LIFE ilhas barreira

REPORT

Action A1 from project Ilhas Barreira.

Native plants distribution on Barreta Island

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COFINANCIAMENTO COORDENAÇÃO PARCEIROS

Action A1 Report from project Ilhas Barreira. Native plants distribution on Barreta Island

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Summary

Dune systems are unstable formations associated with the beach and result from the accumulation of fine and loose materials transported by the action of the wind. However, despite their dynamics being directly associated with geomorphological processes, they also depend on vegetation cover.
Mapping of native vegetation on Barreta Island occurred in March and April 2020 following an adaptation of the Braun-Blanquet Line Transects methodology. A total of 110 plots of 4m^2 were established where all taxa present were identified and the vegetation cover estimated by visual determination.
A total of 51 taxa were found. The species with the higher frequency of occurrence was *Malcolmia littorea*, followed by *Helichrysum italicum picardi* and *Paronychia argentea*. The species with the highest percentage of coverage was *Helichrysum italicum picardi,* followed by *Sarcocornia perennis* and *Artemisia campestris.*
Although not found on the sampling points, other native species are also present on the island, such as *Armeria pungens, Atriplex halimus, Carduus meonanthus, Centranthus calcitrapae, Cistanche phelypaea, Echium gaditanum, Erodium cicutarium, Euphorbia paralias, Euphorbia peplus, Juncus acutus, Linaria polygalifolia ssp. lamarckii, Olea europaea, Pinus pinaster, Salsola kali, Tamarix africana* and *Urtica membranacea.*

Resumo

Os sistemas dunares são formações instáveis associadas à praia e resultam da acumulação de materiais finos e soltos, transportados pela ação do vento. No entanto, apesar da sua dinâmica estar diretamente associada a processos geomorfológicos, também dependem da cobertura vegetal.
O mapeamento da vegetação nativa na ilha Barreta ocorreu em março e abril de 2020, seguindo uma adaptação da metodologia de transectos lineares de Braun-Blanquet. Foram estabelecidos 110 quadrados de 4m^2 onde todas as espécues presentes foram identificadas e a cobertura vegetal estimada por determinação visual.
Foram encontrados 51 taxa. A espécie com maior frequência de ocorrência foi *Malcolmia littorea*, seguida de *Helichrysum italicum picardi* e *Paronychia argentea*. A espécie com maior percentagem de cobertura foi *Helichrysum italicum picardi,* seguida de *Sarcocornia perennis* e *Artemisia campestris.*
Embora não tenham sido detectadas nos pontos de amostragem, na ilha estão presentes outras espécies nativas, como por exemplo: *Armeria pungens, Atriplex halimus, Carduus meonanthus, Centranthus calcitrapae, Cistanche phelypaea, Echium gaditanum, Erodium cicutarium, Euphorbia paralias, Euphorbia peplus, Juncus acutus, Linaria polygalifolia ssp. lamarckii, Olea europaea, Pinus pinaster, Salsola kali, Tamarix africana* e *Urtica membranacea.*

1 | Introduction

The plants that inhabit dune environments are subject to a set of particular ecological limitations, such as low water availability, the low content of some essential elements and the abrasive action of the sea (Costa, 1991). To survive these extreme conditions, these plants had to acquire specific adaptive characteristics.

1.1 Surviving in the dunes

The environmental characteristics of the areas adjacent to the sea act as a selective factor in the vegetation fixation, since coastal plants are subject to certain limiting factors, such as strong winds with salt particles; soil instability and poverty; poor water retention capacity and great luminosity and thermal amplitudes (Costa, 1991; Silva & Moura, 2000).
The transpiration to which they are subject, added to the high dune permeability, makes dissection one of the main problems these taxa face. To survive, they had to adapt to avoid excessive water loss. These adaptations involve reducing the size of the leaves (e.g. *Otanthus maritimus*) and acquiring strong cuticles (e.g. *Eryngium maritimum*) or long-hairs to reflect the light (e.g. *Medicago marina*; Costa, 1991; Neto & Capelo, 1999). In addition, they usually have succulent stems and leaves, with water reserves (e.g. *Artemisia crithmifolia* and *Otanthus maritimus*) or tomentose leaves and stems (e.g. *Helichrysum italicum*). Sometimes they also have deep roots to capture water in-depth or superficial root systems that allow the immediate collection of water that reaches the ground. There are still other cases in which plants have a metabolism where the stomata are only opened at night to avoid losses of water by transpiration (Costa, 1991).
In addition to these adaptations, morphological characteristics that allow these taxa to survive to strong marine winds or the burial caused by the accumulation of sand, are also notable. Strong winds are supported by a flexible structure (e.g. *Ammophila arenaria*) or cushioned bearings (e.g. *Anthemis maritima* and *Thymus carnosus*; Silva & Moura, 2000). In turn, burial is safeguarded by the development of extensive horizontal and vertical rhizomes to resist sand mobility, as well as the development of crisscrossing rhizomes that retain sand and grow towards the surface (e.g. *Ammophila arenaria* and *Elymus farctus*; Costa, 1991; Silva & Moura, 2000).

1.2 The dune plants

Dune systems are unstable formations associated with the beach and result from the accumulation of fine and loose materials transported by the action of the wind. However, despite their dynamics being directly associated with geomorphological processes, they also depend on vegetation cover (Gomes, 1986).
In the area above the level reached by marine waters, the sand, after drying, is transported by the wind to the interior, accumulating in the upper area of the beach in the form of small dunes, called embryo dune. These areas allow the installation of a pioneer vegetation cover, whose

characteristics enable the accumulation of sand to the lee. This constant deposition results in the formation, growth and development of pre-dunes and later of primary dunes (Gomes, 1986). This way, dune systems usually present specific zoning as we move away from the sea towards the interior. This is also observed in the plant communities, which change depending on the specific position occupied in the system.

Much of the area known as the beach does not have any associated vegetation. However, in the pre-dune areas where the waters at high tide can reach and where organic debris transported are deposited, an annual community poor in species appears. This community is composed of pioneer vegetation of medium dimensions, which preferentially settle on the medium-high beach. In the Ria Formosa barrier islands, this community is dominated by *Cakile maritima*, accompanied mainly by *Salsola kali* (Costa et al., 1996).

In the first elevations observed between the beach and the dunes themselves, where a higher accumulation of sand and a higher washing of the same by the rainwater occurs, the formation of the first dune states begins. In these first elevations, known as embryo dunes, the plant community is dominated by the grass *Elymus farctus*. This community is subject to a high movement of sand and is affected by waves during storms (Neto & Capelo, 1999). Of all the dune communities, this is one where the influence of the sea and the mobility of the soil is more noticeable due to the spatial position it occupies (Costa, 1991).

Following the previous community, more specifically on the ridges of mobile dunes, where the saline influence is lower, occurs the communities of *Ammophila arenaria*. These communities are vital in dune formation since the flexible culms of this species slow down the wind and allow the deposition of sand around them, while their rhizomes enable the fixation of sand (Gomes, 1986). In Ria Formosa, this community is usually found between the embryo dunes and the semi-fixed dunes. These areas are known as white dunes or primary dunes and usually have differences on their flanks. On the oceanic side occurs *Otanthus maritimus*, *Lotus creticus* and *Calystegia soldanella*. On the side facing the mainland, the species *Crucianella maritima* and *Thymus carnosus* usually dominate.

In the interior dunes, fixed or semi-fixed, occurs the communities of plants with rigid leaves and sometimes succulents appear (Costa et al., 1996). In this community, the most representative species are *Helichrysum italicum, Artemisia crhithmifolia* and *Armeria pungens*. However, *Thymus carnosus* usually is also present in this community (Neto & Capelo, 1999). Considering this is an area further away from the sea and consequently less influenced by salinity, it enables a more diversified development of the flora, which almost completely covers the soil (Neto & Capelo, 1999).

1.3 The vegetation in Barreta Island

The most complete information about the Ria Formosa vegetation was published by Costa et al. (1996) where the authors studied the halophilic and psamophilic vegetation of Ria Formosa Natural Park and described the different plant communities found and respective syntaxonomic position. During this study, the authors developed an inventory on Barreta Island and identified 14 plant communities present on the island (Fig. 1).

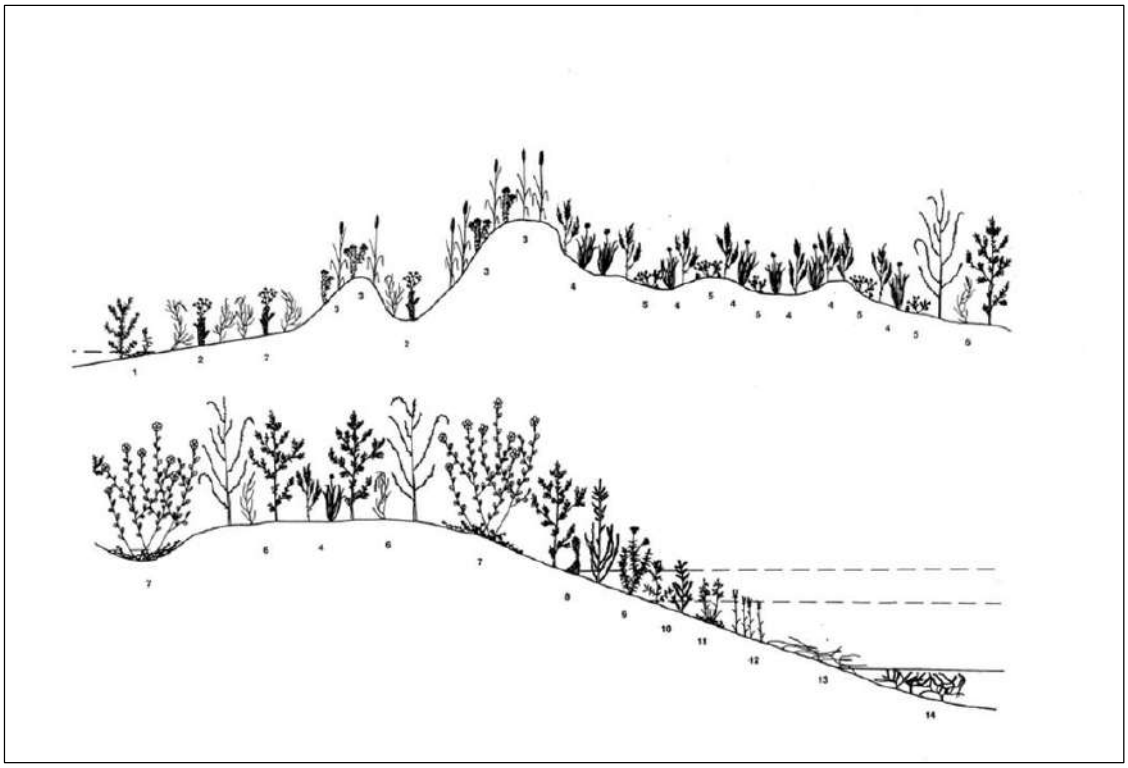

Figure 1 | Transect on Barreta Island. 1. *Salsolo kali-Cakiletum maritimae*. 2. *Euphorbio paraliae-Agropyretum junceiformis*. 3. *Loto cretici-Ammophiletum arenaria*. 4. *Artemisio crithmifoliae-Armerietum pungentis*. 5. *Ononidi variegatae-Linarietum pedunculatae*. 6. *Frankenio laevis-Salsoletum vermiculatae elymietosum boreali-atlantici*. 7. *Polygono equisetiformis-Limoniastretum monopetali.* 8. *Cistancho phelypaeae-Suaedetum verae*. 9. *Inulo crithmoidis-Arthrocnemetum glauci*. 10. *Halimiono portucaloidis-Sarcocornietum alpine*. 11. *Sarcocornio perennis-Puccinellietum convolutae*. 12. *Spartinetum maritimae*. 13. *Zosteretum noltii*. 14. *Cymodoceetum nodosae.* Adapted from Costa et al. (1996)

Considering that the last inventory of Barrier Island flora was carried out in 1996 (Costa et al., 1996) and it was reviewed in 2005, during the revision of the Ria Formosa Management Plan (ICN, 2005), this report aims to present information about the native plants present on the island and actual distribution of plants with higher conservation value.

2 | Methodology

The barrier islands are included in the Ria Formosa Special Protection Area (PTZPE0017). The Ria Formosa is a complex coastal lagoon system, enclosed by five barrier islands (Barreta, Culatra, Armona, Tavira and Cabanas) and two peninsulas (Ancão and Cacela), which extends over 50 km (Pilkey, et al. 1989). Ria Formosa is also classified as Natural Park and Site of Community Importance (PTCON0013). This coastal system is fragile, being conditioned by coastal maritime agitation, tides and is subject to erosion and sand accumulation.
The barrier islands and, in particular, the grey dunes, are areas of high flora and fauna interest. Besides their intrinsic importance, these islands are home to several endemic plant species, priority bird species as well as priority habitats.
Barreta Island (also known as Deserta) has a length of about 8 km and a width between 70 and 700m (Ceia, 2009). It has a curved shape, where Cabo de Santa Maria is situated (36°57′36.57″ N, 7°53′13.55″ W), the southernmost tip of mainland Portugal. The complexity of the island increases as we get closer to the East, where it presents a well-developed dune system, with stabilized dunes up to 700 m wide. The western part of the island is the narrowest, has the lowest elevation and has poor vegetation cover.

2.1 Mapping native plants

On Barreta Island, mapping of native vegetation occurred in March and April 2020. This period aimed to coincide with the flowering peaks of most species.
For mapping native species, we followed the Braun-Blanquet Line Transects methodology with some adaptations. Every 500 meters, a transect covering all-island width (South-North orientation) was defined. 16 transects were identified, with lengths from 142 meters to 768 meters.
In each transect, every 60 meters, a plot of 4 m² was identified. This way, it was possible to cover all different habitats and evaluate the differences between dune types and assure plots were randomly placed.
A total of 110 plots were identified. In each plot, we identified all the taxa present and the vegetation cover was estimated by visual determination. Each plot was sampled only once. The value of cover proportion for each species was recorded, as well as the percentages of bare soil, sand, rock and unidentifiable dry vegetation cover (labeled as ‘other vegetation’). Whenever found, the exotic plants were also identified.
For each plant species recorded in the vegetation plots frequency of occurrence (FO) was calculated, given as the number of plots where the species was registered divided by the total number of vegetation plots, in percentage. It was also calculated the coverage given as the total percentage cover of each species in all plots divided by the total number of vegetation plots, in percentage.

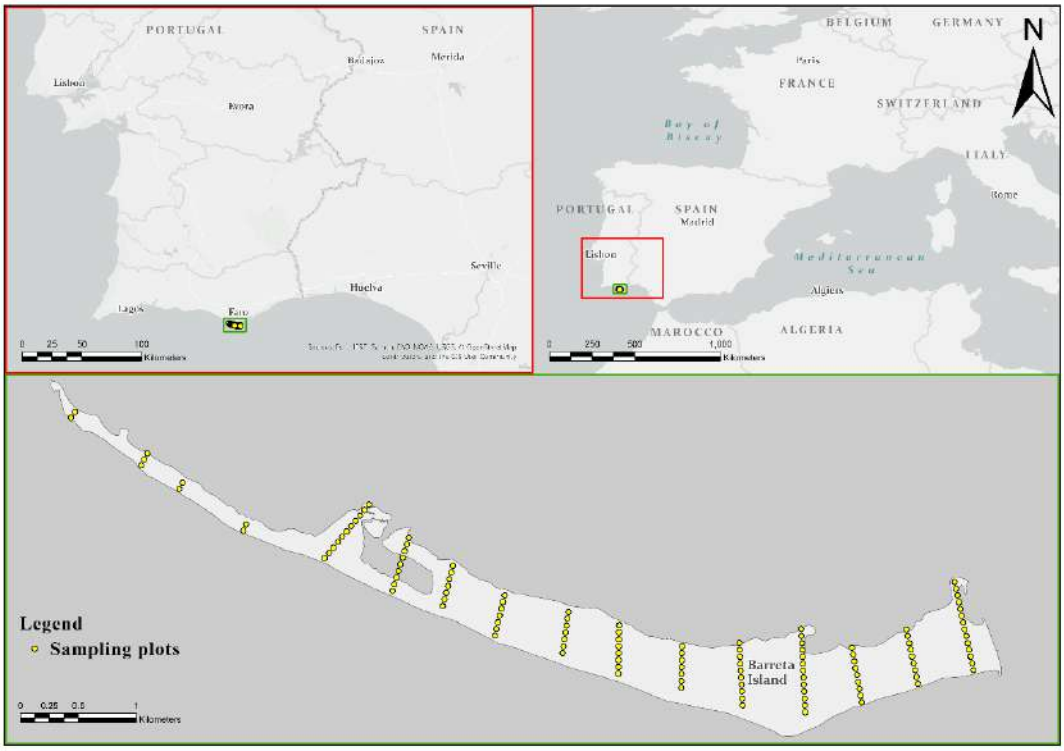

Figure 1 | Location of the study area and map of Barreta Island with the 110 sampling plots for mapping native vegetation.

3 | Results

The vegetation inventory carried out along the Barreta Island was developed by a team of two members, and it took ten working days (7 hours) to complete it. During this inventory, was found 51 taxa (Table 1).

Table 1 | Frequency of occurrence (FO) and cover percentage of plant species recorded in the 110 vegetation plots defined on Barreta Island.

Species	FO	Coverage (%)
Aetheorhiza bulbosa	6.36	0.25
Ammophila arenaria	1.82	0.09
Anacyclus radiatus	2.72	0.04
Anthemis maritima	2.73	0.09
Artemisia campestris	18.18	3.10
Cakile maritima	4.55	0.16
Calystegia soldanella	2.73	0.11
Carpobrotus edulis	0.91	0.45
Corynephorus canescens	24.55	1.15
Crucianella maritima	10.91	0.85
Cutandia maritima	4.54	0.62
Cyperus capitatus	1.82	0.04
Elymus farctus	10	0.54
Erodium laciniatum	26.36	1.01
Eryngium maritimum	5.45	0.24
Halimione portulacoides	8.18	1.31
Hedypnois arenaria	0.91	0,01
Helichrysum italicum ssp. picardi	35.45	4.48
Hypecoum littorale	0.91	0.01
Limoniastrum monopetalum	7.27	2.66
Limonium ovalifolium	2.72	0.08
Linaria munbyana	0.91	0.01
Linaria pedunculata	0.91	0.03

Species	Sampling points	Maximum coverage (%)
Lotus creticus	16.36	0.79
Malcolmia littorea	41.82	1.45
Medicago littoralis	16.36	0.36
Medicago marina	8.18	0.41
Otanthus maritimus	7.27	0.38
Oxalis pes-caprae	0.91	0.04
Pancratium maritimum	7.28	0.35
Paronychia argentea	30.91	1.15
Plantago coronopus	2.73	0.12
Polycarpon alsinifolium	11.82	0.21
Polygonum maritimum	4.55	0.08
Pseudorlaya minuscula	1.82	0.09
Puccinellia maritima	0.91	0.05
Reichardia gaditana	17.27	0.43
Salsola vermiculata	3.64	1.14
Sarcocornia fruticosa	3.64	0.55
Sarcocornia perennis	11.82	3.77
Sarcocornia ssp.	0.91	0.01
Sedum sediforme	0.91	0.06
Senecio gallicus	18.18	0.50
Seseli tortuosum	3.64	0.47
Silene niceensis	17.27	0.45
Sonchus tenerrimus	0.91	0.01
Suaeda splendes	1.82	0.05
Suaeda vera	1.82	0.23
Thymus carnosus	24.55	2.49
Trifolium ssp.	0.91	0.02
Zostera noltii	2.73	1.00
Other vegetation	13.63	0.50

The species with the higher frequency of occurrence was *Malcolmia littorea* (present on 46 sampling points), followed by *Helichrysum italicum picardi* (39 points) and *Paronychia argentea* (34 points). The species with the highest percentage of coverage was *Helichrysum italicum picardi* (4.48%), followed by *Sarcocornia perennis* (3.77%) and *Artemisia campestris* (3.10%).
Ten of the species found are in the IUCN Red List (IUCN, 2022). Nine are classified as Least Concern (*Artemisia campestris, Cyperus capitatus, Eryngium maritimum, Helichrysum italicum, Salsola vermiculata, Medicago littoralis, Elymus farctus, Pancratium maritimum* and *Zostera noltii*) and one as Near Threatened (*Thymus carnosus*).
Also noteworthy is the presence of five species listed in the Portuguese Red List of Vascular Flora (Carapeto et al., 2020). Two species are classified as Least Concern (*Thymus carnosus* and *Linaria pedunculata*), two classified as Near Threatened (*Linaria munbyana* and *Zostera noltii*) and one classified as Vulnerable (*Hypecoum littorale*).
The individual distribution maps of the species present in the Portuguese Red List of Vascular Flora are shown below.

Figure 2 | Distribution map of *Thymus carnosus* on Barreta Island and respective percentage of coverage

Thymus carnosus is endemic to the Atlantic coast of the Iberian Peninsula, being present in Spain and Portugal. It was detected in 27 sampling points, occurring mainly in white and grey dunes. The highest percentage of coverage was 30%. The map shows that the species is well distributed along the island, except on the west side where the habitat is not suitable.

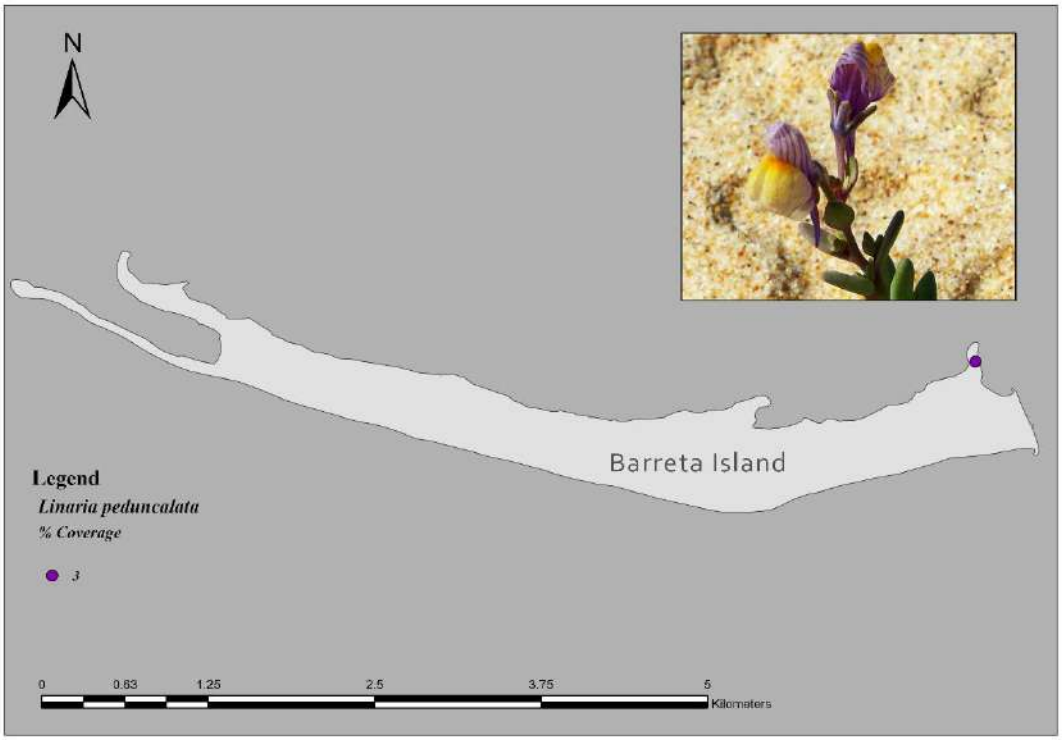

Figure 3 | Distribution map of *Linaria pedunculata* on Barreta Island and respective percentage of coverage

Linaria pedunculata is a small plant that occurs in dunes, especially in white and embryo dunes. In Portugal has a restricted distribution to Algarve, Troia and Figueira da Foz. It was only detected in one sampling point on the Northeast side of the island, an area with high human pressure during the summer months.

Figure 4 | Distribution map of *Linaria munbyana* on Barreta Island and respective percentage of coverage

Linaria munbyana is a yellow flowering plant that blooms between February and April. It occurs mainly in grey dunes and, in Portugal, its distribution is limited to the South coast of the Algarve region. It was only detected in one sampling point near the Audouin's Gull colony.

Figure 5 | Distribution map of *Hypecoum littorale* on Barreta Island and respective percentage of coverage

Hypecoum littorale occurs in coastal dunes and other sandy places close to the sea. In Portugal, its distribution is limited to the Algarve coast. On Barreta Island it was found in one sampling point on the Ria Formosa side, near the wooden path. Its yellow flower blooms in April.

Figure 6 | Distribution map of *Zostera noltii* on Barreta Island and respective percentage of coverage

Zostera noltii is a herbaceous, aquatic, submerged plant occurring in estuaries, beaches, coastal lagoons and sometimes in salt marshes, next to river estuaries. With a preference for muddy substrates, it forms meadows that can often cover extensive areas in the intertidal zone. It also occurs in sandy areas and subtidal zone. It was found in three sampling points in the Ria Formosa side. The highest percentage of occurrence (45%) was registered on the West side of the island.

Although not found on the sampling points, some native species are also present on the island, such as *Armeria pungens, Atriplex halimus, Carduus meonanthus, Centranthus calcitrapae, Cistanche phelypaea, Echium gaditanum, Erodium cicutarium, Euphorbia paralias, Euphorbia peplus, Juncus acutus, Linaria polygalifolia ssp. lamarckii, Olea europaea, Pinus pinaster, Salsola kali, Tamarix africana* and *Urtica membranacea*. Besides, there are also other exotic species such as *Aeonium arboretum, Aloe maculata, Cylindropuntia imbricata, Myoporum laetum, Nerium oleander, Pelargonium graveolens.* and *Yucca aloifolia.* These species are mostly present near the areas where the fisherman community used to live.
There are also other invasive species present such as the *Acacia saligna* and *Agave americana*. The distribution of the invasive species can be found in the report “Action A1 Report from project Ilhas Barreira. Invasive plants on the five barrier islands”.

4 | Discussion

This inventory was the first one with an incidence only on Barreta Island. Previous studies (e.g. Costa et al., 1996; ICN, 2005) were focused on characterizing the vegetation of the entire Ria Formosa Natural Park, so there is no point of comparison regarding the number of taxa found and their distribution.

Besides differences in the methodology applied, some of the plant communities identified by Costa et al. (1996) on Barreta Island were also found, such as:

- Salsolo kali-Cakiletum maritimae: Poorly covered community, which lives on the residues brought by storm tides. It is constituted by the taxon *C. maritima*, frequently accompanied by *S. kali* and less often by *E. peplis, Polygonum maritimum, S. tenerrimus* and *E. farctus*. It appears, during the summer and autumn, on sandy beaches and more rarely on the edge of salt marshes. This community usually is often destroyed by people using the beaches.
- Euphorbio paraliae-Agropyretum junceiformis: Community formed by the grass *E. farctus* accompanied by few species, the most common being *E. paralias, E. maritimum, O. maritimus*, *Pancratium maritimum* and *Polygonum maritimum*. It usually forms on high beaches or embryo dunes near the upper limit of high tides. Of all the dune communities, it is the one in which the influence of the sea and the great mobility of the soil are most noticeable.
- Loto cretici-Ammophiletum arenaria: Lively vegetation dominated by the grass *A. arenaria* that colonizes the crests of mobile dunes, helping to fix them. In the Ria Formosa Natural Park, this plant usually is accompanied by *O. maritimus, E. maritimum, L. creticus, C. maritima, A. campestris, M. marina, Pancratium maritimum, A. maritima, S. niceensis* and *M. littorea*. In the peninsulas and barrier islands of the Ria Formosa Natural Park, it is usual for this community to form continuous ridges along the beach, which allows the dunes fixation. Usually found between embryo dunes and semi-fixed dunes.
- Artemisio crithmifoliae-Armerietum pungentis: Association made up of plants with rigid and sometimes succulent leaves that populate the semi-fixed interior dunes. It starts from the back of the dune ridge and then spreads through the depression to the marsh. The species present are *H. italicum picardi, L. creticus, M. littorea, C. maritima, A. campestris, S. niceensis, A. maritima, R. gaditana, Pancratium maritimum, T. carnosus, Linaria lamarckii, C. canescens* and *P. argentea*.
- Frankenio laevis-Salsoletum vermiculatae elymietosum boreali-atlantici (Suaedo verae-Salsoletum vermiculatae elymietosum boreali-atlantici): Community dominated by *S. vermiculata*, *Frankenia laevis, S. vera* and *E. farctus*. It appears in certain sandy places of the barrier islands, making the transition between the marsh and the dune or, more rarely, bordering the ria on sandy soils. The salinity of the groundwater table is very low, but the salt brought by the wind is fundamental for the development of the community. Other species present in this community are *L. monopetalum, L. creticus, P. coronopus, P. argentea* and *A. arenaria*.
- Sarcocornio perennis-Puccinellietum convolutae (Puccinellio maritimae-Arthrocnemetum perennis): This community is dominated by *S. perennis*, accompanied by *P. maritima* and is subject to the daily flow of the tides. In the Ria Formosa, *H. portulacoides, S. perennis* and *S. fruticosa* are also common.
- Zosteretum noltii: association formed almost exclusively by the species *Z. noltii*, on which algae live epiphytically. It develops in estuaries and shallow sandy or muddy coasts, usually

uncovered at low tide. It is an Atlantic association that appears throughout the Ria Formosa area.

The fact that plant communities identified by Costa et al. (1996) were not all found may be due to the difficulty in identifying some species and differences in the methodology used by both studies. Besides, the present inventory was not carried out by botanists and the flowers of some species bloom later in the spring.

It should be noted that despite the unfavourable conservation status of *T. carnosus* at a global level (IUCN, 2022), in Portugal, the population is numerous and stable in several places in its distribution area, as recorded on Barreta Island. In addition, it is a legally protected species, with the majority of known populations occurring in Protected Areas (Carapeto et al., 2020). However, some pressures with local significance are identified, such as tourism development, the expansion of invasive alien plants and the erosion of dune environments, due to the rise in the average sea level (Carapeto et al., 2020). For these reasons, the Life Barrier Islands project proves to be very important for the conservation of this species.

In the last year of the project (spring 2023), it is planned to repeat this work of inventorying the native vegetation and we believe that after the various actions of removing invasive plants and mammals, and raising awareness among the island's users, it will be possible to find more individuals of *Linaria pedunculata, Linaria munbyana* and *Hypecoum littorale* as well as recording higher values of coverage for most of the species recorded in this inventory.

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