10.2478/botlit-2018-0019

BOTANICA
ISSN 2538-8657

2018, 24(2): 202–210

EFFECT OF EDAPHIC FACTORS ON THE VEGETATION ZONATION IN SOME LITTORAL AND INLAND SALT MARSHES OF EGYPT

Ramadan Shawky

Desert Research Centre, Mathaf El-Matariya Str. 1, Cairo EG-11753, Egypt
E-mail: ramadan_salam@hotmail.com

Abstract

Shawky R., 2018: Effect of edaphic factors on vegetation zonation in some littoral and inland salt marshes of Egypt. – Botanica, 24(2): 202–210.

The segregation of a few dominant plant species into distinctive zones is characteristic of salt marshes. Vegetation zonation was investigated in the littoral salt marshes (South Marsa Alam region) and the inland salt marshes (Wadi El-Natrun region) of Egypt. Twenty taxa belonging to 18 genera and 11 families were recorded and classified into two sets at the two studied sites and subdivided into four groups by TWINSPAN, according to a relevance value: group A) co-dominated by *Juncus acutus* and *Juncus rigidus*; B) – dominated by *Aeluropus lagopoides*; C, D) – *Limonium axillare*. The analysis of species diversity in the inland salt marshes as well as the Shannon and the Simpson indices showed the highest species richness compared to that in the littoral salt marshes. The soil of the inland salt marshes was characterized by high percentages of silt, clay, also the soluble anion SO_4^{-2} was the highest. While the most effective factor in the littoral salt marshes was EC, sand fractions, moisture content, soluble cations as Na^{+}, Ca^{+2}, soluble anions as Cl^{-}, organic matter and $CaCO_3$. The proximity matrix between the two types of salt marshes indicated that they were different, except for the stands of *Juncus rigidus*, the elucidation distance was the smallest and they were similar together.

Keywords: diversity, edaphic factors, inland, littoral, proximity matrix salt marshes, vegetation, zonation.

INTRODUCTION

The zonation pattern of halophytic vegetation in the salt marshes of Egypt has not been enough described. The studies of Kassas & Zahran (1967) and Abd El-Ghani (2000) have described the vegetation of salt marshes, but haven't compared the littoral and inland salt-marsh habitats of Egypt. Moreover, wetlands are one of the most threatened habitats in Egypt, and estimation of relationships between wetland vegetation and environmental conditions is essential for nature conservation. Ecologically, some plant species tend to have a restricted range of distribution; others have a wide range of ecological amplitudes and some others are absent from some sites (Zahran & Willis, 2009; El-Amier & Shawky, 2017).

Salt marshes constitute an example of an ecosystem that comprises stable species-poor or mono-specific communities with distributions that are related to environmental physical and chemical gradients. Pennings & Callaway (1992) have proposed the 'new paradigm' concept related to the zonation of salt-marsh plants, whereby upper limits are set by competition in relatively low-stress environments, whereas lower limits are set by tolerance to harsh physical conditions (Sánchez et al., 1998).

The composition and distribution of plant communities in salt marshes are related to the ability of individual species to tolerate environmental conditions that are associated with flooding, salinity and nutrient limitation. Salt-marsh vegetation typically forms distinct and predictable zones that are superimposed on soil gradients. Sharp physical gradients in these communities allow close examination of the effects of physicochemical factors on species interactions (Pennings & Callaway, 1992; Bertness & Hacker, 1994; Van Wijnen & Bakker, 1999).

Salt-marsh communities are generally dominated by a small number of species that are spatially segregated into pronounced vegetation zones. The succession of salt-marsh vegetation is affected by several factors, most common of which are edaphic factors or condition and flooding. These factors are often considered to determine the establishment and zonal patterns of species in salt marshes (Ungar et al., 1979; Pennings & Callaway, 1992). Succulence is a common phenomenon in the vegetation of saline habitats (Abd El-Ghani, 2000). Some problems, which the salt marsh plants are facing, have been identified by Bertness & Allison (1987). For example, the physical gradients of the marsh restrict the distribution of the high marsh perennials such as: *Spartina patens* (Aiton) Muhl and *Juncus gerardi* Loisel. The authors suggest that the competitive advantage of phalanx morphology over guerilla morphology and that of clonal plants over solitary ones does exist.

Vegetation zonation in salt-marsh environments may also reflect biotic interactions, such as interspecific competition and symbiotic activity. In addition, pressure by herbivores and parasites may play important roles in shaping salt-marsh vegetation (Ungar, 1998). It has also been suggested that electrical conductivity determines the coarse patterns of plant-community composition, whereas ionic composition is responsible for the fine scale pattern (Cantero & Leon, 1996).

The zonation of salt marsh vegetation is a universal phenomenon. Concentric zonation of halophytic communities in small lakes and salt marshes of Egypt has been described by Kassas (1971). The relationship between the pattern of halophytic vegetation and the environmental factors such as edaphic factors associated with distribution has been studied by many authors (Hassib, 1951; Kassas & Zahran, 1967; El-Ghareeb, 1975; El-Demerdash et al., 1990; Sharaf El-Din et al., 1993; Abd El-Ghani, 2000; Badreldin et al., 2015; Zahran et al., 2017; Shawky, 2018).

Understanding of the effects of soil conditions on vegetation zonation will contribute to the correct utilization and rehabilitation of salt marshes. Therefore, the present study addresses the following objectives: (i) to determine the effects of edaphic factors on the zonation pattern of salt-marsh vegetation and (ii) to compare between the inland and littoral salt-marsh vegetation.

MATERIALS AND METHODS

Data collection

The data collection was done in 2017. Two linear transects 120 m long were drawn across the littoral salt marshes (South Marsa Alam region) and the inland salt marshes (Wadi El-Natrun region) (Fig. 1). A total of 23 stands were selected at the sites representing the study areas (11 at South Marsa Alam site and 12 at Wadi El-Natrun site). Along each transect, plots were placed within each stand according to the dominant species, and the size of plots was determined as the minimal areas (10 m^2) of relatively uniform stands and approximating the mean minimum area of the prevailing plant communities (Mueller-Dombois & Ellenberg, 1974). Within each stand, the species were recorded. Nomenclature of vascular plant species follows Boulos (2009). Coverage (%), densities and frequencies of species were analysed in each stand quantitatively by the line intercept method (Canfield, 1941). Relative density, frequency and coverage of each species were summed to give its importance value (IV) out of 300. Life forms were identified according to the scheme of Raunkiaer (1934).

From each stand, three soil samples (0–50 cm) were collected, pooled together to form a composite sample, spread over sheets of paper, air dried, passed through 2 mm sieve, and packed in plastic bags ready for physical and chemical analyses in the Desert Research Centre, Cairo. Soil pH was measured in soil-water extracts at 1:1 (w:v) with a Beckman pH meter. Electrical conductivity (dS m^{-1}) was determined in soil–water extracts at 1:5 (w:v) using the Jenway analyser. Na^+ and K^+ were determined using atomic absorption spectrophotometer. Ca^{2+} and Mg^{2+} were determined using EDTA (disodium dihydrogen ethylenediamine tetraacetate) and murexide indicator for calcium and eriochrome black indicator for calcium and magnesium together. Cl^- and SO_4^{2-} were determined by gravimetric and turbid metric methods, respectively according to Rayan et al. (2001).

Species richness (alpha diversity) was calculated for each vegetation group as the average number of species per stand. Species turnover (beta diversity) was calculated as a ratio between the total numbers of species in a specific vegetation group and its alpha diversity (MAGURRAN, 2004). Relative evenness or equitability (Shannon indices) of the importance value of species was expressed according to the formula of PERKINS (1982).

Study area

Two study areas representing the inland and littoral salt marshes of Egypt were selected: Wadi El-Natrun region (representing the inland salt marshes) in the Western Desert and South of Marsa Alam region (representing the littoral salt marshes) along the Red Sea coast. Wadi El-Natrun is a part of the Western (Libyan) Desert adjacent to the Nile Delta (23 m below sea level), located approximately 90 km southwards of Alexandria and 110 km northwards of Cairo. It is oriented between longitudes 30° 05’ E and latitudes 30° 17’ N (KING & SALEM, 2009). It is about 50 km long, narrow at both ends (2.6 km in the north and 1.24 km in the south) and wider in the middle, about 8 km. The depression is characterized by small disconnected lakes at the bottom of the Wadi, aligned along its general axis in the north-westerly direction, except for Lake El-Gara (ZAHRAN & WILLIS, 2009). The total area of Wadi El-Natrun is approximately 281.7 km^2, extending in a NW-SE direction. The origin of the underground water in Wadi El-Natrun is seepage from the Nile. The water level in the lakes fluctuates seasonally along the year rising up in winter and falling down in summer, but never get dry. Wadi El-Natrun region is regarded as an extremely arid region, where mean annual rainfall, evaporation, and temperature are 41.4 mm, 114.3 mm, and 21 °C, respectively. Also the geology of Wadi El Natrun has been studied by many authors (SHATA & EL-FAYOUMI, 1967; LA MOREAUX, 1962).

South of Marsa Alam region, is located about 150 km south of Marsa Alam city and north of Wadi El-Gimal protectorate between longitudes 35° 07′ E and latitudes 24° 40′ N. It is about 7 km long southwards Hamata city and 4 km directed to the sea shore. Climatically, the study area lies within the hyper-arid provinces with mild winters and hot summers. The main bulk of rain occurs in winter, i.e. the Mediterranean affinity, and summer is, in general, rainless. Variability of annual rainfall is not unusual. Total annual rainfall is 2 mm and 3.1 mm, respectively (KASSAS & ZAHRAN, 1962; 1965). Temperature is high and ranges between 14–21.7 °C in winter and 23–46.1 °C in summer. Relative humidity ranges from 43% in summer to 65% in winter. The Piche-evaporation is higher in summer (13.7–21.5 mm/day) than in winter (5.2–10.4 mm/day). These two regions represent the natural habitats mainly inhabited by halophytes (Fig. 1).

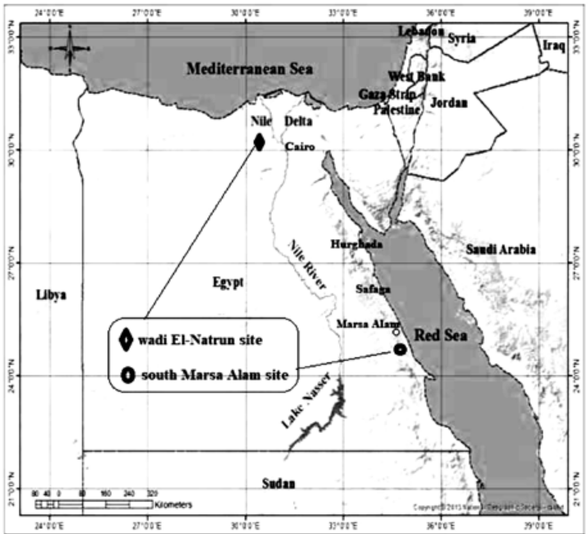

Fig.1. Map of Egypt showing the studied sites

Data analysis

A floristic data matrix (20 species × 23 stands) was subjected to classification by cluster analysis of the computer programme CAP (Community Analysis Package) version 1.2 (HENDERSON & SEABY, 1999) using the minimum variance as an algorithm, and a dendrogram was presented. The vegetation groups produced from cluster analysis were then subjected to ANOVA (One-Way Analysis of Variance) based on soil variables to find out significant variations among groups. (FLINN et al., 2008). All the edaphic variables were assessed for normality using COSTAT software for Windows version 4.6. For the proximity matrix, the cluster analysis was carried out using the hierarchical clustering method on all plant types in the plant communities to classify them by the importance value using SPSS for windows version 25.

RESULTS

Vegetation patterns and marsh geometry

The application of TWINSPAN led to the recognition of four vegetation groups (one group in the Inland salt marshes and three in the littoral salt marshes) (Fig. 2). The vegetation composition of these groups is presented in Table 1.

Group A: It was comprised of 12 stands of the inland salt marshes co-dominated by *Juncus acutus* and *Juncus rigidus* (IV= 73.9 and 66.3, respectively). The stands of these communities were characterized by high pH (7.68) and sulphate (6.88 meqL^{-1}). However, different fractions of sand predominated in soils (Table 2). The diversity measurements showed the highest species richness average – 6.25 (species/stands), the Simpson index – 0.79, the Shannon (H) index – 1.69 and Shannon (E) index – 0.62 (Table 3).

Group B: Three stands of the littoral salt marshes were dominated by *Aeluropus lagopoides* (IV = 112.7). The important species in this group was *Juncus rigidus* (IV = 68.3). The stands of these communities were characterized by a high content of fine sand, moisture, and highly affected by EC (24.9 ds/cm), Na (101.7 meqL^{-1}), Ca (39.7 meqL^{-1}), Mg (76.7 meqL^{-1}) and organic matter (0.89%)

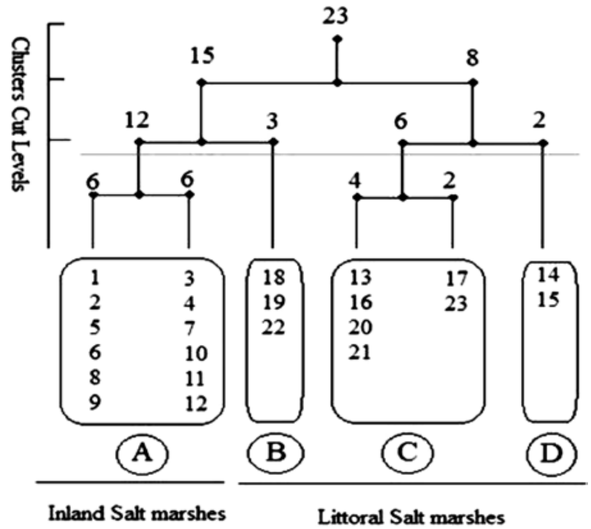

Fig. 2. Two Way Indicator Species Analysis (TWINSPAN) dendrogram of 23 sampled stands based on the importance values of 20 dominant species

Table 1. Floristic composition and mean of the importance values (out of 300) of the recorded species in different vegetation groups resulting from TWINSPAN classification of the study area

Species	Vegetation Groups			
	A (n = 12)	B (n = 3)	C (n = 6)	D (n = 2)
Acacia tortilis (Forssk.) Hayne	0.00	0.00	17.2 ± 7.81	0.00
Aeluropus lagopoides (L.) Trin. Ex Thw.	0.00	112.7 ± 44	0.00	0.00
Aeluropus littoralis (Gouan) Parl.	6.95 ± 3.77	0.00	0.00	0.00
Alhagi graecorum Boiss.	7.58 ± 2.71	0.00	0.00	0.00
Arthrocnemum macrostachyum (Moric.) Moq.	0.00	0.00	0.00	41.9 ± 34.2
Cressa cretica L.	5.30 ± 2.92	0.00	0.00	0.00
Cynodon dactylon (L.) Pers.	5.38 ± 2.82	0.00	0.00	0.00
Cyperus laevigatus L.	15.03 ± 5.9	0.00	0.00	0.00
Desmostachya bipinnata L.	19.1 ± 9.27	0.00	0.00	0.00
Imperata cylindrica (L.) Raeuschel.	17.1 ± 5.33	0.00	0.00	0.00
Juncus acutus L.	73.9 ± 8.57	0.00	0.00	0.00
Juncus rigidus Desf.	66.3 ± 10.7	68.3 ± 34.8	0.00	0.00
Limonium axillare (Forssk.) Kuntze	0.00	0.00	122 ± 26.8	177.6 ± 13
Phragmites australis (Cav.) Trin. ex Steud.	15.9 ± 6.12	58.1 ± 31.4	0.00	0.00
Sonchusmaritimus L.	2.26 ± 1.22	0.00	0.00	0.00
Sporobolus spicatus (Vahl) Kunth	4.53 ± 3.06	0.00	0.00	0.00
*Suaeda monoica (*Forssk.) ex J.F.Gmel.	0.00	0.00	24.5 ± 18.3	0.00
Tamarix nilotica (Ehrenb.) Bunge	16.5 ± 7.02	24.5 ± 24.5	61.9 ± 18.2	80.6 ± 21
Typha domingensis Pers.	17.1 ± 5.96	0.00	0.00	0.00
Zygophyllum album L.	27.1 ± 6.88	36.3 ± 23.9	74.1 ± 14.7	0.00

n – number of relevés.

Table 2. Comparison of the soil variables or properties of 23 stands representing four vegetation groups (A–D) obtained by the cluster analysis

Variables		Vegetation Groups				$LSD_{0.05}$
		Inland Salt Marshes	Littoral Salt Marshes			
		Group A (n = 12)	Group B (n= 3)	Group C (n = 6)	Group D (n = 2)	
Coarse sand	%	12.7 ± 1.76	5.60 ± 0.89	13.3 ± 0.8	12.9 ± 1.39	10.2^{ns}
Medium sand		29.6 ± 2.15	27.57 ± 4.95	54.5 ± 0.75	53.2 ± 2.25	13.5^{***}
Fine sand		19.8 ± 2.27	40.50 ± 6.46	25.9 ± 0.88	24.8 ± 1.14	16.1^{**}
Silt		18.8 ± 2.28	11.7 ± 1.17	3.13 ± 0.33	4.06 ± 0.52	13.8^{***}
Clay		19.1 ± 2.47	14.6 ± 0.75	2.47 ± 0.04	5.05 ± 1.52	13.9^{***}
Moisture		13.7 ± 0.58	34.6 ± 0.9	16.2 ± 1.58	16.7 ± 0.9	5.54^{***}
pH		7.68 ± 0.03	7.67 ± 0.02	7.42 ± 0.02	7.37 ± 0.04	0.17^{***}
Electric conductivity (Ds/cm)		1.78 ± 0.14	24.9 ± 0.09	11.7 ± 1.41	14.9 ± 0.24	3.78^{***}
Na^+	Meq/L	27.03 ± 0.8	101.7 ± 1.1	76.4 ± 9.75	88.4 ± 1.22	26.3^{***}
K^+		3.97 ± 0.62	12.3 ± 0.09	16.7 ± 1.9	19.6 ± 0.61	6.26^{***}
Ca^{+2}		3.89 ± 0.29	39.7 ± 1.86	36.8 ± 3.8	38.3 ± 0.37	10.3^{***}
Mg^{+2}		1.21 ± 0.13	76.7 ± 0.41	32.2 ± 2.66	31.5 ± 1.14	7.12^{***}
Cl^-		23.7 ± 1.51	60.3 ± 1.45	72.9 ± 5.66	75.2 ± 2.94	17.3^{***}
SO_4^{-2}		6.88 ± 0.47	0.71 ± 0.04	0.71 ± 0.14	0.83 ± 0.04	2.93^{***}
$CaCO_3$		18.6 ± 0.86	28.1 ± 1.64	37.6 ± 7.45	42.3 ± 2.08	20.3^{**}
Organic Matter	%	0.76 ± 0.04	0.89 ± 0.01	0.71 ± 0.08	0.73 ± 0.03	0.29^{ns}

Variables expressed as mean values ± standard errors, LSD – Least Significant Difference between means, n – number of relevés, significant differences according to ANOVA are marked as *** at $p \leq 0.05$, ** at $p < 0.01$.

Table 3. Comparison of species diversity of 23 stands representing four vegetation groups (A–D) obtained by the cluster analysis

Parameters	Vegetation Groups				$LSD_{0.05}$
	Inland Salt Marshes	Littoral Salt Marshes			
	A (n = 12)	B (n = 3)	C (n = 6)	D (n = 2)	
Species Richness	6.25 ± 0.49	3.33 ± 0.88	3.50 ± 0.34	2.50 ± 0.4	3.07**
Dominance (D)	0.21 ± 0.02	0.37 ± 0.09	0.38 ± 0.04	0.48 ± 0.06	0.18***
Simpson index (1-D)	0.79 ± 0.02	0.63 ± 0.09	0.62 ± 0.04	0.52 ± 0.06	0.18***
Shannon (H)	1.69 ± 0.08	1.09 ± 0.26	1.10 ± 0.1	0.82 ± 0.14	0.62***
Shannon (E)	0.62 ± 0.03	0.50 ± 0.12	0.50 ± 0.05	0.38 ± 0.07	0.25*

Variables expressed as mean values ± standard errors, LSD – Least Significant Difference between means, n – number of relevés, significant differences according to ANOVA are marked as *** at $p \leq 0.05$, ** at $p < 0.0$.

(Table 2). The diversity measurements in this stand revealed an average species richness 2.5 (species/stands), the Simpson index – 0.52, the Shannon (H) index – 0.82 and the Shannon (E) index – 0.5 (Table 3).

Group C: Six stands of the littoral salt marshes were dominated by *Limonium axillare* (IV = 122.3). The important species in this group was *Zygophyllum album* (IV = 74.1). The stands of this group were characterized by high contents of coarse (13.3%) and medium sand (54.5%) (Table 2). The diversity measurements in this stand showed the lowest species richness – 3.5 (species/stands), the Simpson index – 0.62, the Shannon (H) index – 1.1 and the Shannon (E) index – 0.5 (Table 3).

Group D: It was comprised of two stands of the littoral salt marshes and dominated by *Limonium axillare* (IV = 177.6). The important species in this group was *Tamarix nilotica* (IV = 80.6). The stands of this group were affected by high content of K^+ (19.6 $meqL^{-1}$), Cl^- (75.2 $meqL^{-1}$) and $CaCO_3$ (42.3 %) (Table 2). The diversity measurements in this stand

Table 4. Proximity matrix between the studied stands using the hierarchical cluster method

Sites	Wadi El-Natrun (inland salt marshes)												
	Stand No.	1	2	3	4	5	6	7	8	9	10	11	12
South Marsa Alam (littoral salt marshes)	13	2.22	2.09	1.45	1.00	1.84	1.92	1.28	1.35	1.88	2.24	1.81	1.89
	14	2.05	1.98	1.46	0.95	1.68	1.68	1.07	1.08	1.74	2.16	1.62	1.72
	15	2.08	1.99	1.40	0.89	1.79	1.81	1.00	1.03	1.72	2.12	1.56	1.65
	16	2.15	2.04	1.42	0.93	1.81	1.84	1.08	1.12	1.75	2.15	1.61	1.70
	17	2.19	2.06	1.39	0.96	1.83	1.91	1.23	1.30	1.81	2.15	1.75	1.82
	18	2.78	2.68	2.14	1.64	2.28	2.32	1.54	1.63	2.07	2.64	1.75	2.15
	19	2.93	2.79	2.24	1.77	2.35	2.44	1.69	1.79	2.07	2.70	1.73	2.23
	20	2.12	2.01	1.38	0.99	1.74	1.77	1.03	1.08	1.69	2.09	1.56	1.65
	21	2.18	2.08	1.48	0.96	1.79	1.80	1.06	1.09	1.74	2.18	1.57	1.68
	22	2.66	2.65	2.29	1.68	2.32	2.26	1.53	1.52	2.18	2.68	1.87	2.10
	23	2.24	2.29	1.65	1.04	2.36	2.21	1.08	0.99	2.01	2.21	1.66	1.66

indicated an average species richness – 2.5 (species/stands), the Simpson index – 0.52, the Shannon (H) index – 0.82 and the Shannon (E) index – 0.38 (Table 3).

Zonation of salt-marsh vegetation

Proximity matrix between stands

Table 4 shows the distance between the stands of Wadi El-Natrun site (inland salt marshes) and South Marsa Alam site (littoral salt marshes). The number of species in stand 4 (littoral salt marshes) and stand 15 (inland salt marshes) was the smallest 0.89 and represented the shortest distance that can be found between two stands, so the two stands had the same characteristics, while the distance between stand 1 (littoral salt marshes) and stand 19 (inland salt marshes) was the longest, so it means that the two stands were far away and had different characteristics.

Proximity tree of hierarchical clustering

According to the hierarchical clustering method, the stands were classified into five groups. The distances between the stands and dominant species was divided and measured in the values ranging from 0 to 25. All vegetation zones were divided into two main sets (Fig. 3).

The first set contained two groups, which included the stands of inland salt marshes (1 to 12). One group (A) contained the co-dominated zone of *Juncus rigidus* and *Juncus acutus*. Another group (B) was a co-dominated zone of *Juncus rigidus* and *Desmostachya bipinnata*.

The second set contained three groups, which included the stands of littoral salt marshes (13 to 23).

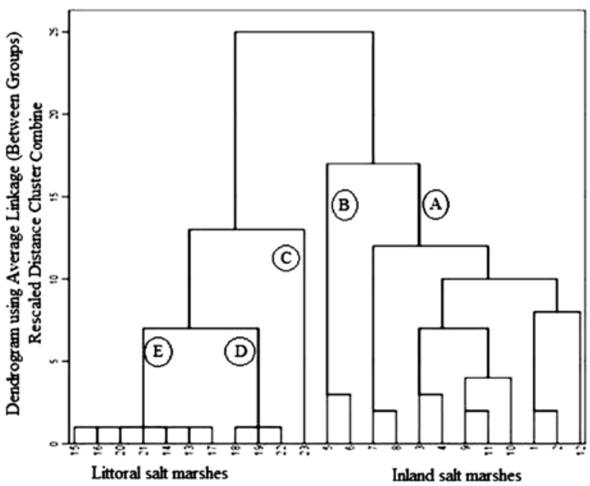

Fig. 3. Hierarchical clustering analysis of the stands at the studied sites

One group (C) was the dominated zone of *Aeluropus lagopoides*. Another group (D) was the dominated zone of *Limonium axillare*. The third group (E) was the co-dominated zone of *Suaeda monoica* and *Tamarix nilotica*.

DISCUSSION

The vegetation distribution pattern in the study areas was mainly related to the gradients in salinity, soil moisture and fine fractions. Concentration of calcareous deposits, especially in the inland salt marshes, was also important. The distribution of species in saline and marshy habitats relates to salinity in many arid regions (Caballero et al., 1994; Flowers, 1975; Kassas, 1957; Maryam et al., 1995; Ungar, 1968). Ungar (1965, 1974) has indicated that the distribution of inland halophytes in the United States is mainly dependent on the salinity gradient, while climate, topography, soil moisture and biotic factors are less important. This is in line with the results of the present study.

The diversity of plant species in salt marshes is poor, due to the limitation in species which are distributed in the salt-marsh habitats (Shawky & El-Khouly, 2017; Shawky, 2018). In the present study, the diversity was also shown to be low, but it was higher in the inland salt marshes than in the littoral salt marshes.

The distribution pattern and the overlap occurrences of halophytes in salt marshes indicate overlap in environmental requirements or tolerance of environmental stress. In the present study, EC, Na^+, Cl^-, sand fraction and clay are the key factors related to vegetation zonation. Vegetation zonation in salt marshes is affected by physical stress and nutrient limitation, and these factors can result in modification of the pattern of plant zonation, (Barbour et al., 1987; Bertness, 1991).

The application of cluster analysis in the present study showed that the stands, which were dominated by *Juncus rigidus* in the inland and littoral salt-marsh habitats, were closely related due to the similarity of soil factors or maybe the physiological characters in *Juncus rigidus* species. This statement requires more detailed studies. While the dissimilarity between the two sites is related to the elevation above the sea level and the water supplying to the marsh, which is in agreement with Abd El-Ghani (2000) and Kassas & Zahran (1967).

The salt marshes are a community that tends to show niche relation to certain soil factors such as soil salinity, moisture and EC on the distribution and the structure of plant communities. Also, soil pH should not be neglected as an important factor crucial for the pattern of vegetation in coastal wetlands (Li et al., 2008). Mean electrical conductivity declined with increasing distance from the sea and increasing altitude, in clear accordance with the principal pattern of vegetation zonation (Moffett et al., 2010; El-Khouly & Khedr, 2007). Sánchez et al. (1998) have stated that Na^+ and Cl^- concentrations decline with increasing distance from the sea, in clear accordance with the principal pattern of vegetation zonation.

CONCLUSION

The distribution of halophytic species is subjected to a varying condition of salinity concentrations, cations and anions. However, the influence of other environmental factors needs to be analysed before the current zonation pattern can be properly understood. Therefore, it is essential to understand the structure and composition of natural plant communities along environmental gradients and its underlying ecological determinants in this part of the world.

The present study concluded that the halophytic vegetation in the salt marshes is poor. The stands dominated by *Juncus rigidus* in the inland and littoral salt marshes are similar and need more studies to understand the physiological behaviours of this species and its relations with the edaphic factors.

REFERENCES

Abd El-Ghani M.M., 2000: Vegetation composition of Egyptian inland salt marshes. – Botanical Bulletin of Academia Sinica, 41: 305–314.

Badreldin N., Uria-Diez J., Mateu J., Youssef A., Stal C., El-Bana M., Goossens R., 2015: A spatial pattern analysis of the halophytic species distribution in an arid coastal environment. – Environmental Monitoring and Assessment, 187(5): 224, 1–15.

Barbour M. G., Rejmánek D.M., Johnson A.F., Pavlik B.M., 1987: Beach vegetation and plant distribution patterns along the northern Gulf of Mexico. – Phytocoenologia, 15: 201–233.

Bertness M.D., 1991: Zonation of *Spartina patens* and *Spartina alterniflora* in a New England salt marsh. – Journal of Ecology, 72: 198–148.

Bertness M.D., Allison A.M., 1987: Determinants of patterns in a New England salt marsh community. – Ecological Monograph, 57: 129–147.

Bertness M.D., Hacker S.D., 1994: Physical stress and positive associations among marsh plant. – American Naturalist, 144: 363–372.

Boulos L. (eds), 2009: Flora of Egypt-Checklist. – Cairo.

Caballero J.M., Esteve M.A., Calvo J.F., Pujol J.A., 1994: Structure of the vegetation of salt steppes of Guadelentin (Murcia, Spain). – Student Oecologia, 10–11: 171–183.

Canfield R., 1941: Application of the Line Interception Method in Sampling Rang Vegetation. – Journal of Forestry, 39:288–394.

Cantero J.J., Leon R.J.C., 1996: Comparison of vegetation classifications from Argentine salt marsh landscapes. – Abstracta Botanica, 20(2): 69–83.

El-Amier Y.A., Shawky R.A, 2017: Floristic Features and Vegetation Structure of Salt Affected Lands at the North Nile Delta, Egypt. – Journal of Environmental Sciences, 46(1): 71–88.

El-Demerdash M.A., Zahran M.A., Serag M.S., 1990: On the ecology of the deltaic Mediterranean coastal land, Egypt. III. The habitat of salt marshes of Damietta–Port Said coastal region. – The Arab Gulf Journal of Scientific Research, 8(3): 103–119.

El-Ghareeb R., 1975: A Study of the Vegetation-Environmental Complex of Saline and Marshy Habitats on the Northern Coast of Egypt. – Ph.D. Thesis, Faculty of Science, Alexandria University, Egypt.

El-Khouly A.A., Khedr A.A., 2007: Zonation Pattern of *Avicennia marina* and *Rhizophora mucronata* along the Red Sea Coast, Egypt. – World Applied Sciences Journal, 2(4): 283–288.

Flinn K.M., Lechowicz M.J., Waterway M.J., 2008: Plant Species Diversity and Composition of Wetlands within an Upland Forest. – American Journal of Botany, 95(10): 1216–1224.

Flowers T.J., 1975: Halophytes. – In D.A. Baker and J.L. Hall (eds), Ion Transport in Cells and Tissues: 309–334. – Amsterdam.

Hassib M., 1951: Distribution of plant communities in Egypt. – Bulletin of the Faculty of Science, University of Fouad I (now University of Cairo), Cairo, Egypt, 29: 59–261.

Henderson P.A., SEABY R.M.H., 1999: Community Analysis Package (CAP) version 1.2. – Lymington.

Kassas M., 1957: On the ecology of the Red Sea coastal land. – Journal of Ecology, 45: 187–203.

Kassas M., 1971: Pflanzenleben in der östlichen Sahara. – In H. Schiffers (ed.), Die Sahara und ihre Randgebiete. 1 (Physiogeographie), Weltforum, 1: 477–497. – München.

Kassas M., Zahran M.A., 1962: Studies on the ecology of the Red Sea coastal land. I. The district of Gebel Ataqa and El-Galala El-Bahariya. – Bulletin of Geographical Society, Egypt, 35: 129–175.

Kassas M., Zahran M.A., 1965: Studies on the ecology of the Red Sea coastal land. II. The district from El-Galala El-Qibliya to Hurghada. – Bulletin of Geographical Society, Egypt, 38: 185–193.

Kassas M, Zahran M.A., 1967: On the ecology of the Red Sea Littoral Salt Marsh, Egypt. – Ecological Monographs, 37(4): 297–315.

King C., Salem B.B., 2009: Comparison of biophysical changes affecting oasis ecosystems using remote sensing data and published local environmental assessments. – Journal of Arid Land Studies, 19(1): 45–48.

La Moreaux P.E., 1962: Reconnaissance report and recommendations for ground water investigations, Wadi El-Natrun, Western Desert, Egypt. The General Desert Development Organization, Cairo. – Bulletin de I 'Institut du désert d'Egypte, 81: 12–25.

Li W.Q., Liu X.J., Khan M.A., Gul B.Q., 2008: Relationship between soil characteristics and halophytic vegetation in coastal region of North China. – Pakistan Journal of Botany, 40(3): 1081–1090.

Magurran A.E., 2004: Measuring Biological Diversity. – Oxford.

Maryam H.S., Ismail F.A., Ahmed R., 1995: Studies on growth and salt regulation in some halophytes as influenced by edaphic and climatic conditions. – Pakistan Journal of Botany, 27: 151–163.

Moffett K.B., Robinson D.A., Gorelick S.M., 2010: Relationship of Salt Marsh Vegetation Zonation to Spatial Patterns in Soil Moisture, Salinity, and Topography. – Ecosystems, 13(8):1287–1302.

Muller-Dombis D., Ellenberger H., 1974: Aims and Methods of Vegetation ecology. – New York.

Perkins J., 1982: Shannon-Weaver or Shannon-Weiner. – Journal of Water Pollution Control Federation, 54: 1049–1050.

Pennings S.C., Callaway R.M., 1992: Salt marsh plant zonation: The relative importance of competition and physical factors. – Journal of Ecology, 73: 681–690.

Raunkiaer C., 1937: The Life Forms of Plants and Statistical Plant Geography. – London.

Rayan J., Garabet S., Harmson K., Rashid A. (eds), 2001: Soil and Plant Analysis Laboratory Manual. – Damascus.

Sánchez J.M., Otero X.L., Izco J., 1998: Relationship between vegetation and environmental characteristics in a salt-marsh system on the coast of Northwest Spain. – Journal of Plant Ecology, 136: 1–8.

Sharaf El-Din A., El-Kady H.F., Al-Sodany Y., 1993: Gradient analysis of common species in the saline and marshy habitats in the Nile Delta. – Feddes Repertorium, 104: 387–394.

Shata A., El-Fayoumi I.F., 1967: Geomorphological and morphological aspects of the region west of the Nile Delta with special reference to Wadi El-Natrun area. – Bulletin de I 'Institut du désert d'Egypte, 17(1): 1–28.

Shawky R.A., 2018: Plant Life along the Red and Mediterranean Seas Coastal Lands, Egypt. – Germany.

Shawky R.A., El-Khouly A.A., 2017: Plant species diversity of some Wadis at Red Sea Coast, Egypt. – Journal of Botanical Science, 6(2): 25–35.

Ungar I.A., 1965: An ecological study of the vegetation of the big salt marsh, Stafford County, Kansas. – University of Kansas, Science Bulletin, 46: 1–99.

Ungar I.A., 1968: Species-soil relationships on the Great Slat Plains of northern Oklahoma. – The American Midland Naturalist, 80: 392–406.

Ungar I.A., 1974: Halophyte Communities of Park County, Colorado. – Bulletin of Torrey Botanical Club, 101: 145–152.

Ungar I.A., 1998: Are biotic factors significant in influencing the distribution of halophytes in saline habitats? – Botanical Review, 64: 176–199.

Ungar I.A., Benner D.K., Mcgraw D.C., 1979: The distribution and the growth of *Salicornia europaea* on an inland salt pan. – Journal of Ecology, 60: 329–336.

Van Wijnen H.M., Bakker J.P., 1999: Nitrogen and phosphorus limitation in a coastal barrier salt marsh: the implications for vegetation succession. – Journal of Ecology, 87: 265–272.

Zahran M.A., El-Amier Y.A., Shawky R.A., 2017: On the ecology and role of the wild flora in the sustainable development of the Deltaic Mediterranean coastal desert, Egypt. – International Journal of Life Sciences and Technology, 10(5): 45–59.

Zahran M.A., Willis A.J. (eds), 2009: The Vegetation of Egypt. – London.

EDAFINIŲ VEIKSNIŲ ĮTAKA AUGALIJOS PASISKIRSTYMUI KAI KURIOSE DRUSKINGOSE LITORALINĖSE IR ŽEMYNINĖSE EGIPTO PELKĖSE

Ramadan Shawky

Santrauka

Druskingoms pelkėms būdingas dominuojančių augalų rūšių pasiskirstymas atskirose jų zonose. Augalijos zonavimas buvo tirtas litoralinėse (Pietų Marsa Alam regionas) ir žemyninėse (Wadi El-Natrun regionas) druskingų pelkių bendrijose. Nustatyta 20 augalų rūšių iš 11 šeimų, kurios pagal dominavimą, naudojant dviejų indikatorinių rūšių analizę TWINSPAN, suskirstytos į dvi pagrindines grupes ir keturis pogrupius. Išskirtoje A grupėje dominavo *Juncus acutus* ir *J. rigidus*, B – *Aeluropus lagopoides*, C ir D – *Limonium axillare*. Išskirtų grupių analizė parodė, kad druskingose žemyninėse pelkėse buvo didesnis rūšių skaitlingumas ir aukštesni Šenono-Vierio bei Simpsono indeksai, lyginant su litoralinėmis pelkėmis. Žemyninių druskingų pelkių dirvožemiui būdingas didelis drėgmės ir molio kiekis bei didesnė tirpaus anijono $SO4^{-2}$ koncentracija. Litoralinės zonos druskingų pelkių svarbiausi dirvožemio veiksniai buvo tirpūs katijonai Na^{+}, Ca^{+2} ir anijonai kaip Cl^{-}, organinės medžiagos ir $CaCO_3$. Dviejų druskingų pelkių tipų artumo matrica parodė jų skirtumus, išskyrus *Juncus rigidus* dominavimą, kuris liudija šių zonų panašumą.