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Vegetation diversity of dune slacks in Egypt

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Key words: Dune slacks, brackish slacks, Saline slacks, cultivated slacks, and plant diversity.

Abstract

The present study intends to evaluate the dune slacks vegetation inside the sand dune ecosystem of Egypt. It represented by fives slacks in three different habitats: two brackish, two saline and one cultivated slacks in North Sinai. The density and cover of species were measured in 26 stands, 2X2 m^2 each. The total number of their cover was 56 species. The richest habitat was the brackish slacks followed by cultivated and saline slacks respectively. By using two way indicator species analysis (TWINSPAN) it gives 12 groups as follow (5 cultivated groups, 4 brackish groups, and 3 saline groups). By using ordination methods CCA we found highly correlation between cultivated and brackish slacks and the fine soil particles silt and clay and the percentages of organic matters; and salinity, chlorides and sodium salts and the saline slacks. Line Regression between the number of species and the area of stand is positive in case of cultivated and brackish slacks, and negative between saline slacks and its areas.

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Introduction

One of the characteristic features of dunes are the damp or wet hollows, commonly called slacks, left between successive dune ridges or which have been formed as a result of complete blow-outs. In such places the ground water may reach the surface throughout the year or only in winter months, and this undoubtedly greatly influences the vegetation, not only as regards composition and distribution, but the plants themselves are often depauperate as compared with the same species elsewhere (Chapman, 1964). When the water is present throughout the year, a pond of varying size is present with reed-swamp species present such as *Typha domingensis* and *Phragmites australis* in our study it is looks like a typical reed swamp habitat or aquatic habitat, Floristic composition consists of fresh water species and algae. It is commonly called s·olma in Arabic between local inhabitants. Where there is only standing water in winter, the habitat is favorable by halophytes such as *Juncus rigidus*, and *Cyperus leavigatus*.

Leaching occurs on the dunes, washing humus and other components into the slacks, and the slacks may be much more developed than the exposed tops of the dunes. It is usually in the slacks that more rare species are developed and there is a tendency for the dune slacks soil to be waterlogged and where only marsh plants can survive.

Dune slacks appear as flat valleys in the dune system, usually rich in species and associated with other wetland habitats.

Humid dune slacks represent the wetland component of dune systems, usually where the underlying water table reaches the surface. There are two main types. Primary dune slacks run parallel to a dune coastline and are formed when a developing sand ridge cuts off a portion of beach. Secondary dune slacks are formed by the landward movement of dune ridges over stable wet sand at the water table (Grootjas *et al*, 2002).

A lot of studies were performed on the sand dune habitats in Egypt especially the major dune formations in the western desert and Sinai Peninsula (e.g: Ayyad,1973; Shaltout, 1985; Pye & Tsoar, 1990; Abd EL – Ghani & EL- Sawaf, 2006;El- Bana *et al*. 2007). Unfortunately, none of them gave attention to the dune slacks habitats. They consider the wet regions between the sand dunes as a salt marshes habitat although, there are many species with affinities to reed swamps and brackish water habitat. Moreover, there are many present and future threats facing this unique habitat in Egypt. The present threats includes: land reclamation for agricultures programmes, overgrazing and excessive water uses. The future threats could be caused by predicted sea level rise due to over all changes in climatic condition (Noest, 1991). Therefore, the main objectives of this study are: to highlight the importance of the dune slacks habitat in Egypt, to represent the vegetation diversity of this habitat, and to study the most important factors affecting the distribution and diversity of the vegetation inside the slacks.

Materials and methods

Vegetation analysis

The field study was based on regular visits to the study area. The study was conducted in summer and winter season of 2013. The present study was represented by five sites which cover the different types of dune slacks; two brackish slacks, two saline slacks and one cultivated slack. In each slacks many stands were made in order to investigate the vegetation cover and floristic compositions. The total number of stands is 26 stands: 6 brackish, 10 saline and 10 cultivated stands. The area of each stand is $4m^2$ (2X2) randomly made for measuring the relative density as the number of species per unit area. The nomenclature of plant species followed by Bolous (1995, 1999, 2000, 2002, and 2005). The sum of the relative density of the all plots gave the relative density of each stand. The plant canopy cover, as a percentage of ground surface was determined by line intercept method through many line intercept transect 10 meter for each was randomly placed

within the site. The sum of the relative density and relative cover gave the importance value of each species (Ludwing & Reynolds, 1988).

Soil analysis

Soil samples were collected from the study stands at 0-25 depth. All samples were brought to the laboratory shortly after collection , air dried and sieved through 2 mm sieve to get rid of debris and coarse gravel . Soil fractions (sand, silt and clay) were determined by sieves methods. Organic matter percentage was determined gravimetrically. Soil reaction (pH) was determined from (1:1) soil water extract. The percentage of anion (So_4^{2-} , Cl^-), and cation (K^+ , Na^+ , Ca^{2+}) were calculated from the soil extract by flame and titration methods. The percentage of calcium carbonate was detected by calcimeter method. Soil salinity as electronic conductivity was assessed by conductivity meter. All these procedure are outlined by Jakson (1962) and Allen *et al* (1986).

Statistical Analysis

The initial hierachical classification was made by the two way indicator species analysis (TWINSPAN). Classification of TWINSPAN was stopped at the sixth level. Ordination was used to detect the relation between the environmental factors and the floristic composition. Ordination was applied by detrended correspondence analysis (DCA) implanted by DECORANA programme (Hill, 1979b), and Canonical corresponding analysis (CCA), implented by CANOCO programme (Ter Braak, 1987). Regression analysis was performed to determine relationship between the plant diversity and the area of the slacks by SPSS (SPSS.10.)

The different groups of the TWINSPAN were subjected to four diversity indices: Richness, it is the number of species per specified area (Kershaw& Looney, 1985). Dominance indices, one of the most important index Simpson's index (D) was used in this study where $D = \sum P_i^2$. As D increase the diversity decrease. Shannon's index of diversity ($\dot{H}$) which calculated from the equation $\dot{H} = -\sum p_i \ln p_i$ (Kreds, 1985), where p_i is the proportion of individuals found in ith species. Eveness index (E) which calculated from the equation $E = \dot{H} / \text{Ln}(S)$ where S is the total number of species.

Study area

Location

Study area located in the coastal sand dunes between El- Sheikh Zweiud and Rafah (Fig 1). This area is characterized by its prosperity in cultivation of fruits, vegetables, and medicinal plants. Fruits such as olives, mango, kalamantin, pomegranate, guava, apples, and cantaloupes. vegetables such as, tomatoes, potatoes, and pepper. medicinal plants such as *Saliva officinalis*, and *Organium* ssp.

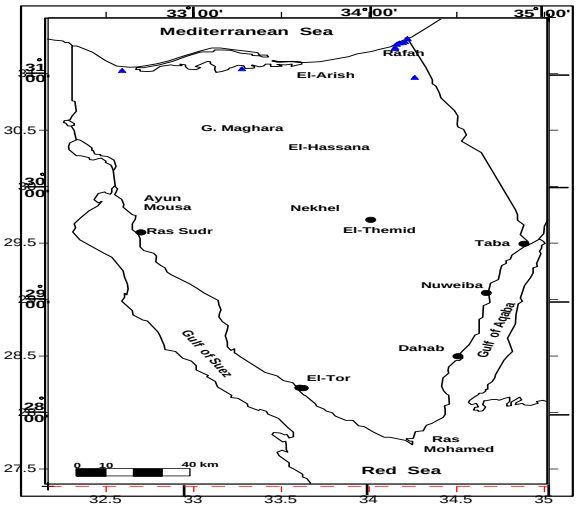


Fig. 1. Location map showing the study are in the NE of the Sinai corner at Rafah area.

Climate

The north coastal areas of Sinai are characterized by the Mediterranean climate with relatively rainy, cool winter and dry hot rainless summer. Air temperatures are similar to those of the Northern west coast of Egypt. The greatest amount of rainfall in Egypt (300 mm/yr) occurs on the far northeast of North Sinai (at Rafah). Generally about 70 % of rain along the North Coastal Zone occurs in winter and 30 % falls during the transitional months.

Results & discussion

Floristic composition

Vegetation analysis output by TWINSPAN gives 12 groups (Table 1), represents the different three slacks types (saline, brackish, and cultivated). Cultivated slacks consists of 5 groups represents 10 plots and 39 species (22 perennials, 17 annuals). It is dominated by *Phragmites australis* and *Phoenix dactylifera* (IV= 28, 25) respectively specially at raised and marginal areas. The main associated species are *Tamarix aphylla* (IV=23) in marginal areas, *Stipagrostis scoparia* (IV=14), *Calligonium comosum* (IV=13) in barren sandy areas, Rhizomatous species like *Cyperus rotundus*, *Cynodon dactylon*, *Typha domingensis* and *Imperata clyindrica* are common in the wet areas around the fruits tree . Annuals are common around the fruit trees forming a very dense growth or mats in this place moisture content is higher than the other places besides, the availability of organic matters and shade place e.g.: *Malva parviflora*, *Rumex pictus*, and *Senecio desfontaina* whereas annuals such as *Mesembrayanthemum crystallinum*, and *Chenopodium album* are common in raised areas. Trees however wild or cultivated may have complex effects on annuals growth and distributions. In addition to providing shade, they may moderate air and soil temperature, create nutrient islands as their litter decomposes and alter the spatial distribuation of soil water (Shumway, 2000).

Table 1. List of species of the different groups of TWINSPAN of the vegetation of dune slacks, Dominant species are in bold.

Species **Perennials**	**Cultivated slacks No. of Groups (5) Stands (17-26)**	**Brackish slacks No. of Groups (4) Stands (1-6)**	**Saline slacks No. of Groups (3) Stands (7-16)**
Acacia saligna L.	8	7	1
Anchusa azurea Mill.	1	1	0
Artemisia monosperma Delile.	6	8	1
Atriplex halimus L.	2	6	11
Bacopa monnieri (L.) Pennell.	0	0	51
Calligonum comosum (L'Hér)Soskov	13	16	0
Centaurea pallescens Delile	1	2	0
Cynodon dactylon (L.) Pers.	11	3	0
Cyperus laevigatus L.	0	0	**72**
Cyperus rotundus L.	12	5	0
Erodium hirtum (Forssk.) Willd	4	1	0
Frankenia pulverulenta L.	0	0	3
Haplophyllum tuberculatum (Forssk.)	2	0	0
Imperata cylindrical (L.) Raeusch.	7	6	4
Juncus rigidus Desf.	0	0	28
Lantana camara L.	0	4	0
Medicago marina L.	1	1	0
Nicotiana glauca R. C. Graham	0	11	0
Panicum turgidum Forssk.	11	2	0
***Phoenix dactylifera* L.**	**25**	21	6
***Phragmites australis* (Cav.) Trin. ex steud.**	**28**	19	5
Polygonum equisetforme Sm.	2	0	0
Solanum elaeagnifolium Cav.	3	0	0
Spergularia marina (L.) Bessler.	1	1	0
Stipagrostis scoparia (Trin. & Rupr.)	14	5	0
Tamarix aphylla (L.) H. Karst.	23	7	0
Tamarix nilotica (Ehrenb.) Bunge.	1	0	15
***Typha domingensis* (Pres.) Poir. ex Steud.**	11	**59**	0
Annuals			
Anchusa hispida Forssk.	0	0.5	0
Atriplex semibaccata R.Br.	0	0	1
Avena barbata Pott ex Lik.	1	0.5	0
Bassia murcata (L.) Asch.	0.5	0.5	0.5
Brassica tournefortii Gouan.	0.5	0.5	0.5

Species **Perennials**	**Cultivated slacks No. of Groups (5) Stands (17-26)**	**Brackish slacks No. of Groups (4) Stands (1-6)**	**Saline slacks No. of Groups (3) Stands (7-16)**
Buglossoides tenuiflora (l. f.) I. M. Johnst	0	0.5	0
Capsella bursa-pastoris (L.) Medik.	0.5	0	0
Carduus pycnocephalus L. spp. *arabicus* (Jacq.ex Murray) Nyman	1	0.5	0
Chenopodim murale L.	0.5	1	0
Chenopodium album L.	1	1	0
Emex spinosus (L.) Campd.	0	0.5	0
Erodium arborescens (Desf.) Willd	0	0.5	0
Hordeum marinum Huds.	0.5	0.5	0
Lobularia Arabica (Boiss.) Muschl.	0	0.5	0
Malva parviflora L.	1	1	0
Mesembrayanthemum crystallinum L.	1	2	0
Neurada procumbens L.	0	0.5	0
Ononis variegate L.	0	0.5	0
Recharida tingitana var. *orientalis* (L.) Asch. & Schweinf.	0	0.5	0
Rumex pictus Forssk.	1	0	0
Salsola kali L.	0	0	1
Schismus barbatus (L.) Thell.	1	0.5	0
Senecio desfontainei Druce, Brit.	1	0.5	0
Sisymbrium irio L.	0.5	0.5	0
Solanum nigrum L.	0	0.5	0
Trigonella Arabica Delile.	0.5	0	0
Urtica urens L.	1	1	0
Xanthium strumarium L.	0.5	0.5	0
Diversity indices			
Total	39	43	15
Simpson (D)	0.071	0.095	0.204
Shannon ($H^{'}$)	2.872	2.982	1.867
Eveness (E)	0.796	0.744	0.815

Vegetation of brackish slacks is the most diverse one between the different types of slacks (Shannon index= 2.982). It consists of 43 species most of them are annuals (23) species and the rest are perennials distributed over 6 plots and forming 4 groups having the same edaphic and chemical factors. It is dominated by *Typha domingensis* (IV=59). Common associated species includes *Phoenix dactylifera* (IV=21), *Phragmites australis* (IV=19), *Calligonium comosum* (IV=16), and *Nicotiana glauca* (IV=11). The most common annuals are *Mesembrayanthemum crystallinum*, and *Chenopodium* species. There are a direct correlation between the number of species and the area of dune slacks in case of cultivated (R^2=0.95, P<0.05) and brackish slacks (R^2=0.81, P<0.05) and a negative one in case of saline slacks (R^2=0.02, P<0.05) (Fig.4). The smallest number of species is recorded in saline slacks 15 species (11 perennials, 4 annuals). Ayaad & El- Ghareeb (1982) stated that within a certain region, therophytic species become less adapted to drought particularly where salinity is the limiting factor.

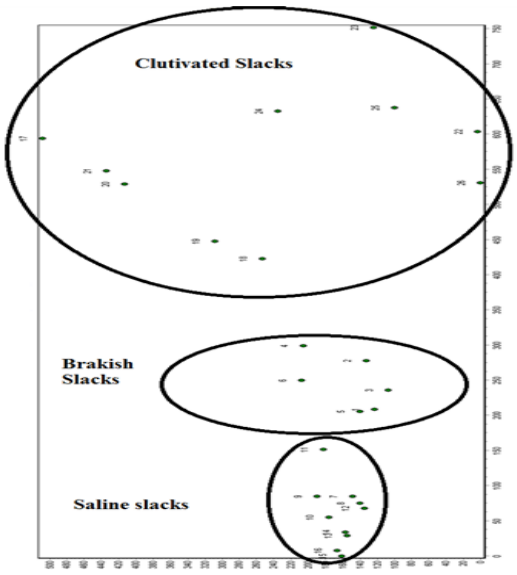


Fig. 2. The relationship between the vegetation groups generated after the application of TWINSPAN of dune slacks and their cluster centroids along the first and second axes of DCA.

The dominant species is *Cyperus laevigatus* (IV=72) followed by a mat of *Bacopa monnieri* (IV=51) and *Juncus rigidus* species (IV=28). There are four annuals species distributed along the margin of saline slacks namely *Salsola kali*, *Atriplex semibaccata*, *Bassia murcata*, and *Brassica tournefortii* . This result are agree with that of Ali (2012).

Vegetation ordination

Using ordination by DCA put brackish slacks between saline and cultivated slacks (Fig.2). This result enhance the assumption that brackish slacks may be converted to saline one in case of higher rates of evaporation and small amount of rainfall or it may be covered with mud layer and reclaimed for cultivation. This type of slacks is easily converted to the other types of slacks.

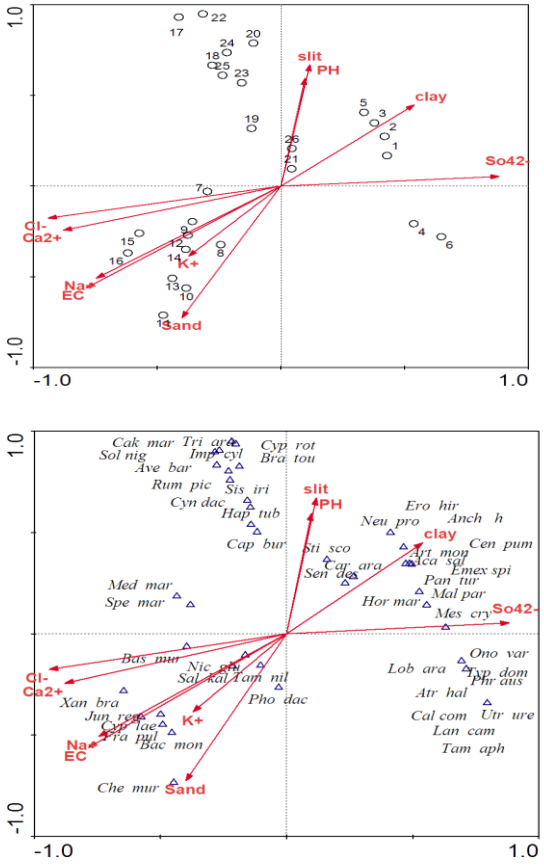
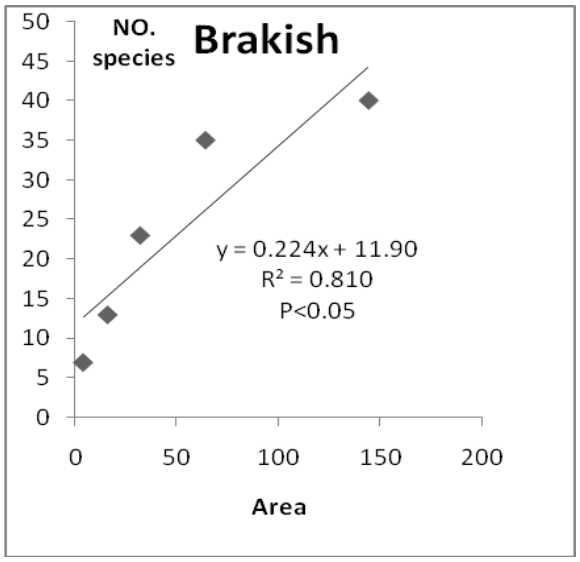
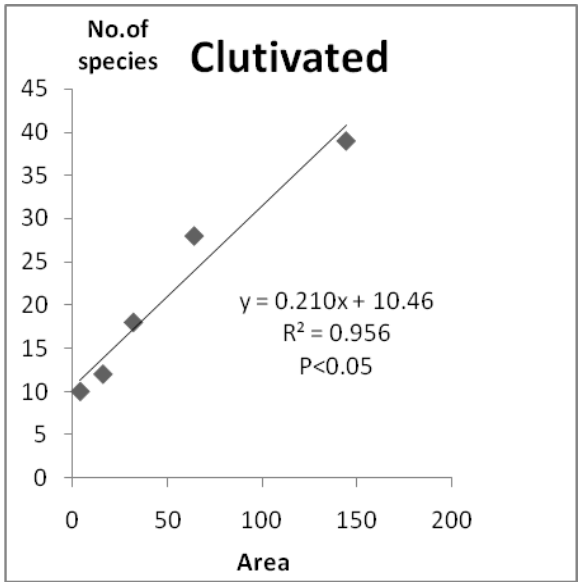


Fig. 3. CCA. Biplot of 10 edaphic factors and 26 stands (a bove), and 56 species (down).For complete names of species see table (1).Abbreviations: EC: Electric conductivity, Org mat: Organic matter.





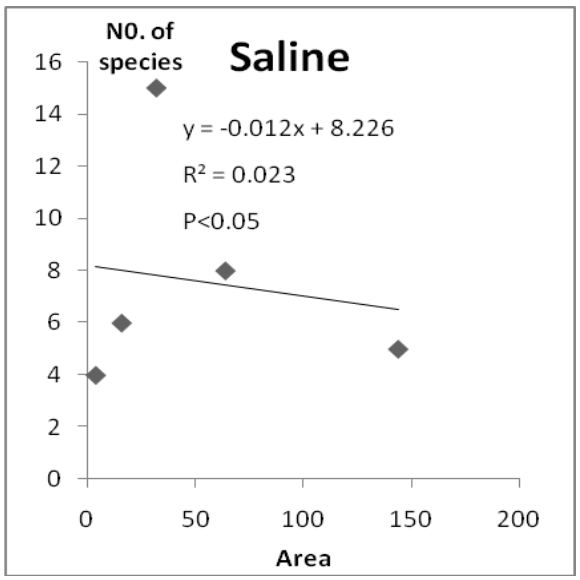


Fig. 4. Liner regression between the area of the slacks and the number of species.

Ordination biplot by CCA in Fig. (3) shows that the groups of brackish and cultivated slacks are highly correlates with organic matters and the percentages of slit and clay. These results are expected because of presence of mud layer covering the sand layers in the cultivated slacks, and presence of dense cover in case of brackish slacks. On the other hand groups of saline slacks are present in high gradients of salinity, sodium, chlorides, calcium, and the percentages of sand. These results enhance presence of halophytes and salt tolerant species within these slacks.

Unfortunately, human impacts in the dune slacks habitat are rapidly increased. These impacts that contributed to the decline of biodiversity are: lowering the water level according to the excessive use of water for water drinking purposes for man and animals (Bakker& Stuyfzod, 1993); reclamation for agricultural uses (Munoz- Reinoso, 2001) and urbanization of sand dune habitat.

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