

THE IMPACT OF SEA WATER IMMERSION ON THE  
VIABILITY OF PSAMMOPHILOUS SPECIES *LEYMUS*  
*RACEMOSUS* SUBSP. *SABULOSUS* AND *AMMOPHILA*  
*ARENARIA*

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**Abstract**

*Leymus racemosus* (Lam.) Tzvelev subsp. *sabulosus* (M. Bieb.) Tzvelev (mammoth wildrye) and *Ammophila arenaria* (L.) Link (marram grass) are perennial, psammophilous species which dominate sand dunes due to their biological characteristics. Their communities have an important role in the formation of the natural vegetation cover of coastal sand strips along the Bulgarian Black Sea Coast. This study provides the first systematic analysis of tolerance of *L. racemosus* subsp. *sabulosus* and *A. arenaria* to sea water immersion along the Bulgarian Black Sea Coast. It aims to determine effects of flooding stress on whole plants and how long rhizomes can remain viable in sea water. Two experiments establish that decomposition of leaves of immersed plants starts from the 7th day. A growth of stems and root sprouts is observed on the same day. There are no visible decompositions of stems, roots and rhizomes till the end of the experiment (20th day). Rhizomes from the investigated species are able to regenerate after 30 days of submergence and bud viability appears to be enhanced slightly by sea water. *L. racemosus* subsp. *sabulosus* shows higher bud viability than *A. arenaria*. The possible negative consequences of flooding to *L. racemosus* and *A. arenaria* communities based on experimental results, hydrodynamical modelling, detailed topography, bathymetry surveys and detailed GIS mapping on Panorama Beach are discussed.

**Key words:** *Leymus racemosus* subsp. *sabulosus*, *Ammophila arenaria*, immersion tolerance, viability, IDF models

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**Introduction.** *Leymus racemosus* (Lam.) Tzvelev subsp. *sabulosus* (M. Bieb.) Tzvelev (mammoth wildrye) and *Ammophila arenaria* (L.) Link (mar-ram grass) are erect, perennial, rhizomatous grass species [1]. They are major psammophilous species which dominate sand dunes due to their biological characteristics and their communities have an important role in the formation of the natural vegetation cover of coastal sand strips along the Bulgarian Black Sea Coast. These closely-related species form an extensive system of horizontal and vertical rhizomes that support sand stabilization. A good example of the high potential of the root system of these two species to accumulate sands and prevent from washout is the storm in March 2010 in Panorama Natural Beach situated north of the Golden Sands Resort near the town of Varna. A great amount of sediments are preserved within the beach boundaries (Fig. 1), unlike the neighbouring Golden Sands urbanized beach.

Despite their high resistance, *L. racemosus* subsp. *sabulosus* and *A. arenaria* are vulnerable and sensitive to the impact of waves and storms. These factors in combination with anthropogenic impact may lead to various negative consequences. Plants could be affected by direct storm-wave damage, during which they are uprooted or buried by sediments. Furthermore, leaf, stem and root decomposition processes may be initiated as a result of long-term flooding. In addition to this, direct storm-wind activity may also contribute to beach plant uprooting, while sand grain blasts may damage their leaves and stems.

This study investigates the possible negative consequences of flooding to *L. racemosus* and *A. arenaria* communities based on experimental results, hydro-dynamical modelling, detailed topography, bathymetry surveys and detailed GIS mapping on the Panorama beach.

The aim is to establish the changes and adaptations of these psammophilous species in coastal sands to the stress of flooding in certain short-term intervals and the period of which whole plants and rhizomes of *L. racemosus* subsp. *sabulosus* and *A. arenaria* submerged in sea water still maintain viable buds capable of producing new plants.

The study is performed in frames of the THESEUS project “Innovative technologies for safer European coasts in a changing climate” (GA no: 244104) Work Package 1 “Risk assessment, policy, management and planning strategy in study sites”.

**Materials and methods.** Two experiments are performed. Rhizomes and whole plants of *L. racemosus* subsp. *sabulosus* and *A. arenaria* are collected at Panorama Natural Beach, Varna (43°18'23"N, 28°03'15"E) in October 2011 for the first experiment and in December 2011 for the second experiment.

In the first test, whole plants are placed in plastic tanks (20 l) full of sea water which is changed twice daily. The average temperature of water is 15–16 °C. Ten replicates of each investigated plant species are immersed at a depth of 2–4 cm below the water surface for 20 days. Morphological changes of different parts of



Fig. 1. *Leymus racemosus* subsp. *sabulosus* and *Ammophila arenaria* communities along Panorama beach: *a*) after the storm in March 2010; *b*) two month after the storm



Fig. 2. *Leymus racemosus* subsp. *sabulosus*: a) 7-day growth of stems; b) 7-day growth of root sprouts; c) *Ammophila arenaria* vegetative shoot (after 7 days)

the plants (leaves, stems, roots) and the effect of flooding on the viability of the studied specimens are recorded and photographed daily. The experiment starts on 15.10.2011 in the laboratory of the Varna Museum of Natural History.

During the second experiment, rhizomes of *L. racemosus* subsp. *sabulosus* and *A. arenaria* are immersed in plastic tanks (20 l) full of sea water which is changed twice daily. The average temperature of water is 5 °C. Twenty rhizomes per treatment are removed every fifth day and planted in washed and sterilized sand in plastic pots in the glasshouse. Control rhizomes are planted directly. Rhizomes are watered with freshwater as needed and allow growing for one month before harvesting.

Statistical analysis is carried out and some parameters are calculated. Mean bud viability is the percentage of rhizome nodes that produce vegetative shoots and roots. Maximum bud viability for each treatment is the highest number of viable buds on one rhizome replicate. Maximum bud viability for each treatment is calculated as the bud viability of the rhizome replicate with the highest bud viability for that treatment. Rhizomes with maximum bud viability and rhizomes with more than one viable bud are presented in per cent [2].

Various datasets and models are used in order to estimate the possible negative consequences of flooding to *L. racemosus* subsp. *sabulosus* and *A. arenaria* communities. To implement hydrodynamical modelling, detailed topography and bathymetry surveys are carried out and 2 typical cross-shore profiles are constructed along Panorama Beach. Topography surveys are accompanied by detailed GIS mapping of *L. racemosus* subsp. *sabulosus* and *A. arenaria* communities. Flood duration is calculated for four return periods (RP) – 5, 20, 50 and 100 years. IDF (Intensity Duration Frequency) functions are constructed for each representative cross-shore profile.

**Results.** No mortality occurs during the course of the first experiment. Beginning of the decomposition of leaves of the submerged plants starts from the

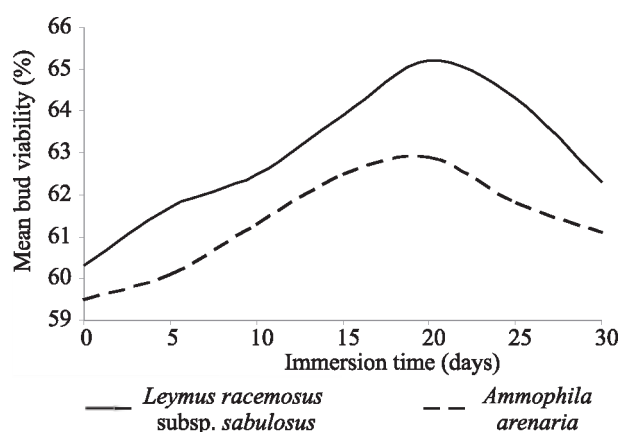


Fig. 3. Mean bud viability following sea water immersion

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Rhizome bud viability following sea water immersion

Submergence duration (days)	Mean bud viability %	Maximum bud viability %	Rhizomes with max. bud viability %	Rhizomes with > 1 viable buds %
<i>Leymus racemosus</i> subsp. <i>sabulosus</i>				
0 (control)	60.3	100	5	85
5	61.7	100	10	90
10	62.5	100	15	95
15	63.9	100	15	95
20	65.2	100	20	100
25	64.3	100	15	95
30	62.3	100	10	90
<i>Ammophila arenaria</i>				
0 (control)	59.5	100	5	80
5	60.1	100	10	80
10	61.3	100	10	90
15	62.5	100	15	95
20	62.9	100	15	90
25	61.8	100	10	85
30	61.1	100	10	80

7th day. On the same day, a growth of stems (Fig. 2a) and root sprouts (Fig. 2b, c) is observed. There are no visible decompositions of stems, roots and rhizomes of the two species till the end of the experiment (20th day).

*L. racemosus* subsp. *sabulosus* and *A. arenaria* rhizomes remain viable for 30 days in sea water (the maximum duration of the second experiment). Bud viability increases till the 20th day of sea water submergence, followed by a slightly decreased bud viability (Table 1). Mean bud viability in the control is 60.3% (*L. racemosus* subsp. *sabulosus*) and 59.5% (*A. arenaria*), gradually increases to the maximum of 65.2% (20th day) and slightly decreases at the end of the immersion (Fig. 3). Each immersion period has a maximum rhizome bud viability of 100%. Even on the 30th day of immersion, 90% of *L. racemosus* subsp. *sabulosus* rhizomes and 80% of *A. arenaria* rhizomes still have at least one viable bud and 10% of rhizomes have 100% bud viability.

IDF models represent that *L. racemosus* subsp. *sabulosus* and *A. arenaria* communities are flooded partly from 24 h (RP 5 years) to 57 h (RP 100 years) (Fig. 4). Comparison to the data of the experiment shows that storm events along this beach do not influence *L. racemosus* subsp. *sabulosus* and *A. arenaria* communities.

**Discussion.** Most of the experimental methods used to study the response of investigated plants to sea water are focused to substrate salinity and salt spray



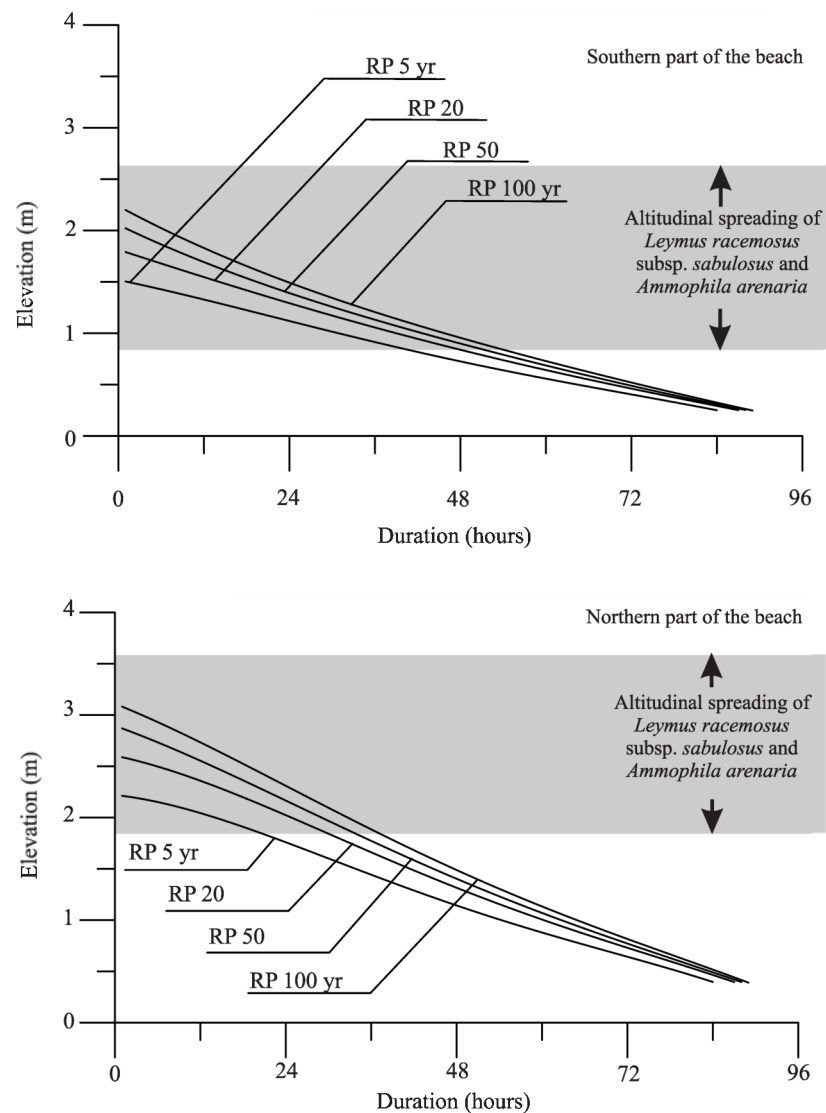


Fig. 4. IDF (Intensity Duration Frequency) functions and spatial distribution of *L. racemosus* subsp. *sabulosus* and *A. arenaria* along Panorama Beach

from waves. The seedling survival of the physiologically and ecologically closely-related species *Leymus mollis* (Trin.) Pilg. remains high under high soil salinity, and salt spray has no significant effect on leaves [3]. Soil salinity higher than 1.5% to 2% is lethal to *Ammophila* [4]. Tests in hydroponic culture of species of genus *Leymus* show that their biomasses vary between 46 and 78% of controls after 2 weeks of treatment with 200 mm NaCl. The buoyancy of *A. arenaria* rhizomes is determined experimentally [5].

These standard methods are inapplicable to define the stress of flooding because *L. racemosus* subsp. *sabulosus* and *A. arenaria* are well adapted to substrate salinity due to their regular exposure to sea water. Therefore, in order to understand the effects of sea water inundation on these species two experiments based on direct submergence are chosen.

Great resistance to flooding is established for a 20-day period. Beginning of the decomposition of leaves of submerged plants starts from the 7th day, which is longer than the flooding with maximum duration for this beach.

The bud viability of both investigated species remains high (> 60%), following submergence in sea water for 30 days and appears to be enhanced slightly by sea water. All the treatments have highest values than the mean viability of the control treatment (60.3%). The higher value is reached on the 20th day (65.2% and 62.9%). This is in agreement with previous studies on *A. arenaria* [2, 5, 6]. *L. racemosus* subsp. *sabulosus* shows higher bud viability than *A. arenaria*.

This high viability appears to be due to the imposition of dormancy on subordinate rhizome buds, which has the effect of keeping in reserve buds and nutrients against the threat of repeated mechanical disturbance [7].

**Conclusions.** *L. racemosus* subsp. *sabulosus* and *A. arenaria* have high tolerance to sea water immersion and show high viability during the negative impact from the storms. These species are considered to be a key species for dune stabilization in the coastal dune systems and could contribute to the protection of coastal sands during storms.

## REFERENCES

- [1] KOZHUHAROV S. In: Field Guide to the Vascular Plants in Bulgaria. (ed. S. Kozhuharov), BAS, Sofia, 1992, 585–610 (in Bulgarian).
- [2] APTEKAR R., M. REJMÁNEK. J. Coastal Conserv., **6**, 2000, 107–111.
- [3] GAGNÉ J., G. HOULE. Am. J. Bot., **89**, 2002, No 3, 479–485.
- [4] SYKES M., J. WILSON. Acta. Bot. Neerl., **38**, 1989, 173–182.
- [5] KONLECHNER T., M. HILTON. J. Coast. Res., **56**, 2009, 434–437.
- [6] GORHAM J., E. McDONNELL, R. WYN JONES. J. Exp. Bot., **35**, 1984, 1200–1209.
- [7] HARRIS D., A. DAVY. J. Ecol., **74**, 1986, 1045–1056.

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