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Dynamics of exotic plants in the dune spaces of the Llobregat Delta (Barcelona)

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SUMMARY: The floristic composition and the structure of the vegetation of the dune spaces of the Llobregat delta (Barcelona) have undergone major transformations due to both natural and anthropogenic causes. At the beginning of the 20th century, there were dune formations close to a natural situation, but they were repopulated with pine trees and consolidated those made previously to slow down their progress and to establish residential, industrial, leisure or various services.

The result is a dune space with hardly any differential relief and with compacted soils and high levels of moisture and nutrients. The strip close to the beach, where it has not been repopulated with pines or these have succumbed to the salt of the sea, constitutes a refuge for the psammophilous species. Alongside them grows a remarkable number of exotic species, which find a suitable environment for their installation, development and reproduction.

Our interest has focused on its cataloging and typological analysis according to its origin, moment of introduction, colonized environment and relative abundance. The benefits and harms of all kinds derived from the presence of exotic species, especially those considered invasive, are discussed.

Keywords: dune, exotic plant, invasive plant, coastal vegetation.

1. INTRODUCTION

Dunes and coastal sands in general are located in one of the most dynamic areas of the earth's surface. The organisms that colonize these environments have acquired a very special adaptation to the environment due to the dynamics and spatial and temporal variability of the set of these landscapes with a high salt content, mobility of the substrate, strong insolation and great thermal contrast, among other variables environmental to consider.

Naturally, the sand dunes have given rise to landscapes whose structure and floral and faunal composition have been studied with some intensity. Until the end of the 19th century and the beginning of the 20th, the impacts of human presence and activity had generally been unimportant. The Llobregat Delta, for example, housed notable sand dunes with significant psammophilic vegetation, as shown in photographs from the first decades of the 20th century. Font Quer includes in his work on the vegetation of the Iberian Peninsula two photographs by Cuatrecasas, one of which shows a field of dunes colonized by *Ammophila arenaria* and another a fairly stabilized dune set with numerous feet of *Crucianella maritima* and *Thymelaea hirsuta* (Font Quer, 1954).

But over the course of the 20th century, the dunes and the coastal strip in general have undergone major transformations. The advance of dune ridges that threatened cultivated and even urbanized lands led to the realization of dune fixation plans. Some of these projects were already started during the 19th century. In the Llobregat delta, the most important plantations took place between the last years of the 19th century and the first of the 20th century (Valverde, 1997-98).

The Llobregat Delta is currently a peri-urban area with important population centers, such as Hospitalet de Llobregat, Sant Boi de Llobregat, El Prat de Llobregat, Viladecans, Gavà and Castelldefels. Large infrastructures such as the airport and the port have been installed. The Delta is crossed by a first-rate network of roads and railways. The result is a strong environmental pressure on the coastal strip. It has been built right up to the beach, the pine forests have been urbanized or transformed into leisure areas. Yes

reached very high levels of contamination both of the surface and of the aquifers during the second half of the 20th century. At the end of this century, the trend was reversed thanks to several environmental regeneration plans, despite major interventions (Delta Plan) such as the diversion of the final section of the Llobregat River and the expansion of the airport (Figure 1).

The dunes had completely disappeared and are difficult to restore since their essence is the dynamism itself from new contributions of sand. But the Llobregat river barely contributes sandy sediments due to the reservoirs and the re-vegetation of its basin, so it is not possible to set in motion the mechanisms for the natural regeneration of the dunes.

Several environmental regeneration plans have been carried out both for the nearby beaches and sand areas and for the wetlands. In many cases it has not been possible to regenerate the marshes and natural lagoons, since in their place there are constructions or services whose relocation would require a high cost. To compensate, new lagoons and marshes have been created artificially or they have been established indirectly from the extraction of aggregates.

The regeneration of the dune spaces has been more complex since the decrease in solid inputs from the Llobregat River and the wave dynamics have pushed back the coastline. The creation of breakwaters to protect the infrastructure of the port and airport and the urbanized areas have made it difficult to maintain or regenerate beaches. However, in the southern half of the delta, some beaches have been regenerated with the creation of strips in which indigenous or exotic psammophilous species have been planted. Sand has even been brought in to build new dune spaces. It is actually a landscaped recreation with sand.

The result is the existence of a very complex strip of sand with hardly any differential relief and with compacted soils and high levels of moisture and nutrients. The strip close to the beach, where it has not been repopulated with pines or these have succumbed to the salt of the sea, constitutes a refuge for psammophila species, but in a context very far removed from a natural dune landscape. Alongside them grows a remarkable number of exotic species, which find a suitable environment for their installation, development and reproduction.

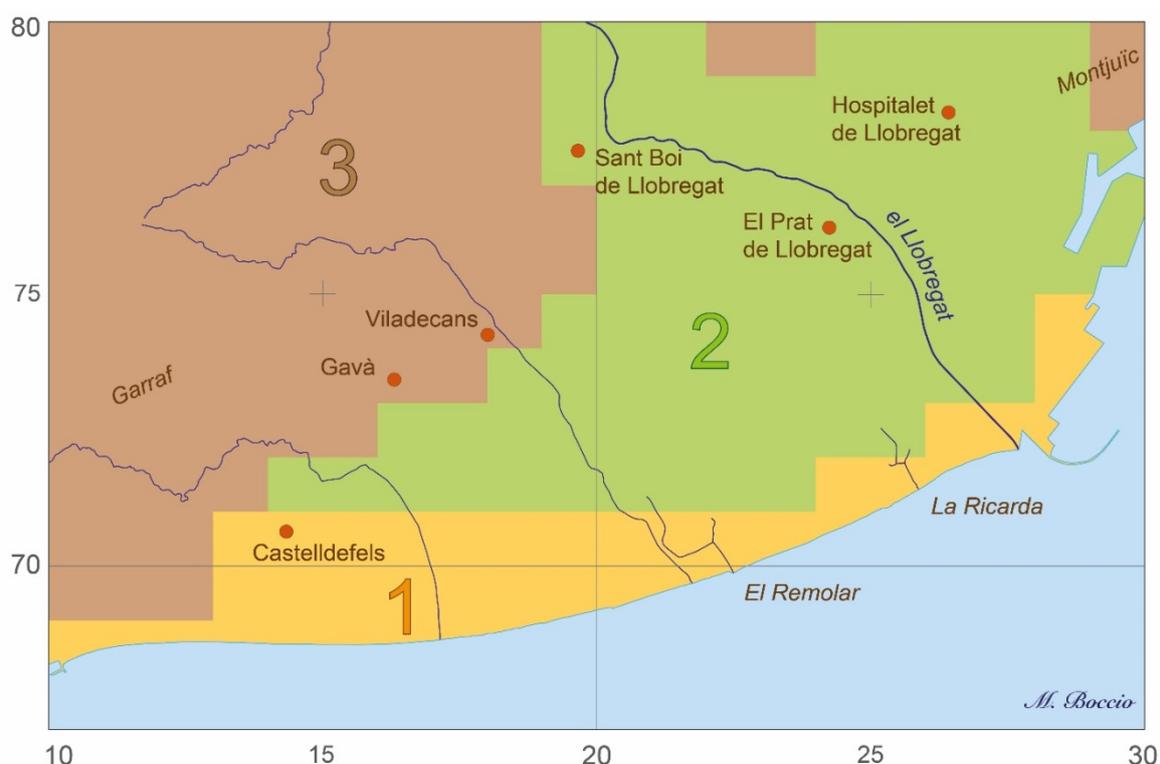


Figure 1. Map of the Llobregat delta with the main toponyms and the UTM grid of 10 and 5 km. Three areas delimited by UTM coordinates of 1 km have been differentiated: (1) deltaic area with fragments of psammophilous environments, (2) deltaic area and alluvial plain without psammophilous environments and (3) area outside the delta and the Llobregat alluvial plain.

The objective of this communication is to present the existence of a large number of exotic plants and analyze the role of some of them according to their origin, moment of introduction, colonized environment and relative abundance. The benefits and harms of all kinds derived from the presence of exotic species, especially those considered invasive, are discussed.

The study area is the entire Llobregat delta and a section of the lower alluvial plain of the Llobregat river up to the town of Santa Coloma de Cervelló, two kilometers north of Sant Boi de Llobregat. The sectors likely to harbor sand dunes have been explored, although in practice the study area has been primarily defined in a strip of about 2 km wide from the coastline. This space, as already indicated, has been drastically transformed initially for cultivation or for the fixation of the dunes by planting pine trees. Subsequently, various urban planning actions and the installation of large infrastructures have reduced the area of the sands.

Currently, psamóphilous environments are only found in a very narrow farm parallel to the beach, rarely exceeding 100 meters. Toward the interior, small corners with scattered psammophilous plants are located; they normally correspond to sectors of erosion that leave the remains of ancient dunes uncovered. On the map, the 1x1 km squares have been differentiated in which fragments of sand are located, often of small size. In total there are 42 squares capable of harboring remains of psamóphilous environments, 32% of the 130 squares that contain deltaic territory (Figure 1).

2. METHODOLOGY

The data used have been obtained from the bibliographic consultation, the documentary consultation and the field work. Previous studies on the specific topic of exotic species are scarce, but there is remarkable documentation about the flora of the Llobregat delta with data published throughout the 20th century, as discussed in the following section. Likewise, sufficient cartographic and photogrammetric material is available, which allows a fairly detailed follow-up of the evolution of the delta, especially of the coastal strip. The fieldwork was carried out on foot along the coastal strip to record the presence, abundance and condition of the psammophilous populations. Phytosociological inventories have been obtained on time and transects have been drawn up in representative sectors.

The data obtained are entered in various databases, which allows their arrangement, analysis and interpretation. The data are grouped based on UTM squares of 1x1 km.

The results are expressed by means of maps and thematic profiles, tables and various diagrams, together with the summary text of the results.

2.1. Data sources

As indicated, there are several published texts about the flora and vegetation of the Llobregat Delta. The reference work is the flora of Antonio and Oriol de Bolòs (1950) in which, despite the fact that the title indicates that it is a study of vegetation, it is actually an excellent flora with a first approximation to the vegetation. In addition, all previous studies are collected and analyzed with great care.

Later Oriol de Bolòs (1962) produced an extensive book exclusively on vegetation with a large annex with inventory tables of the communities discussed. The same author published a book about the plant communities of the regions close to the coast between the Llobregat and Segura rivers, in which he comments again on the vegetation of the delta, also including some inventory tables (Bolòs, 1967).

Of great use for comparative studies is the extensive work of Guy Lapraz, which was published in French in a fragmented manner in the magazine *Collectanea Botanica* (Lapraz, 1962-1976). Lapraz presents a systematic study of the territory that is currently known as the Metropolitan Area of Barcelona. It includes several inventories carried out on the coast of the Delta del Llobregat.

No new relevant studies were published until the 1990s. The most significant were published in *Spartina*, a local magazine of great scientific interest. The contributions of González, del Hoyo, Macías, Pérez, Pino, Roa, Seguí and Valverde stand out (González et al., 2001, 1997-98, 2006; Hoyo and González, 2001; Pino, 1995-96; Pino and Roa, 1997-98; Seguí, 1996; Seguí and Pérez, 2006; Valverde, 1997-98). Subsequently, a collective work of synthesis focused on the analysis of the Llobregat River has been published (Prat and Tella, 2005).

There are numerous data obtained by us over the last 15 years, which have been partially published in articles or presented at conferences. The monographic book about an area derived from the abandonment of pits excavated for the extraction of aggregates, known as "Basses de can Dimoni", located in the central sector of the Delta, within the municipality of Sant Boi de Llobregat (Panareda y Sans, 2002). With regard to the phytogeography of the sandy areas of the Llobregat Delta, we highlight our contributions in Pintó et al. (2008 and 2014).

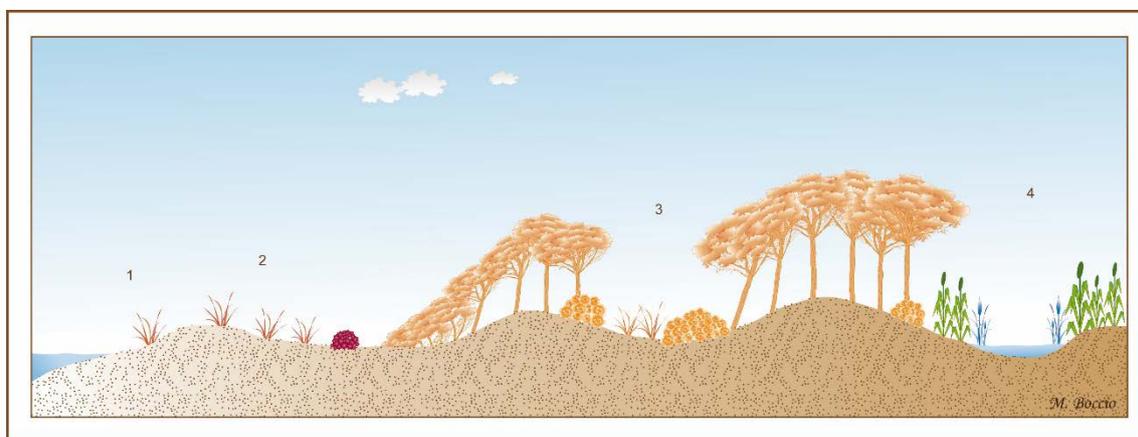


Figure 2. Profile of coastal vegetation in the Ricarda lagoon area. It corresponds to the existing landscape before the implementation of the Delta Plan, whose execution considerably modified this sector. (1) Sandy beach devoid of vegetation. (2) Dune with communities of *Elymus factus* next to the beach, *Ammophila arenaria* in the ridges and *Crucianella maritime* on somewhat stabilized sands. (3) Dunes stabilized and colonized by thickets of *Thymelaea hirsuta* and plantations of *Pinus pinea*, tree that acquires aerodynamic forms; towards the interior under the continuous tree layer of pines develops a thicket of *Cistus salviifolius* and progressively an incipient machia of *Pistacia lentiscus*. (4) Marsh and Laguna de la Ricarda with reeds and reed beds.

3. RESULTS

3.1. The environments of the sands

Traditionally, three large sandy environments have been distinguished on the coast of the Llobregat Delta: the beach, the active dunes and the stabilized dunes. In addition, the very variable interdunal spaces must be considered depending on the presence of fine materials and salt. As indicated, these environments do not currently exist, at least as they would naturally be (Figure 2).

Today's typical beaches are made up only of sand, which is regularly removed and mechanically cleaned. It is the place of leisure par excellence without any plants, with the exception of some seedlings *Cakile maritima* or *Kali salt*, which rarely thrive due to permanent trampling or mechanical cleaning (Figure 3 map A).

The presence of buildings such as bars or restaurants, for surveillance services or boats leads to the creation of small temporary shelters for *Cakile maritima*, *Salsola kali*, *Suaeda maritima* or some other opportunistic plant, especially from the chenopodiaceae family.

The installation of showers and other water points create a particularly humid soil environment. Its surroundings are usually colonized by a lawn of creeping plants, among which grass stands out (*Cynodon dactylon*).

In flat places more or less far from the sea and little trampled, a grassland dominated by exotic plants is usually established, such as various species of *Conyza* *Xanthium echinatum*. In these environments it has entered and developed widely *Cenchrus incertus*, a very annoying grass for bathers.

On some beaches of the Llobregat Delta, protected areas have been erected, limited by wooden poles joined by a rope. These spaces have been the object of sowing and planting of rare psammophilous species or those that have disappeared from the Delta, or psammophilous species from other regions. The visitors are quite respectful of the passage limitations and the result is the presence of patches with favored and controlled psammophilous vegetation. In some sectors, the abundance is surprising, for example, of

Pancratium maritimum, *Silene niceensis*, *Cyperus capitatus*, *Sporobolus pungens* *Calystegia soldanella*, next to exotic plants for the Llobregat Delta, like *Lotus creticus*, *Otanthus maritimus* or *Malcolmia littorea* (Figure 3 maps B and C))

On the beach, the existence of humid and nutrient-rich environments is also noteworthy. They correspond to ancient mouths of streams or drains. They stand out in the landscape due to the presence of a grassland made up of a predominance of exotic plants, especially of the chenopodiaceae, grass and polygonaceae families. This community has a maximum vegetative development at the beginning of summer.

It has already been indicated that there are currently no dunes in the Llobregat Delta. They have been eliminated or stabilized with plantations of pine trees, especially pino piñonero. In turn, these pine forests have been urbanized or transformed into camping areas. An opportunistic vegetation has developed under the pines with a large number of exotic species. When the pine forest reaches a certain density and the ground is covered with leaf litter, the vegetation is scarce. If the pine forest is kept open, the herbaceous undergrowth usually has significant coverage. In these conditions, the presence of numerous species of orchids stands out, which have been the object of study and protection (González et al, 1997-98 and 2001).

Gradually, the undergrowth of the pine forest is colonized by shrubs and trees. Among the shrubs stand out the gorse (*Cistus salviifolius*, *C. albidus*) and the torvisco (*Daphne gnidium*). It's not uncommon *Pittosporum tobira*, frequent in nearby gardens. Between the trees it stands out *Pistacia lentiscus* which spontaneously colonizes forming large thickets. Oak also has a significant presence, although it penetrates more slowly. The pine forest spontaneously evolves into a low forest or maquis.

It usually grows on the margins of pine forests *Myoporum laetum*, which is an evergreen tree native to New Zealand. It supports the slightly saline environment. It comes from plantations and is easily reproduced by cuttings.

In some sectors the pine forest has suffered some disturbance and has opened up leaving the sand exposed. It is in these sectors where the plant communities closest to the semi-fixed dunes are located with the presence of the tiny *Maresia nana*.

3.2. Exotic plants

The dunes and in general the sands usually contain few species due to the environmental conditions. Their number increases in the transect from the sea (beach) towards the continent, being higher in sectors with certain humidity and with a notable content of organic matter (Figure 2).

Exotic species are more abundant in removed land, with moisture and important organic matter. There is a great diversity of exotic plants in relation to their origin, inheritance system, preferred environment, phenology and abundance.

When at the beginning we distinguished the archaeophyte species from the neophytes. In studies about exotic species, more attention is paid to neophytes and archaeophytes are often considered as part of the natural landscape. This is the case of the piñonero pine, which is abundant due to historical plantings and plantations. On the other hand, the cane, which was planted for its multiple uses, is considered an invasive exotic plant due to its ability to expand in open humid spaces.

There are various strategies for exotic species to establish themselves and reproduce spontaneously in the Llobregat Delta. Table 1 includes some of the most significant exotic species that have been identified during field work. In the first column, the 44 selected species are indicated in alphabetical order, in the second the geographical origin, in the third the consideration of the plant on a regional scale (adventitic, naturalized, invasive) and in the fourth the degree of presence in the Delta of the Llobregat (rare, scarce, frequent and abundant), if it has been introduced through planting (agriculture, gardening, forestry) and if it reproduces spontaneously.

In a first group we must consider the numerous plants introduced directly for gardening, agriculture, slope defense or some other use. Most of these plants do not usually develop outside the environment in which they are grown or planted and only exceptionally some regenerate sporadically or accidentally in the vicinity, such as *Cercis siliquastrum*. Others reproduce spontaneously and maintain stable individuals more or less permanently, although without forming large populations and without spreading over large areas. This is the case of *Myoporum laetum*, tree planted to protect farms and roads from the sea; supports low levels of salt and forms dense protective hedges, but rarely gives rise to extensive populations (Figure 3 map D).

Table 1. Significant exotic plants of the sand dunes of the Llobregat Delta.

<i>plant</i>	<i>origin</i>	<i>Regional status</i>	<i>Arenales delta Llobregat</i>
<i>Acacia retinodes</i>	Australia S	adventitia	rare, planted
<i>Agave americana</i>	Mexico	invasive	sparse, planted, spontaneous
<i>Amaranthus muricatus</i>	America S	invasive	scarce, spontaneous
<i>Ambrosia coronopifolia</i>	North America	naturalized	frequent, spontaneous
<i>Aptenia cordifolia</i>	S Africa	adventitia	scarce, planted
<i>Araujia sericifera</i>	America S	invasive	frequent, spontaneous
<i>Arctotheca calendula</i>	S Africa	adventitia	frequent, expanding
<i>Arundo donax</i>	Asia C	invasive	sparse, planted, spontaneous
<i>Aster squamatus</i>	America	invasive	abundant, spontaneous
<i>Carpobrotus edulis</i>	S Africa	invasive	frequent, planted
<i>Cenchrus incertus</i>	tropical America	naturalized	abundant, spontaneous
<i>Cercis siliquastrum</i>	Mediterranean E	adventitia	rare, planted
<i>Chenopodium ambrosioides</i>	tropical America	invasive	scarce, spontaneous
<i>Conyza bonariensis</i>	tropical America	invasive	frequent, spontaneous
<i>Conyza canadensis</i>	North America	invasive	abundant, spontaneous
<i>Conyza sumatrensis</i>	America S	invasive	abundant, spontaneous
<i>Coronopus didymus</i>	neotropical	naturalized	frequent, spontaneous
<i>Cortaderia Selloana</i>	America S	invasive	scarce, spontaneous
<i>Cuscuta campestris</i>	North America	naturalized	abundant, spontaneous
<i>Eleusine tristachya barcinon.</i>	neotropical	invasive	frequent, spontaneous
<i>Euphorbia maculata</i>	North America	naturalized	scarce, spontaneous
<i>Euphorbia prostrata</i>	America	invasive	scarce, spontaneous
<i>Euphorbia snakes</i>	America S	naturalized	scarce, spontaneous
<i>Ficus carica</i>	Mediterráneo S	naturalized	sparse, planted, spontaneous
<i>Gazania</i> sp.	S Africa	adventitia	scarce, planted
<i>Gomphocarpus fruticosus</i>	S Africa	naturalized	frequent, planted, spontaneous
<i>Kochia scoparia</i>	asia	naturalized	frequent, spontaneous
<i>Limoniastrum monopetalum</i>	Mediterranean	adventitia	scarce, planted
<i>Lonicera japonica</i>	East Asia	invasive	sparse, planted, spontaneous
<i>Lotus creticus</i>	Mediterráneo S	adventitia	scarce, planted
<i>Myoporum laetum</i>	New Zealand	adventitia	abundant, planted
<i>Nicotiana glauca</i>	America S	invasive	scarce, spontaneous
<i>Oenothera glazioviana</i>	Europe, hybrid	naturalized	abundant, spontaneous
<i>Opuntia ficus-indica</i>	tropical America	invasive	sparse, planted, spontaneous
<i>Otanthus maritimus</i>	Multiregional	adventitia	scarce, planted
<i>Oxalis pes-caprae</i>	S Africa	invasive	frequent, spontaneous
<i>Panicum repens</i>	paleotropical	adventitia	frequent, spontaneous
<i>Pennisetum villosum</i>	S Africa	invasive	scarce, spontaneous
<i>Pinus pinea</i>	Mediterranean E	naturalized	abundant, planted, spontaneous
<i>Pitosporum tobira</i>	Asia S	naturalized	frequent, planted, spontaneous
<i>Sporobolus indicus</i>	tropical America	invasive	frequent, spontaneous
<i>Stenotaphrum secundatum</i>	tropical America	adventitia	sparse, planted, spontaneous
<i>Xanthium echinatum italicum</i>	North America	invasive	abundant, spontaneous
<i>Xanthium spinosum</i>	North America	invasive	scarce, spontaneous

Some plants, few, reproduce in large quantities and often with certain speed in concrete environments, especially in open spaces. In that last case, if their development is very large and they are able to significantly displace native species, we will talk about invasive exotic species.

Some trees tend to stay in the places where they have been planted and expand their area if the conditions are favorable. This is the case of the piñonero pine and other plants used to fix the dunes, such as *Ammophila arenaria* and *Carpobrotus edulis*. The pine is an exotic species and in the initial stages it spontaneously consolidates the occupation of the space where it has been planted, with the exception of the strip next to the beach, where salt severely damages its development with the death of pioneer trees or conditioning the typical flag shape. The barrón is a native species, but it was systematically planted in the initial phases to stabilize the dunes; its presence in the middle of the planted pine forest, currently rare, is testimony to this activity. Balsamo, on the other hand, is an exotic plant used effectively to fix dunes and spontaneously colonizes its environment without difficulty; for its success it is currently considered one of the most formidable invaders of dune spaces;

Some grasses grown in gardens have indeed generated notable disturbances in the sands, as is the case of *Kochia scoparia* and *Oenothera glazioviana*, which are very competitive locally since they constitute high and dense populations, severely damaging the native grasses. *Stenotaphrum secundatum*, used for the formation of lawns in gardens and sports facilities, expands easily, colonizing sandy areas along the coast, since it tolerates salinity and trampling well.

The most feared invasive exotic plant from gardening is *Cortaderia Selloana*, which constitutes dense and tall plant masses. It has a great capacity to regenerate vegetatively and through seed. In the sandy areas of the Llobregat Delta, it is not very abundant, but its presence stands out in sectors with certain soil moisture, in marshes and abandoned plots. Its eradication is complicated by its ease of reproduction and by the fact that it is a large mass that is difficult to uproot in its entirety.

Some species of the composites family, which are very popular in gardening, have established themselves spontaneously in the sandy areas. Two plants in the expansion phase stand out, *Artotheca calendula* and *Gazania* sp., both from South Africa. It will be necessary to follow its evolution, especially of the first (figure 3 map F).

A second group of exotic plants are those that have arrived accidentally, without direct human intervention. The same considerations as in the previous case can be applied. The propagules (seeds, rhizomes, bulbs, tubers, trunks) can be displaced naturally by the wind or sea currents. It has always been like this, but since the large movements of people and goods, the number of propagules that are moved to long distances crossing oceans, mountain ranges and deserts has increased a lot. The result is a great increase in propagules that come from distant lands to humanized areas. This is the case of the Llobregat Delta, which apart from housing a high human population, is located next to a large port and an airport with heavy traffic.

In many cases it is difficult to discern the exact moment and route of penetration. The majority of propagules do not achieve the installation of a new species. Only rarely do they give rise to new individuals and that these manage to reproduce and become naturalized. But when the case arises, its presence can be disturbing for native species and communities. Many colonize only open spaces, sometimes as pioneering and opportunistic species such as the annuals of the genus *Amaranthus*, *Conyza* and *Chenopodium*, which constitute temporarily dense populations in some heavily populated sandbanks. Something similar happens with the small and crawling ones *Euphorbia*. Others are perennial plants able to last a few years until other plants manage to block their development, like *Aster squamatus*, *Coronopus didymus* and *Oxalis pes-caprae*. The latter has registered a considerable expansion during the last years; it reproduces easily from the numerous bulbs that give rise to very dense populations with maximum vegetative development in winter and early spring; it is considered a very aggressive invader.

Other perennial herbs with a great capacity to reproduce and establish themselves are clearly invasive and their eradication is difficult. It is the case of *Sporobolus indicus*, abundant in trampled sands and *Panicum repens* which forms dense masses in somewhat humid sands.

It is necessary to consider separately *Cenchrus incertus*, a lively grass whose spike is made up of spiny fruits. In a few years it has colonized the sands of the Delta del Llobregat, especially on the beaches of Castelldefels. It is a recent introduction whose presence bothers bathers and walkers already.

that the fruits are easily detached from the spike and stepping on them causes serious injuries to bare feet.

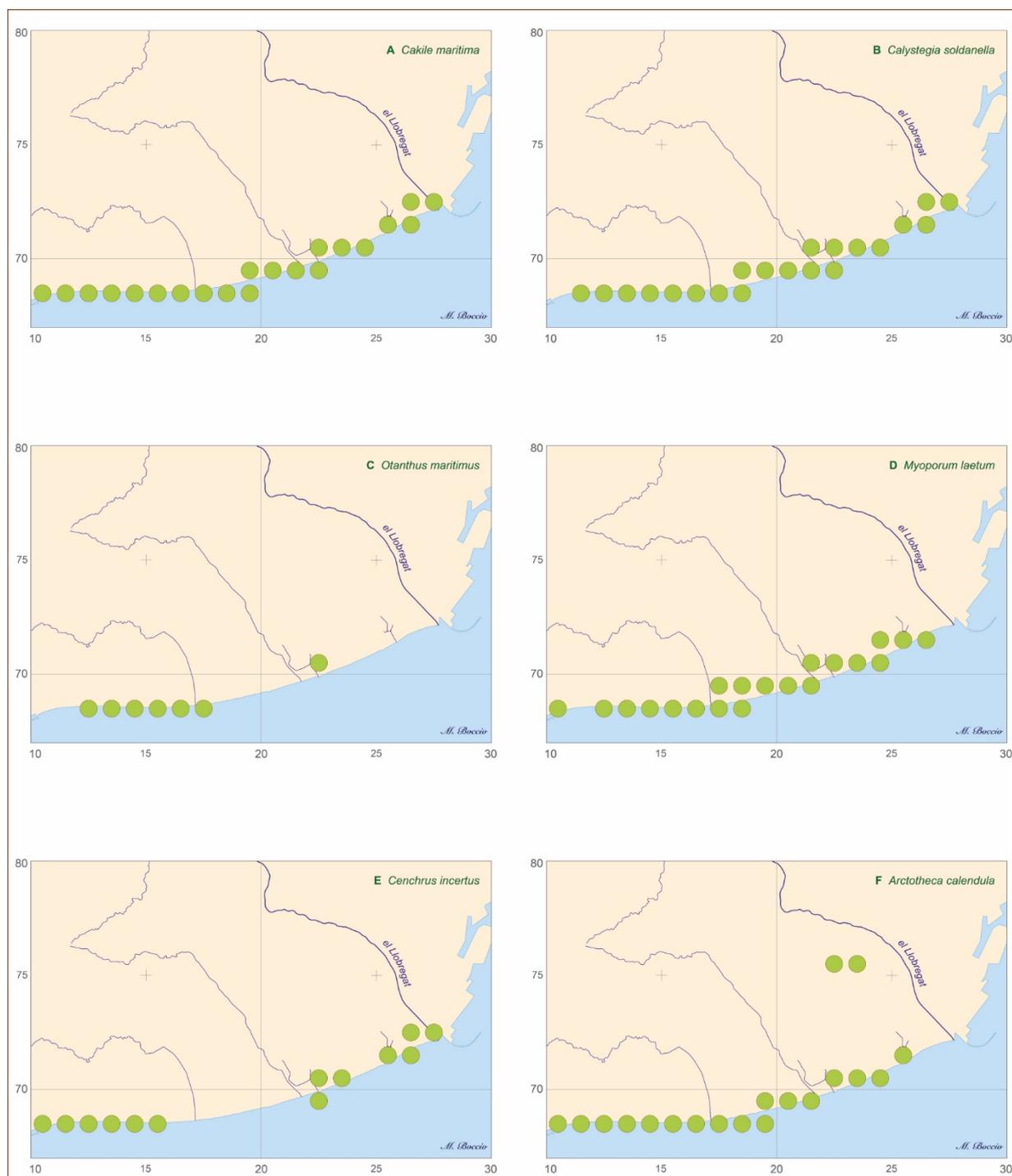


Figure 3. Chorological maps of 6 plants characteristic of the sandy areas of the Llobregat delta. The unit of reference is the square resulting from the 1 km UTM grid. A: indigenous species indirectly favored as a result of human intervention; B: native species that has been repopulated; C: exotic species proper to the sand dunes introduced through planting for the biological regeneration of the dune environment; D: exotic species adapted to marine environments, planted on the edges of paths and properties. E: exotic species with a great capacity for dissemination and which causes graves harm to bathers and walkers; F: expanding exotic species, planted and appreciated for its flowers.

It has also caused damage to dogs, numerous in the sands, since the pungent fruits are embedded between the toes and their extraction is complex. Its effects are more serious than those caused by *Tribulus terrestris*, a native zygophyllácea, also with fruits with hard spines and that shares territory with *Cenchrus incertus*. Both species are usually known as abrojo, due to their resemblance to the weapon of the same name (Figure 3 map E).

It is abundant *Xanthium echinatum* subsp. *italicum* also with a very prickly fruit very annoying for bare feet. It is an annual and robust plant that germinates with great ease in coastal and fluvial sands. Dense populations are located in the Llobregat delta, especially in the humid sectors and with organic matter. Its congener *Xanthium spisosum* has a smaller presence and the discomforts derived from the thorny fruits are milder.

Finally, a third group of exotic plants are those introduced recently with an ecological purpose. These are psammophilous plants not spontaneously present in the sands of the Llobregat Delta, but characteristic of these environments, such as *Otanthus maritimus*, *Malcolmia littorea* and *Lotus creticus*. Currently there are groups of dense populations of these species, which are maintained in fairly good condition. Its introduction justified with ecological arguments when favoring the regeneration of psamófilo environments has been discussed by the alterations it causes in the local natural dune system. In reality, it is about regenerating and enriching very degraded spaces, which have been landscaped as leisure spaces in an urban context (Figure 3 map C).

4. CONCLUSIONS

In this first and brief contribution about the exotic plants of the Llobregat Delta, the basic ideas about the presence and problems of a space where some exotics find a suitable environment to establish themselves and develop have been noted.

The disappearance of the dunes in the Llobregat Delta has given rise to a diversity of sandy areas, all of them far from natural environments, which has conditioned the existence of a great variety of biological adaptation strategies, where native plants have to menudo a secondary role.

In future publications, the detailed mapping of the distribution of exotic plants and a series of transects that show the great diversity of spatial and temporal successions in the sandy coastal strip will be presented in greater detail.

Until now, we cannot confirm the existence of highly invasive exotic plants in the sands of the Llobregat Delta. Although it is true that on a regional scale some of the species mentioned have a clearly invasive behavior, we believe that none of them behaves as such in the studied area, despite the prominent presence locally of populations of *Ambrosia coronopifolia*, *Arctotheca calendula*, *Artemisia annua*, *Cenchrus incertus*, *Cuscuta campestris*, *Oenothera erythrosepala*, *Panicum repens* or *Purslane oleracea*, algunas chenopodiáceas or those of the genus *Conyza*. In any case, the current expansion has a clear relationship with the various human interventions that block the development of both native and exotic plants. It is necessary to follow the expansion of certain species and to pay attention to their temporal and spatial dynamics.

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5. BIBLIOGRAPHY

- Bolòs, A. de and Bolòs, O. de (1950). *The vegetation of the Barcelona districts*. Barcelona, Instituto Espa- School of Mediterranean Studies.
- Bolòs, O. de (1962): The vegetal landscape of Barcelona. Barcelona, University of Barcelona, Faculty of Philosophy and letters
- Bolòs, O. de (1967): Vegetal communities of the counties close to the coast located between the rivers Llobre- cat and Segura Mem. R. Acad. hundred Arts, 38 (1). Barcelona
- Font Quer, P. (1954): Vegetation. In Terán, M. de. *Geography of Spain and Portugal*. Madrid, Montaner and Simon, II: 245-280.

- González, V. and Hoyo, R. del (2001): New contributions to the knowledge of orchids (Orchidaceae) from Llobregat Delta. *Spartina*, 4: 33-52.
- González, V.; Hoyo, R. del y Valverde, R. (2006): Valuation of the populations of *Otanthus maritimus*(L.) Hoffmanns. & Link (*Compositae*) in the Llobregat delta and revision of the distribution of the species in Catalonia". *Butll. Inst. Cat. Hist. Nat.*, 74: 29-36.
- González, V.; Hoyo, R. del y Macías, C. (1997-98): Floristic study and chorology of the Orchidaceae family in Llobregat delta. *Spartina*, 3: 11-31.
- Hoyo, R. del y González, V. (2001): Analysis of the state of the vegetation and floristic catalog of the site of the pine swimming in Cal Francès and its coastal area (Viladecans, Delta del Llobregat). *Spartina*, 4: 1-28.
- Lapraz, G. (1962-1976): Phytosociological research in Catalonia. *Collectanea Botanica*, 6: 49-171 and 545-607; 8:5-61; 9: 77-181; 10: 205-279.
- Panareda, JM and Sans, J. (2002): Les Basses de can Dimoni: Sant Boi de Llobregat, Llobregat Delta. Sant Boi de Llobregat, Sant Boi de Llobregat City Council.
- Pino, J. (1995-1996): Contribution to the knowledge of the allochthonous flora of the Llobregat delta. *Spartina*, 2:37-40.
- Pino, J. and Roa, E. de (1997-98): Comparison of the structure and floristic composition of the vegetation of two Prat del Llobregat beaches. *Spartina*, 3: 33-46.
- Pintó, J. and Panareda, JM (2008): Changes in coastal dunes of Catalonia in the last 150 years. ICCD 2007. International Conference on Management and Restoration of Coastal Dunes. Santander, University of Cantabria.
- Pintó, J.; Panareda, JM and Martí, C. (2014): The vegetal landscape of the dunes of the Llobregat delta (Barcelona), In Camera E. et al. (eds.) Biogeography of Coastal Systems. Dynamics and conservation. Seville, University of Seville. 27-33.
- Prat, N. and Tello, E. (eds.) (2005): El Baix Llobregat. Environmental history and current affairs of the river. Sant Feliu de Llobregat, Center for Regional Studies of Baix Llobregat.
- Seguí, JM (1996): The aquatic plants of the Llobregat delta, a parameter to evaluate the state of conservation of the environment. *Spartina*, 2: 19-32.
- Seguí, JM and Pérez, C. (2006): Assessment of the botanical interest of the Cal Tet pond, a newly created habitat in the Llobregat Delta. *Spartina*, 5: 1-15.
- Valverde, A. (1997-98): Historical evolution, origin and significance of the coastal pine forest of the Llobre delta-cat, I (16th-19th centuries). *Spartina*, 3: 63-101.