ECOLOGICAL NOTES ON HALOPHYTES SPECIES FROM MEDITERRANEAN CLIMATE

OBSERVAŢII ECOLOGICE LA SPECII DE HALOFITE DIN CLIMATUL MEDITERANEAN

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Abstract. *Salt marshes represent special ecosystems where plant species adopt different adaptive strategies, according to spatial disposition, association with other species or in terms of accurate specialization related to salinity factor. The aim of this work is to present some ecological notes regarding halophytes occurring in maritime and continental salt marshes from Spain. Our observations were conducted during July-November, 2010. These observations lead to the idea that each species has, in fact, a number of morphological, anatomical and physiological adaptations, strictly correlated with environmental factors. Some of these taxa are dominant in salt marshes, having very efficient adaptive strategies assuring them the stability in hyper saline environments. We discuss, extensively, some examples, in a holistic manner.*
Key words: halophytes, ecology, adaptation, mediterranean, integrative.

Rezumat. *Sărăturile reprezintă ecosisteme deosebite, în cadrul cărora speciile de plante adoptă strategii adaptative diferite, în funcţie de poziţia spaţială, asocierea cu alte specii sau în funcţie de specializarea strictă în relaţie cu factorul salinitate. Lucrarea de faţă îşi propune să prezinte unele observaţii ecologice la specii de halofite care vegetează pe sărături maritime şi continentale din unele regiuni ale Spaniei. Observaţiile noastre au fost efectuate în perioada iulie-noiembrie 2010. Am putut constata că fiecare specie prezintă, de fapt, un set de adaptări morfo-anatomice şi fiziologice, în deplină concordanţă cu factorii de mediu. Unii taxoni sunt dominanţi în aceste ecosisteme, prezentând strategii adaptative foarte eficiente care le asigură stabilitatea în cadrul mediilor hipersaline. Pe larg, sunt discutate unele exemple, într-o manieră holistică.*
Cuvinte cheie: halofite, ecologie, adaptare, mediteranean, integrativ.

INTRODUCTION

The Mediterranean climate is characterized by strong seasonality which involves the association of a drought period when temperatures are at their hottest and a cool (and cold in many areas) moist period (Thompson, 2005). The summer drought can limit growth, flowering, and fruiting, and is a major cause of seedling mortality. The Mediterranean ecoregions are usually defined by their particular climates, which are transitional between temperate and dry tropical climates

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(Médail, 2009). These conditions occur on the west coasts of all continents between latitudes 30° and 45°. Rainfall is extremely variable, with mean annual values ranging from 100 to 2000 mm. Aridity and temperature play an essential role in the structure and composition of Mediterranean ecosystem. Five ecoregions of the world possess a Mediterranean climate and form the Mediterranean biome: Mediterranean Basin, California, central Chile, the southern and southwestern Cape Province of South Africa, the southwestern and parts of southern Australia (Joffre et al., 2007; Keddy, 2007; Médail, 2009).

From these regions, Mediterranean Basin occupies the biggest area (2.3 millions km^2) where vegetate approximately 25.000 plant species (Keddy, 2007).

Due to the high heterogeneity of factors characterizing this type of climate (topographic, climatic, lithological substrate, hydric regime, soil fertility diversity), attention should paid on the fact that sometimes authors are referring on Mediterranean climate, Mediterranean ecosystem-types, Mediterranean biome, and sometimes on Mediterranean-type environments.

In the present work, our intention is to propose an ecological integrative approach of halophytes; this would imply that ecological observations gathered in the field were correlated with morphology and anatomy of halophytes, and, when possible with physiological and biochemical data (obtained in the lab). In this way, we intended to obtain a complete picture of interrelationships established between halophytes and corresponding environmental factors.

Halophytes are plants adapted to survive in high salinity conditions in soil or water; their biology, as well the great number of difficulties related to their definition and classifications were extensively discussed by our group dealing with halophytology (Grigore, 2008a; 2008b, Grigore and Toma, 2010a; 2010b, Grigore et al, 2010).

MATHERIAL AND METHOD

Our observations in the field were conducted between July and November of 2010, in maritime and inland salt marshes from Spain. We investigated over 30 halophytes collected from these ecosystems. Biochemical investigations were followed in Instituto de Biología Molecular y Celular de Plantas (Universidad Politécnica de Valencia) and anatomical investigations were done in UPV and Plant Morphology and Anatomy Laboratory, from "Alexandru Ioan Cuza University", Iasi.

RESULTS AND DISCUSSIONS

In a maritime salt marsh from Alicante (SE Spain), it can be noticed the disposition of vegetation in concentric belts, following the intensity of soil salinization (fig. 1). Thus, the salt marsh is bordered on the lower part by a relatively thin belt with *Phragmites australis* (1), which occupies a lower, less salinized area in the configuration of salt marsh. Towards the interior, few isolated plants of *Tamarix boveana* and *T. canariensis* (3) may be found. The last mentioned species is usually confined to upper, peripheral areas, avoiding thus the waterlogging conditions. This saline ecosystem is dominated by *Sarcocornia* *fruticosa* and *Arthrocnemum macrostachyum*, which form a relatively large belt towards the center of salt marsh (2), where the salinity is the most elevated. Between patches built by these two species, another species from *Chenopodiaceae* can be noticed: *Salicornia ramosissima*, an annual species that achieve in the late autumn an intense, beautiful red colour (fig. 2).

Fig. 1 - General appearance of a salt marsh in Alicante (Spain), July of 2010 (original, the explanation of numbers in the text)

These two chenopods are perennial, being - as we will see in the further paragraphs – strictly adapted to high salinity. Right in the center of salt marsh (4), they appear as small patches or even izolated plants (fig. 3).


Fig. 2- *Salicornia ramosissima* (original)


Fig. 3 - Izolated plants of *Sarcocornia fruticosa*, located in the center of salt marsh (Alicante, Spin, July of 2010, original)

In this part of salt marsh salt efflorescence may be formed, especially in the dry season, due to strong variations in the hydric regime of atmosphere and soil; this leads to formation of crusts in soil surface, after the intense evaporation accompanying the end of dry season (fig. 3).

The other peripheral belt, opposite to that formed by *Phragmites* actually represents the transitional zone to an ecosystem less salinized, more elevated in comparatively with the proper salt marsh (fig. 1). As we left behind the salt marsh, we can find, gradually species such as: *Suaeda splendens, S. vera, Salsola oppositifolia, Frankenia, Limonium* species, which are well adapted to salinity conditions, but mainly dried, due to the soil less permeable to water, facilitating the drainage to lower parts. Returning to this relatively large belt of vegetation (fig. 1, no. 5), it consists of species as: *Limonium furfuraceum, L. santapolense, L. parvibracteatum,* izolated plants of *Tamarix*, *Mesembryanthemum nodiflorum*, *Juncus acutus, J. maritimus,* and *Suaeda vera*. On the slope connecting the zones 5 and 4, in places more shaded and rich in vegetation, we found *Centaurium spicatum* (fig. 4), and *Inula crithmoides* - in the lower parts. This species is succulent, growing in wet places; we noticed that when occurring as isolated individuals, this species is more robust and branched, in contrast to the individuals grouped in patches.

Fig. 4 - *Centaurium spicatum* (original)

Sometimes, after abundant rainfalls (especially in the autumn), here are conditions for flooding, which change the general appearance of these ecosystems (fig. 5).

Fig. 5 - General appearance of a maritime salt marsh, after a rainy seson (Spain, November of 2010; compare with Fig. 1; original)

It's very interesting to siscuss the intensity and relevance of halophytes' adaptations, following the salinity gradient. Thus, *Chenopodiaceae* species, which are well represented in these salt marshes, have the most complex adaptations related to salinity factor. All these taxa are succulent, perennial (almost in all cases), flowering usually in the late autumn (*Sarcocornia, Arthrocnemum, Salicornia, Sueda*). The succulence of vegetative axial organs allow the dilution of salts (Grigore, 2008b; Grigore and Toma, 2010a), as well acting as a compensatory mechanism for the lack of well developed stereome. Biochemically, *Arthrocnemum* and *Sarcocornia* species have high osmotic potentials (Waisel, 1972); our investigations revealed that they accumulate small amount of proline and synthesize high amount of glycine betaine, in elevated salinity conditions (Grigore et al., unpublished data). But other halophytes have built, durring the evolution (Grigore, 2011) another mechanisms, allowing them to cope with the toxic effects of salts in excess. We refer on secretion, a complex largely distributed phenomenon among halophytes (Grigore and Toma, 2010b); it may be found in *Limonium* and *Tamarix* species (Grigore and Toma, unpublished data). *Tamarix* (fig. 7) are phreatophytes and posses salt glands having a great capacity to excrete salts and concentrations of salts in the solutions may be 20 times greater than those in the local ground water.

Fig. 6 - Branches with leaves of *Tamarix canariensis.* It can be noticed the salted drops, secreted by salt glands (Alicante, July of 2010, original)

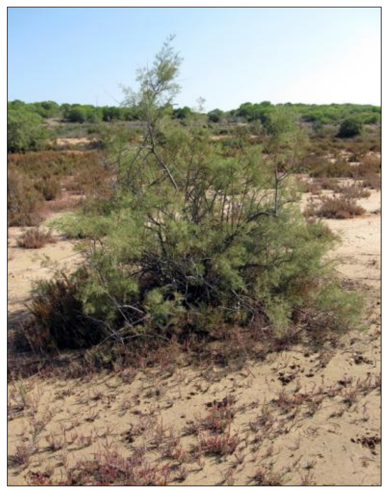

Fig. 7 - *Tamarix canariensis.* (Alicante, July of 2010, original)

The special anatomical and ecological features found in *Tamarix* species (Grigore and Toma, 2010b) seem to have very complex and subtle implications in the interrelations established between these plants and other species from a given ecosystem. It is more likely that roots of *Tamarix* species can access the salinized deep ground water and can induce the salinization of the upper parts of the soil, which could lead to elimination of species vegetating in the non-salinized layers of the soil (Grigore and Toma, 2010b). Perhaps due to this kind of interrelations, under *Tamarix* „canopy" only halophytes – adapted to survive in high concentrations of salts – can vegetate (fig. 6).

PRELIMINARY CONCLUSIONS

Data presented here – and only in a concise manner – suggest that halophytes from Mediterranean are well specialized species adapted to vegetate in particular ecological conditions. Taking into consideration that we can obtain a complete adaptive profile of halophytes but only using morphological, anatomical, physiological and biochemical information, we propose that this kind of approach to be called *plant integrative ecology*.

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