ANATOMICAL AND ECOLOGICAL OBSERVATIONS ON PSAMMO-HALOPHYTES SPECIES (EASTERN PART OF SPAIN)

OBSERVAȚII ANATOMO-ECOLOGICE LA SPECII DE PSAMO-HALOFITE (PARTEA ESTICĂ A SPANIEI)

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Abstract. *In this work, we included preliminary data regarding anatomical and ecological adaptations in species collected from littoral in Spain, during 2010. Species we have anatomically investigated are: Crithmum maritimum L. (Apiaceae), Plantago coronopus L. (Plantaginaceae), Sporobolus pungens (Schreb.) Kunth (Poaceae), Cakile maritima Scop. (Brassicaceae), Bassia hyssopifolia (Pall.) Kuntze, Salsola kali L. (Chenopodiaceae) and Frankenia laevis L. (Frankeniaceae). Several taxa have a deep rooting system (Cakile, Salsola) and others display shoot succulence (Crithmum, Cakile); these features should be regarded as an adaptation to xeric conditions. Species like Sporobolus and Frankenia posses salt glands, special devices involved in removal of concentrated salts.*

Key words: halophytes, psammophytes, salinity, adaptations, ecology

Rezumat. *În acest studiu, am inclus rezultatele preliminare referitoare la adaptările anatomo-ecologice ale unor specii colectate de pe litoralul maritim din Spania, în anul 2010. Aceste specii sunt: Crithmum maritimum L. (Apiaceae), Plantago coronopus L. (Plantaginaceae), Sporobolus pungens (Schreb.) Kunth (Poaceae), Cakile maritima Scop. (Brassicaceae), Bassia hyssopifolia (Pall.) Kuntze, Salsola kali L. (Chenopodiaceae) şi Frankenia laevis L. (Frankeniaceae). Unele specii prezintă sistem radicular foarte profund (Cakile, Salsola) şi suculența părților aeriene (Crithmum, Cakile), ca o adaptare la condițiile de xerofitism. Alte specii posedă glande saline (Sporobolus, Frankenia), care intervin în eliminarea excesului de sare.*

Cuvinte cheie: halofite, psamofite, salinitate, adaptări, ecologie

INTRODUCTION

Halophytes are a remarkable ecological group of plants, including very different species in terms of habitats where they vegetate, taxonomical diversity and adaptive strategies (Grigore, 2008a, 2008b; Grigore and Toma, 2010 a, 2010b).

In the current paper, we try to go further in a series of studies focused on adaptations of Mediterranean species; this imply histo-anatomical investigations (Grigore, Toma, Ivănescu, 2011), and especially an integrative ecological approach,

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an issue previously proposed and described in detail (Grigore et al., 2011).

Species restricted to littoral zone are confined to an area making transition from sea to the land; there were several attempts to classify littoral and corresponding vegetation (Warming, 1909; Ranwell, 1972). In this work, we define "littoral zone" as that area, delineated one side by line where the action of weaves stops and in the opposite side, by the line where surface covered by sand ends, usually due to an antropic impact. This is not the case of sand dunes, *stricto sensu*; therefore, in this paper we shall not deal with sand dunes.

Henslow (1895), Schimper (1903), Warming (1906), Chermezon (1910) have sporadically mentioned adaptations of littoral plants in time; but they dealt with plants discussing adaptations regarding only limited aspects of their biology.

The predominant ecological factor in the area that we previously defined is water deficit; this is because the soil is physically or even physiologically dry, due to salty water in the upper part of soil. Water stress could be also related to insolation. Moreover, attention should be paid on salinity influence, regarded both as saline water in the soil, as well as salt spray. These environmental conditions and the nature of adaptations that we discuss here suggest the use of term psammo-halophytes, namely plants that vegetates on maritime sands also exposed to salinity.

MATERIAL AND METHOD

In this study, we included ecological notes for the follow species: *Crithmum maritimum* L. *(Apiaceae), Plantago coronopus* L. *(Plantaginaceae), Sporobolus pungens* (Schreb.) Kunth *(Poaceae), Cakile maritima* Scop. *(Brassicaceae), Bassia hyssopifolia* (Pall.) Kuntze, *Salsola kali* L. *(Chenopodiaceae)* and *Frankenia laevis* L. *(Frankeniaceae)*. Field observations and plant material collection for subsequent histo-anatomical investigations were done during July-December 2010 in littoral zone of Valencia Community.

Anatomical investigations were conducted following the standard method fixed by our group working in plant anatomy from Faculty of Biology Iaşi (for a detailed description of this method, see: Grigore et al., 2010).

RESULTS AND DISCUSSION

It is worth noting that in the field we made several interesting morphological and ecological observations. Species vegetating on sand, located to a considerable distance from seawater (and therefore free from its direct action) display a deep radicular system, as comparatively to their aerial part. This is the case of *Cakile maritima* (fig. 1) and *Salsola kali* (fig. 2), where principal root has approximately 1.2-1.3 meters in length, while the shoot reaches only 20-30 centimeters. This is an obvious adaptation to xerophytic conditions related to maritime sand that is permeable to water and that does not allows its retaining in the upper layers. Consequently, species that vegetate in this area must develop a deep root system in order to find and reach the water table.

Fig. 1 - Root/shoot length ratio in *Cakile maritima* (blue line shows the limit between roots and shoot; ending blue point marks the root tip) (original)

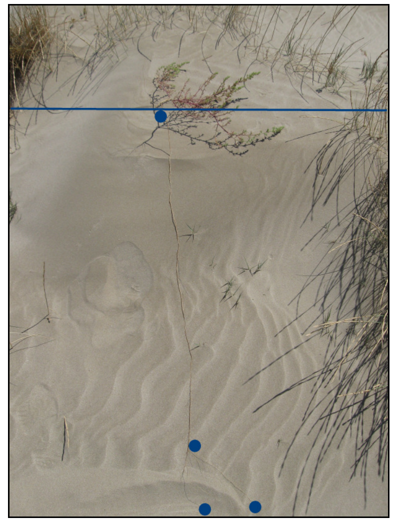

Fig. 2 - Root/shoot length ratio in *Salsola kali* (blue line shows the limit between roots and shoot; ending blue points mark the root tips) (original)

In addition, *Cakile* is a succulent species (original anatomical results not shown) (Toma et al., 1979), and *Salsola* (*Chenopodiaceae)* has C_4 photosynthetic pathway, a feature with complex ecological and adaptive implications (Grigore, 2008a, b; Grigore et al., 2012). *Crithmum* has also a succulent lamina (fig. 3) and a strong rhizome that we think that this is an adaptation to sandy soil, more compact than in the case of other previously mentioned species.

The lamina of *Plantago coronopus* has a bifacial-heterofacial structure, with palisade tissue under both epidermis (fig. 4) and 2-3 layers of rounded cells in the center.

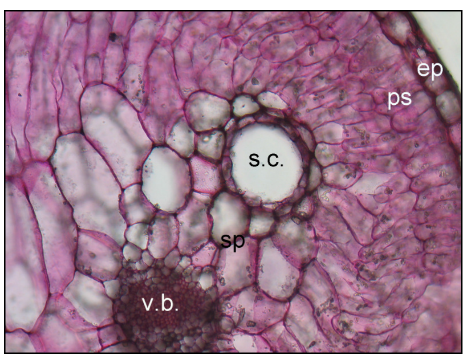

Fig. 3 - Cross section through the lamina of *Crithmum maritimum* (X 200); ep – epidermis; ps – palisade tissue; sp – spongy tissue; v.b. – vascular bundle

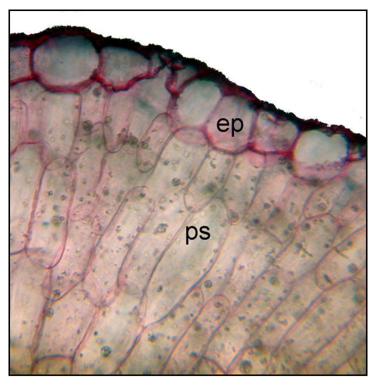

Fig. 4 - Cross section through the lamina of *Plantago coronopus* (X 200); ep – epidermis; ps – palisade tissue

A well-developed palisade tissue under both epidermis could be regarded as an adaptation to sandy environment, where the insolation is considerable; moreover, the albedo effect may be also involved, by reflecting radiation of sun to lower epidermis. Moreover, in order to make photosynthesis more efficient, the leaves of *Plantago* are arranged in a basal rosette and approximately parallel to aerial stem; this might be an adaptation to a uniformly exposure to sun radiation affecting the entire surface of lamina.

Sporobolus pungens is a typical psammophyte, as an older name of it suggests: *S. arenarius* Duval-Jouve. This species has, as adaptations to sandy environment a repent, extensive, and branched rhizome, with long internodes (fig. 5). The rhizome is usually located in the upper layer of sand soil, forming a dense underground network, easily to note when we tried to extract the aerial stem from sand. In this way, aerial stems are very close each other (fig. 6) and sometimes could be covered by sand in their basal part, due to the wind action. Perhaps this underground network is involved in plant anchoring in the sand, assuring a mechanical resistance to high wind intensity. In addition, as an adaptation to salinity conditions – occurring as saline source in water table or as salt spray – this species presents bicellular salt glands (fig. 7); these structures are involved in removal of concentrated salts (Grigore şi Toma, 2010b).

Fig. 5 - *Sporobolus pungens*: underground and above ground organs

Fig. 6 - *Sporobolus pungens*: aerial stems

Frankenia laevis also presents salt glands; these have a multicellular structure, consisting of six cells (fig. 8).

Bassia hyssopifolia vegetates on beaches from Alicante-Santa Pola, as isolated vigorous individuals, preferring relatively shading areas.

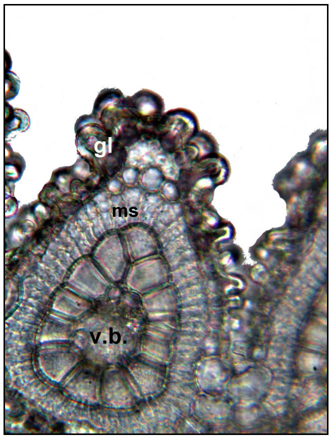

Fig. 7 - Cross section through the lamina of *Sporobolus pungens* (X 200); gl – salt gland; ms – mesophyll; v.b. – vascular bundle

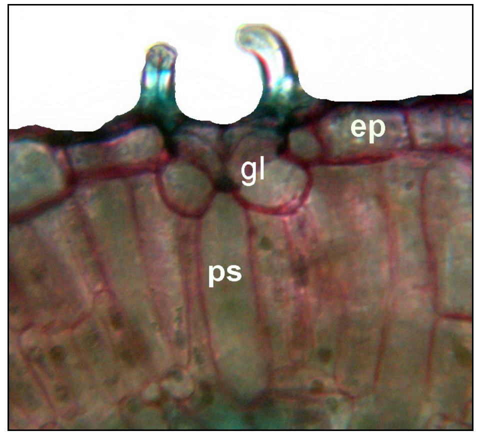

Fig. 8 - Cross section through the lamina of *Frankenia laevis* (X 400); ep – epidermis; gl – salt gland; ps – palisade tissue

CONCLUSIONS

Our preliminary observations suggest that here is a close correlation between morpho-anatomical adaptations and ecological factors predominating in coastal ecosystems. These adaptations are of xerophytic and halophytic nature and reflect in fact each major part of environmental convergent factors: hydric deficit and salinity influence, respectively.

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