more detailed study on the frequency of the weed in this part of Galicia. As for its ecological characterization and impact assessment, we try to delimit its altitudinal position with respect to plant communities of NW Iberian saltmarshes and to evaluate the effect of its intrusion on plant diversity.

Material and methods

The plant

In contrast to the huge amount of studies on the ecology of *S. patens* in the U.S.A., this plant has commonly been neglected in Europe, probably because its populations, wich rarely flower, are easy to confuse with other common coastal grasses (Pignatti, 1982).

Based on the existing studies carried out in North America, *S. patens* does not tolerate waterlogging and the growth and size of the plant is controlled largely by drainage: in poorly drained areas it tends to be eliminated and replaced by other species (Chapman, 1974). On the other hand, according to Silander (*in litt.*), *S. patens* is not very drought tolerant, but there is ecotypic variation between the American populations, and some clones are better adapted to certain locations than others (however, this variation depends largely on the competing species present). It grows well along a gradient of soil moisture conditions from sand dunes to marshes, and the ability of *S. patens* to develop aerenchyma in response to flooding may be important in maintaining flood tolerance and competitive ability in habitats at various positions on a soil waterlogging gradient (Burdick, 1989). Also, Hester et al. (1996) proved that *S. patens* displays a highly significant intraspecific variation in lethal salinity level, as well as in plant morphological variables (leaf rolling, leaf expansion rates; aboveground, belowground and total biomass, and aboveground/belowground ratio). Nevertheless, none of these variables was associated with the variation in salt tolerance.

In America, sterile clones have been found mainly in the tropics, and less frequently elsewhere (Silander, *in litt.*); in contrast, but in common with other places of Europe, this grass rarely if ever flowers in Galicia (only one spike has been found to date). Looking at its wide distribution it seems to spread easily by rhizome fragments carried by currents and tides (Saint-Yves, 1932). Apparently, the Galician plants grow mainly in saltmarshes – where they reach the highest densities, coverages and heights. Similar results were obtained by Silander & Antonovics (1979) in America. However, this plant can also be found in other places in Galicia, those with tidal influence or wet saline substrate, like beaches, rocky shores, wet dunes and dune slacks.

Distribution in Galicia

In order to assess the current status of the *S. patens* invasion in Galicia, we undertook a broad survey along the coastline, searching for the presence of the species in every 10 × 10 km quadrat of the UTM grid reference system but recording sites with a 1 × 1 km accuracy. In order to determine its distribution pattern on a smaller scale we carried out a more detailed study within one of the 10 × 10 km quadrats (UTM 29TMH91) at the Corrubedo Natural Park, where *S. patens* stands were mapped on a 1:5000 scale which allows us to locate them with a margin of error of less than 10 m.

Altitudinal range and effects on plant diversity

In that site, in order to check for any changes in composition of plant communities invaded by this grass, we sampled locally along three belt transects (T1, T2, T3) across saltmarsh stands of *S. patens* located in the landward zone of a coastal lagoon (see Figure 2). Here, vegetation was analyzed in 50 × 50 cm quadrats along the entire length of each transect (220 m in total), following the methodology of Sánchez et al. (1996). For each species in each quadrat, the cover was estimated visually on a modified Braun-Blanquet scale (1=<10%, 2=10–25%, 3=25–50%, 4=50–75%, 5=>75%). The altitude of each quadrat was determined at the centre of each side between consecutive quadrats, with the aid of a Fuji-Koh FL25M engineer's level and level rods, at the nearest cm. Altitudes were related to the highest tidal level recorded for each transect during the second semester of 1998. Vegetation was characterized based on relevés representative of different plant communities, following Izco et al. (1992) and Izco & Sánchez (1996).

The following plant communities were visually identified along the transects: *Limonio serotini - Juncetum maritimi* subass. *typicum* (henceforth **LJ**), *Li-*

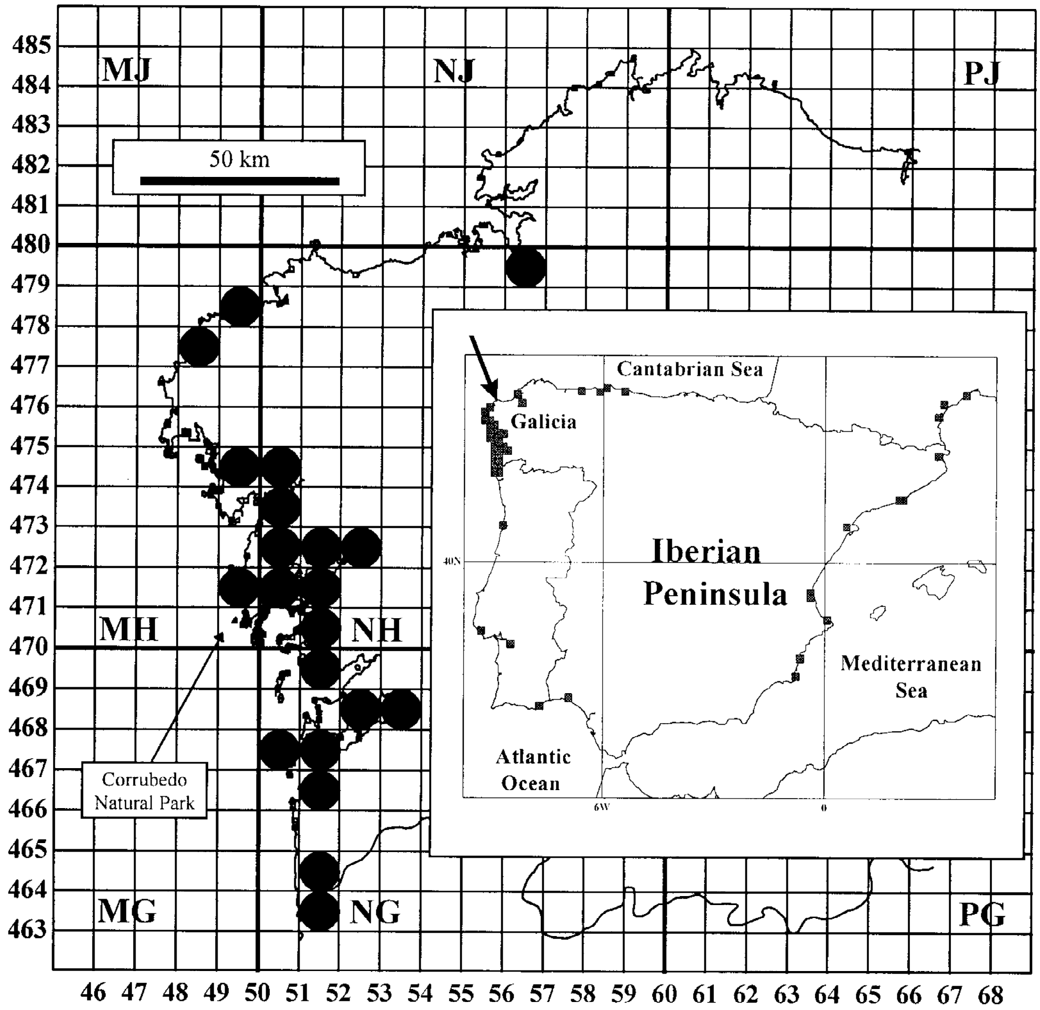

Figure 1. Distribution of *Spartina patens* in Galician saltmarshes in a grid of 10×10 km quadrats (UTM zone 29T) and localization within the Iberian Peninsula.

monio serotini - Juncetum maritimi subass. *halimionetosum portulacoidis* (**LJh**), *Limonio serotini - Juncetum maritimi* subass. *paspaletosum vaginati* (**LJp**), *Agrostio stoloniferae - Juncetum maritimi* subass. *typicum* (**AJ**), *Agrostio stoloniferae - Juncetum maritimi* subass. *stenotaphretosum secundati* (**AJs**), *Bostrychio scorpioidis - Halimionetum portulacoidis* (**BH**), *Puccinellio maritimae - Arthrocnemetum perennis* (**PS**) and patches dominated by *Arthrocnemum perennis* subsp. *alpini* (**Sa**) and by *Spartina patens* (**Sv**). Nomenclature follows Izco et al.. (1992) and Izco & Sánchez (1996).

Data analysis

In order to know the relationship between altitudinal range and abundance of *S. patens* as well as their influence on plant diversity, only the 55 quadrats with a presence of *S. patens* were used in the statistical analysis:

1. Altitudinal range of *S. patens*: mean altitude (non-weighted and weighted by abundances) was calculated, together with Spearman's correlation between altitude and coverage index.
2. Impact of *S. patens* on plant diversity (number of species) and total cover of other plants was tested with two regression analyses, considering

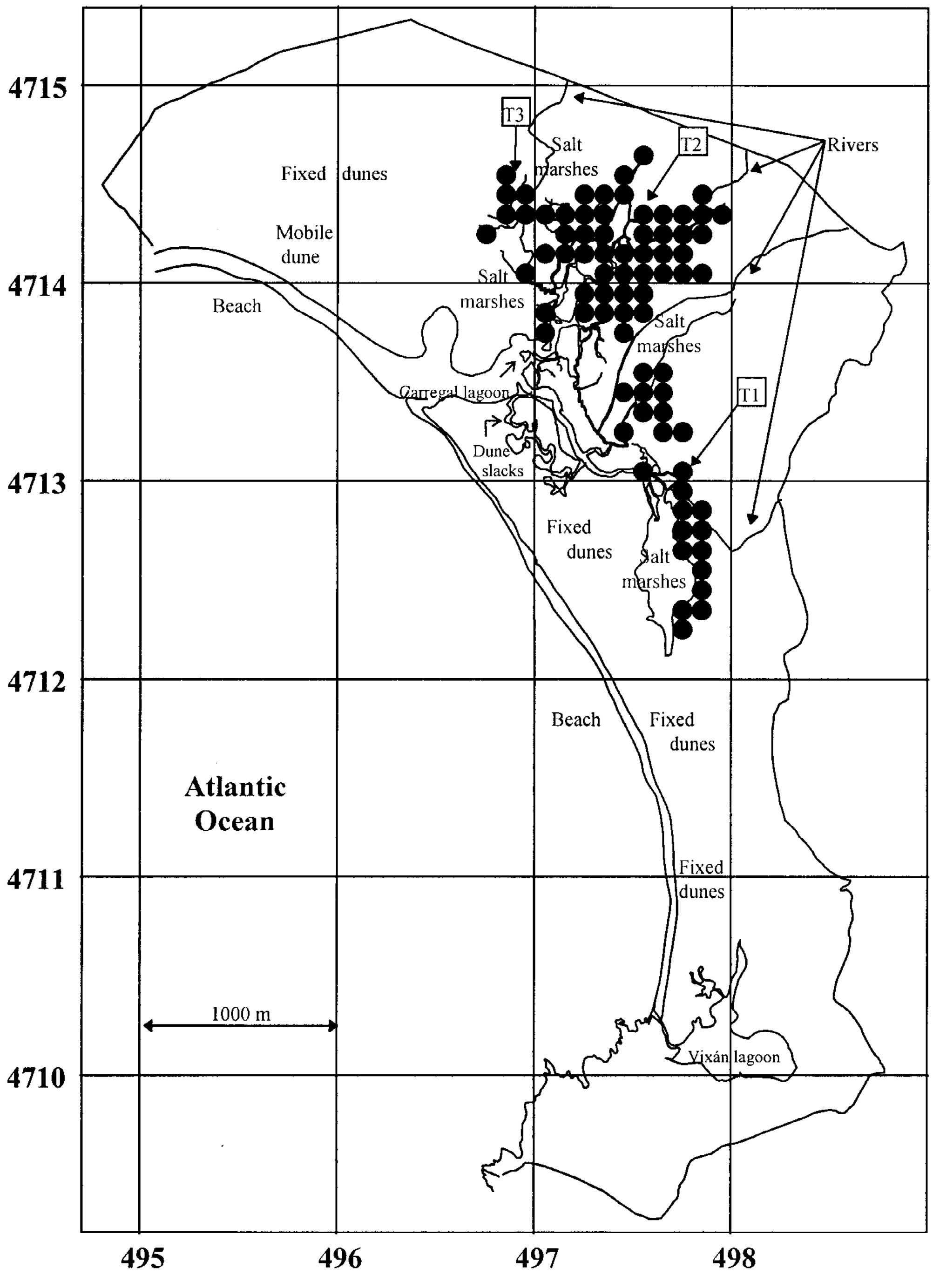

Figure 2. Distribution of saltmarsh *Spartina patens* patches in the studied area (Corrubedo Natural Park) in a grid of 100×100 m quadrats (UTM zone 29TMH).

'*S. patens* cover' and 'altitude' as independent variables. All data were arcsin transformed prior to analysis in order to improve normality.

Results

Distribution in Galicia

The species is already present in 45.83% of the 10×10 km coastal quadrats of the UTM grid (see Figure 1, where only saltmarsh records are represented). However, it becomes much more frequent in the southern estuaries (the proportion rising to 85.29% between cape Fisterra and Portugal) than in the northern ones (only 7.89%). In total, it was found in about 100 sites (1×1 km UTM grid), but only five of them were north of cape Fisterra (29 TMH74). Most of them are in saltmarsh habitats associated with estuaries and bay inlets, and also with coastal lagoons on the western-most coasts of Galicia (29TMH 100×100 km quadrat).

Our detailed study of Corrubedo N.P. saltmarshes (see Figure 2, where a 100×100 m grid was used for better visualization) shows that many little patches of *S.patens* (usually less than 10 m across) occur in the middle of the high marsh rush communities (see transect 3, Figure 5). It also forms linear patches along the elevated margins of saltmarsh creeks (like in quadrats 29–45 of transect 2, Figure 4) and colonizes drift lines in the upper high marsh boundary in contact with terrestrial communities (see transect 1 in Figure 3, and quadrats 175–180 of transect 2, Figure 4).

Altitudinal range

In the studied area, *S. patens* grows in high levels of the marsh, between −40 and 20 cm with respect to the highest tidal level recorded for each transect during the second semester of 1998 (see Figures 3–5); although this is enough to get a reference level and relativize the altitudes of different plant communities, further work is necessary to get more accurate data in order to calculate the inundation time at different levels. The mean altitude of the 55 sampling quadrats with *S. patens* presence is −33.53 cm respect to high tide level. However, the mean altitude rises to −29.48 cm if we weigh the altitude of the quadrat multiplying it by the *S.patens* coverage index, so giving more influence on the mean to those quadrats with higher abundance of *S. patens*.

Furthermore, for the same subsample of quadrats, there is a positive correlation (Spearman's r_s=0.46, $p<0.001$) between altitude and coverage of *Spartina patens*.

Table 1. Results of the two multiple regression analyses to assess the weight of 'altitude' and '*S. patens* cover' on the number and total cover of native species (n.s. = non significant; * = significant, $p<0.05$)

	Total cover of other species	Species number
Independent variables	Standardized Coefficient	Standardized Coefficient
altitude	0.09 (n.s.)	0.28 (n.s.)
S.patens cover	−0.69*	−0.49*
R^2	0.42	0.17

Effects on plant diversity

Looking to the transects represented in the Figures 3–5, the most affected community seems to be the *Agrostio stoloniferae – Juncetum maritimi* association, which shows a very strong reduction in the accumulated cover indexes for all the species other than *S. patens*. This community is the one that usually occupies the highest zones of the saltmarsh. Nevertheless, *S. patens* can also replace the *Limonio serotini – Juncetum maritimi* communities when these are located at a certain altitude. These rush communities are traditionally harvested for cattle bedding in many Galician saltmarshes. Sometimes, the dominance of *S. patens* is so high that the original plant community is no longer recognizable (see Figure 3).

Keeping in mind Figures 3–5, it seems clear that the species number tends to increase in the higher marsh levels, also according to Sánchez et al. (1996). Nevertheless, when *S. patens* is present with high cover indexes there is a remarkable decrease in the species number. This is even clearer if we look at the accumulated cover indexes of all the species other than *S. patens* (of course, bare soil patches have the same effect, this being the reason to represent them in the transects). A multiple regression analysis of data from the quadrats with a presence of *S. patens* produced the results shown in Table 1.

Discussion

Looking at the results of the regional survey, *S. patens* seems to be a very widespread species in southwest-

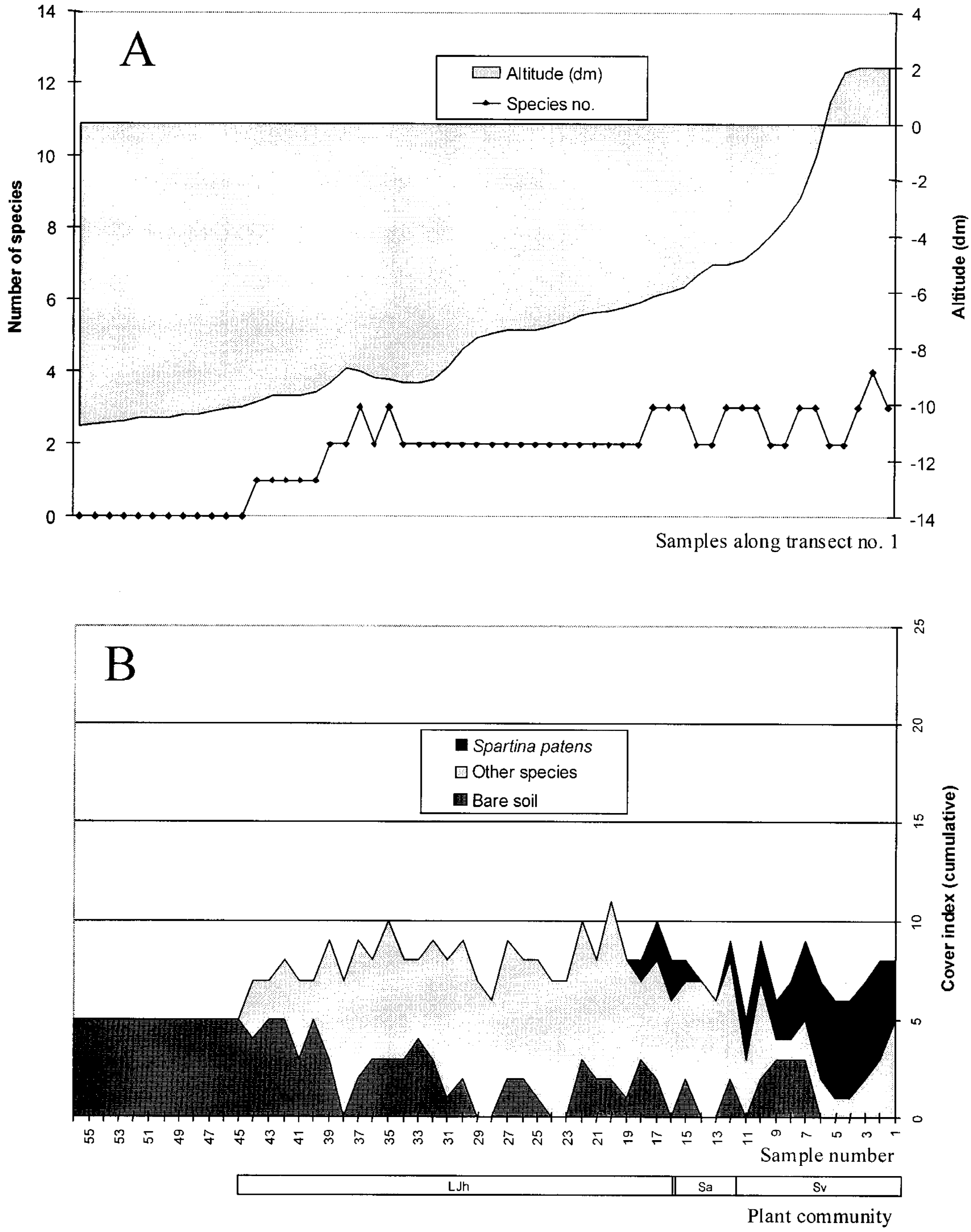

Figure 3. Vertical arrangement of samples along transect 1: (A) altitudes and number of species per sample; (B) Cumulative coverage indexes for *S. patens*, other species and bare soil; abbreviations correspond to names of plant communities cited in the text.

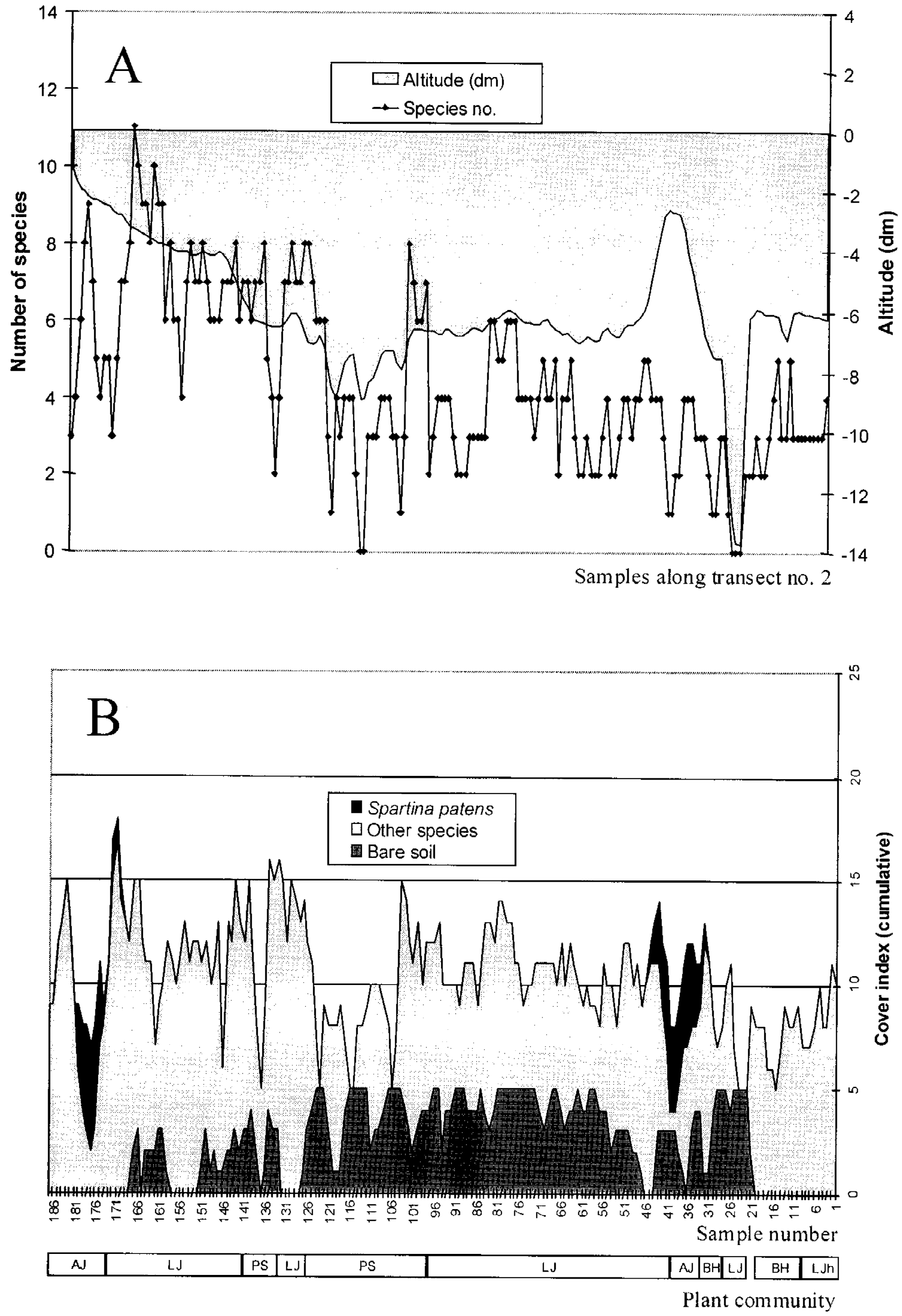

Figure 4. Vertical arrangement of samples along transect 2: (A) altitudes and number of species per sample; (B) Cumulative coverage indexes for *S. patens*, other species and bare soil; abbreviations correspond to names of plant communities cited in the text.

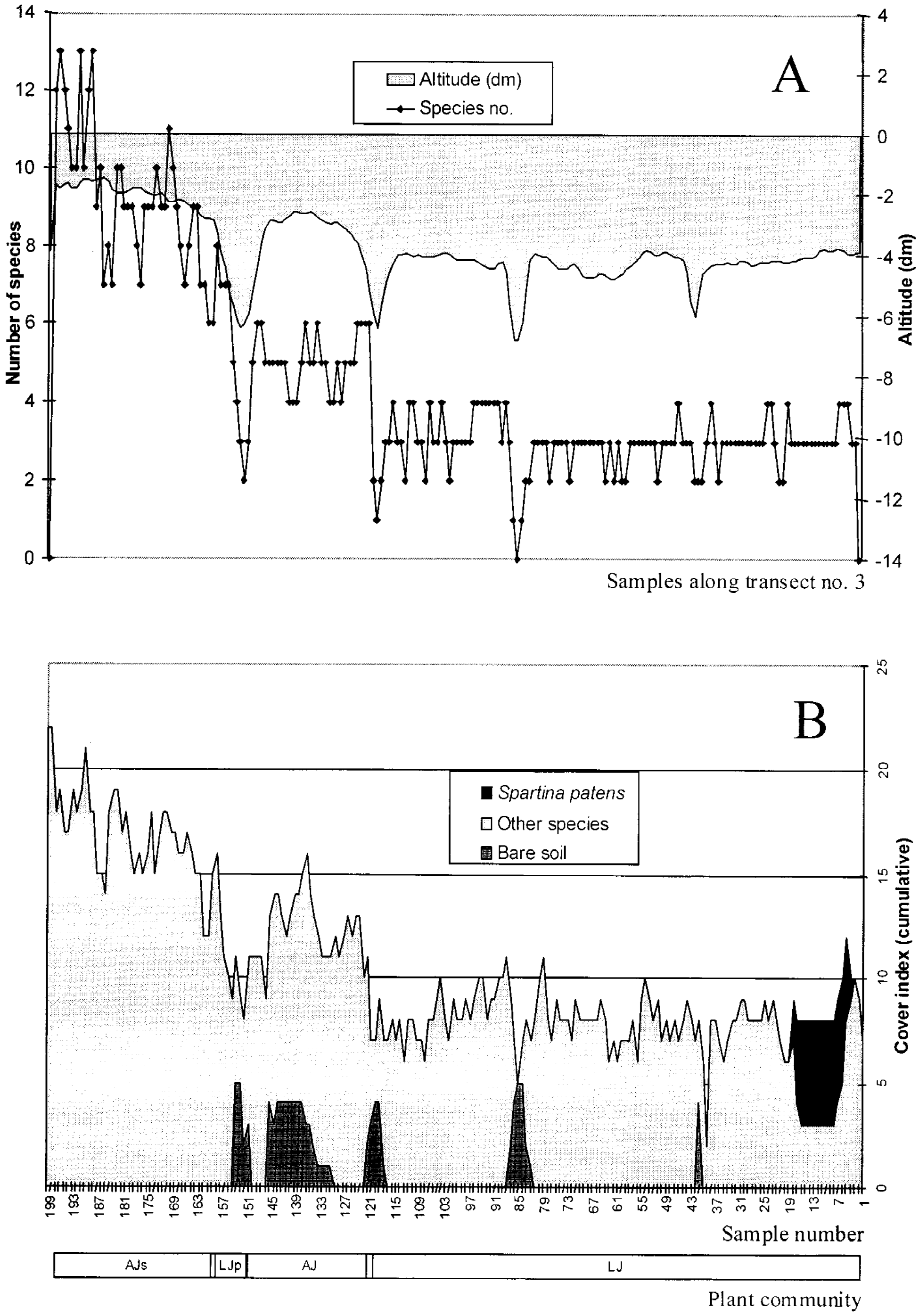

Figure 5. Vertical arrangement of samples along transect 3: (A) altitudes and number of species per sample; (B) Cumulative coverage indexes for *S. patens*, other species and bare soil; abbreviations correspond to names of plant communities cited in the text.

ern Galician estuaries. This is rather surprising, taking in account that the present work constitutes the first published record of this species in Galicia.

Moreover, the results of the local survey carried out in Corrubedo N.P. on a more detailed scale resemble the distribution pattern shown by this plant throughout the southwestern Galician coasts: it becomes apparent that – despite being a neophyte – it is extremely frequent there, dotting the coastline with numerous populations quite variable in size (but locally reaching a considerable extension and density in certain estuaries where big pure stands of *S. patens* dominate the saltmarsh physiognomy).

This suggests that it must be quite an old introduction, not detected until the present date due to its lack of flowering. It is possible that the coastline orientation with respect to dominant winds (SW and NE) could have an influence on the apparently easy establishment of the plant in this area, in contrast to its relative scarcity in Northern Galicia. Another important factor could be that the invasion may have been migrating northward along the Iberian Atlantic coastline, so having had more time to colonize the southern coasts of Galicia.

As for its position within the altitudinal zonation of saltmarsh plant communities, our results clearly show the preference of *S. patens* for the higher levels of the marsh, probably due to a limited ability to oxygenate its rhizosphere in anoxic soils (Bertness, 1991b); nonetheless, the plant only seems to exclude the other main dominant perennial – *Juncus maritimus* Lam. – in the landward zones of the upper high marsh, in contrast to the results of Bertness (1991a) and Bertness & Shumway (1993). On the other hand, the study of sample quadrats with a presence of *S. patens* (both the non-weighted and weighted mean altitudes as well as the correlation between altitude and *S.patens* coverage index) suggests that the plant grows better in the highest part of its altitudinal range, but it can spread downwards and grow new vegetative shoots connected by rhizomes to the clone it grew from (clonal integration *sensu* Hester et al., 1993; see also Shumway, 1995). These shoots would not achieve a very high density in lower levels because the plant is not very waterlogging tolerant, according to the aforementioned results of Burdick (1989), and Burdick & Mendelssohn (1987, 1990). Shumway (1995) suggests that physiological integration of ramets colonizing disturbance-generated bare patches may explain the predominance of vegetative invasion over sexual recruitment in marsh succession. Despite the fact that *S. patens* in our territory seems to invade well established communities rather than disturbance-generated gaps, physiological integration could be also valid to explain the way this plant spreads downwards from upper high marsh boundaries and creek elevated margins to colonize lower marsh levels.

With regard to the influence on plant diversity, and despite the fact that it increases with altitude (see Figures 3–5 and Sánchez et al., 1996), our results seem to indicate that this may not be true where *S. patens* has penetrated, since altitude is not a significant factor in our regression analysis (considering both its effect on species number or on total plant cover).

So, we can conclude from this work that *Spartina patens* is a new alien species for the Galician flora, although probably introduced a long time ago, being specially frequent – and locally very abundant – on the southwestern Galician coasts. Its preferred habitat is the upper limit of saltmarshes, becoming invasive and with a noxious effect on plant diversity of native communities when it forms very dense stands (often pure patches with 100% cover of this grass). Keeping in mind cases of *S. patens* introductions elsewhere (Frenkel, 1987; Frenkel & Boss, 1988; Mumford et al., 1991; Daehler & Strong, 1996), we should consider it as a threat to the biological diversity of Galician saltmarshes and take action towards eradicating the grass or at least curbing its expansion.

Following Daehler & Strong (1996), *Spartina patens* occurs over predictable tidal ranges within its native (e.g. Bertness & Ellison, 1987; Adam, 1990) and non-native (Frenkel & Boss, 1988) habitat range; within a vulnerable site and at a fine scale, the mean tidal range can be used to predict the extent of spatial spread of *Spartina patens* after colonization. Taking in account the rather low presence of this weed in northern Galician coasts, these prediction techniques might be used to identify and prioritize sites for protection against future invasions.

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