

# Trends in the vegetation structure along the environmental gradients in Core Area II of Omayed Biosphere Reserve, Egypt

By  
Mohamed A. El-Sheikh\* and Saneya Kamal\*\*

\*Al Azher University (Assuit Branch), Faculty of Science, Botany Department,  
P.O. Box 71524, Assuit, Egypt. E-mail: [el\\_sheikh\\_eg@yahoo.co.uk](mailto:el_sheikh_eg@yahoo.co.uk)

\*\*Alexandria University, Faculty of Science, Botany Department, Alexandria, Egypt.

## Abstract

The Core area II of Omayed Biosphere Reserve provides an excellent basis for gradient studies at environmental scale. This study describes the vegetation structure and composition at the Core area II. The total numbers of recorded species in three different habitats were 98 (38 annuals and 60 perennials), their life forms, chorotypes and diversity according to habitat gradients and human impact are discussed. Six vegetation groups were generated after the application of TWINSpan and DCA Programs, and identified after the first and second dominant species as follows: *Gymnocarpus decander* – *Artemisia herb-alba*, *Anabasis articulata*, *Noaea mucronata*, *Artemisia monosperma* - *Noaea mucronata*, *Artemisia monosperma* and *Carduncellus eriocephalus*. The clear CCA ordination of these groups reflects topographic, edaphic and human impact gradients (soil salinity, soil texture, organic matter, elevation above sea level and degree of human impact).

**Keywords:** Core Area II, Habitat gradients, Human impact, Omayed Biosphere Reserve, Species richness.

## Introduction

Desert ecosystem is characterized by sparsely of life and austerity and unpredictability of their environment. This causes a limited ability to return an

original state of equilibrium when subjected temporarily to perturbation. Even small perturbations by man can trigger chains of physical and biological changes, which may jerk the ecosystem from its balanced position. The western Mediterranean desert of Egypt is one of arid regions which have a long history of intensive land use, mainly grazing, soil degradation, rain-fed farming and now cultivation of crops by digging irrigation canals. The pressure of land use, coupled with severe environment and uncertainty of rainfall, has resulted in an advanced stage of desertification. The ecosystems have been shifted beyond their zones of equilibrium and are producing at a lower rate than their normal potential. In order to fight against desertification in these ecosystems, land-use planners should adopt practices that will allow vegetation to recuperate in order to sustain the maximum possible productivity (Ayyad and El-Kady 1982).

In 1983, the law was issued for establishment and management of nature reserves in Egypt. After the declaration of this law, the Omayed Biosphere Reserve (OMB) established with an area about 700 km<sup>2</sup>, and is characterized into three major topographic features, depressions, ridges, and inland sandy desert. Its core area is represented by two locations (core area I and core area II). Core area I (1 x 1 km<sup>2</sup>) lies at the eastern side of the reserve. Core area II lies at the western side of the reserve and has an area of (2 x 3.5 km<sup>2</sup>). Both areas are strictly protected and represent almost all the environmental variation in terms of land use and land cover. The buffer zone, covering an area of about 70 km<sup>2</sup> surrounds the two core areas. Some activities are permitted in this zone such as education, training, and recreation. The inhabitants are allowed to practice some of their non-destructive normal activities. The transition area, covers an area of about 700 km<sup>2</sup> surrounding the buffer zone, and extends from the coast in the north to Khashm El-Eish ridge in the south and from El-Hammam in

the east to El-Alamin in the west. It provides other functions of the biosphere reserves including activities of experimental research, and traditional land use (El-Kenany, 1991).

The flora of western Mediterranean desert of Egypt includes almost 50 % of the species recorded in Egypt. It includes the Omayed biosphere reserve area, which have unique variations of species and habitats and also effected by man activities on the natural vegetation. Many studies carried out on the vegetation of western Mediterranean desert of Egypt (e.g. Tadros, 1956, Ayyad, 1971; Ayyad, 1973; Ayyad and Ammar, 1974; Ayyad, and El-Ghareeb, 1974 and 1982, Ayyad, 1976; Ayyad and El-Ghonemy, 1976; Abdel Razik, 1976; Ayyad and El-Bayyoumy, 1979; El-Kenany, 1995): The objective of this study is to describe the vegetation structure and composition at the Core area II, and their trends with environmental gradients and human activities which increases in the present time.

### **Study area**

This study area is part of the western Mediterranean coastal land of Egypt. It is located about 80 km west of Alexandria and 12 km south of the seashore near Omayed village. The area comprises a foreshore plain to the north and the Lybian plateau in the south. The foreshore plain consists of a series of elongated ridges running parallel to the coast. These ridges are the coastal ridge, Abou Sir, Gabel Mariut and Khasm El-Eish. The present study was carried out in Core Area II of the Biosphere Reserve 2x3.5 km<sup>2</sup> plot that transverse three major habitats (non-saline depression, inland ridge and inland plateau) and its elevation varies between 45 and 140 m above sea level (Fig. 1).

The soil in the study area is generally sandy. It is often compact at depths below 25 cm, but the surface layer is loose and subject to active erosion and deposition,

which creates micro topographic variations. The soil throughout the whole profile is brownish-yellow at depths of 50-100 cm due to high percentage of calcium carbonate. In some parts, surface layers include remarkable amounts of shell fragments giving a whitish appearance to these layers and increasing the compactness of the soil (Ayyad, 1976).

According to the bioclimatic map of the world distribution of arid regions (UNESCO, 1977), the study area belongs to the “arid climate with mild winters and warm summers”. It is characterized by one rainy season, mainly between October and November with mean annual rainfall of 150 mm, with a rapid decrease in the amount to the inland desert. The monthly mean temperature varies between 13.0 °C in August. The relative humidity is generally higher in summer than in winter. It reaches a maximum average of 61 % in October. The monthly mean wind velocity ranges between 10.2 km/h in October and 16.8 km/h in March (El-Ghareeb, *et al.* 1991).

## **Methods**

Thirty stands, each of 30x40 m which approximates the minimal area of the prevailing plant communities, were selected so as to represent the physiographic and physiognomic variations in core area II. Three soil samples at 50 cm depth from each stand were collected and mixed as a composite sample, air dried and analyzed for moisture, organic matter, texture, calcium carbonate, pH and electric conductivity (Allen *et al.* 1974). The main habitats recognized in the study are: non saline depression, inland rocky ridge and inland plateau.

The sampling process carried out in April 2000, when most species were expected to be growing. In each stand, species present were recorded and the dominant and codominant species were determined. Plant nomenclature was according to Täckholm (1974) and Boulos (1995, 1999 and 2000). Life forms were classified

according to Ranunkiaer (1934). The chorotypes (i.e. floristic regions) of the recorded species were gathered from Zohary (1966, 1972) and Feinbrun-Dothan (1978, 1986). Plant cover was estimated quantitatively using the line intercept method (Canfield, 1941). Two or three parallel lines, each 25 m long, were laid out in each stand. Two-way indicator species analysis (TWINSPAN) as classification technique and detrended correspondence analysis (DCA) as an ordination one were applied to the cover estimates of the recorded species in the sampled stands according to Hill (1979*a* and *b*).

Relationships between edaphic variables of the habitats and vegetation groups were tested statistically using one-way ANOVA. Correlation analysis was used to determine the relationship between edaphic and community variables including the axes 1, 2, 3 and 4 of DCA (SAS, 1985). The cover values of the indicator and associated species in relation to the environmental factors were analyzed using Canonical Correspondence Analysis (CCA). The result is an ordination diagram in which points represent species and sites and arrows represent environmental variables (Ter Braak 1987 and 1988). Species richness ( $\alpha$ -diversity) of each habitat and vegetation cluster was calculated as the average number of species per stand. Shannon-Wiener index ( $\hat{H} = -\sum p_i \log p_i$ ) was used for calculation of the relative species evenness. Evenness was calculated and constrained between zero and 1, with 1.0 representing a situation in which all species are equally abundant. Simpson index ( $C = \sum p_i^2$ ) was used for calculation of the relative concentration of species dominance. These diversity indices were calculated for each habitat and vegetation cluster on the basis of the relative cover ( $p_i$ ) of species (Whittaker, 1972; Pielou, 1975). The trends of the variation in the species diversity, floristic abundance and life forms of the recorded species in relation to the variation microsites as (in the elevation

above sea level) and human impact scale (0 = no impact, 1 = very low impact, 2 = low impact, 3 = medium impact, 4 = high impact, and 5 = very high impact) were tested using simple linear correlation coefficient (Pearson's correlation).

## RESULTS

A total of 98 species was recorded in the study area (38 annuals and 60 are perennials). The life form spectra show that the therophytes and chamaephytes had the high percentage but the phanerophytes had the lowest 7.9 % (Fig. 2a). Regarding the habitats, the non saline depressions had the highest values of therophytes, phanerophytes. On the other hand, the inland ridge had the highest value of geophytes and the inland plateau had the highest of chamaephytes (Fig. 2b). Regarding the chorotypes (Appendix 1), the monoregional species were the highest represented (37 % species), followed by the bioregionals (34 % species). The Mediterranean species were the highest among the monoregionals, while the Mediterranean-Saharo-Arabian species were the highest among the biregionals. The analysis of soil showed significant differences between the habitats. The non saline depressions had the highest values of moisture, carbonate, sand and the lowest of organic matter, silt, clay, pH and salinity. On the other hand, the rocky ridges had the highest values of organic matter, silt, clay and salinity, and the lowest of moisture and sand. Regarding the species diversity, the rocky ridge had the highest values of species number and species diversity and the lowest concentration of dominance. The non saline depressions had the lowest values of species diversity and the highest of concentration of dominance (Table 1).

The application of TWINSpan to the cover estimates of 98 species in 30 stands led to the recognition of six vegetation groups at level 3, which identified according to

the first dominant species (Fig 3a and b and Table 2). The application of DCA of the same set of data, confirmed the six suggested groups along the ordination plane of axes 1 and 2 (Eigen values of axis 1 = 0.54, axis 2 = 0.461) (Fig 3a and b). The *Gymnocarpos decander* – *Artemisia herb-alba* group A, which inhabits the slope of inland ridge was characterized by the highest values of species diversity and organic matter, silt, clay, salinity and the lowest of sand and pH. On the other hand, the vegetation groups dominated by *Artemisia monosperma* and *Carduncellus eriocephalus* (E and F), that inhabit the degraded sites of non saline depressions were characterized by the lowest values of species diversity, clay and salinity (Table 2 and 3).

The segregation of stands supporting these vegetation groups reflects a complex of environmental gradients of salinity, organic matter, soil texture, elevation above sea level and human impact along DCA axes 1 and 2. This started with stands of elevated land, fine fractions, high organic matter and low human impact (inland rocky ridge and inland plateau) on the left side of DCA ordination plane and ended with low land of sandy texture and high human impact (non saline depressions) on the right side (Fig. 3a and b). The correlation analysis by CCA (Table 4) indicated that salinity, organic matter, silt, clay and elevation correlated positively with axis 1, while sand and human impact correlated negatively with the same axis. The human impact was correlated positively with axis 2. The CCA biplot ordination with species represented by points and environmental variables by arrows showed similar correlations. These suggest that the separation of the species is strongly influenced by gradients of soil salinity, soil texture, organic matter, moisture, elevation and human impact on the first axis. The elevation increased with the increase of fine fractions, salinity and organic matter, but with the decrease of soil moisture, sand and human impact.

The distribution of *Artemisia monosperma*, *Bassia muricata*, *Asphodelus ramosus*, *Launaea nudicaulis*, *Launaea tenuiloba*, *Centaurea calcitrapa* and *Carduncellus eriocephalus*, coincide with the sand, soil moisture, calcium carbonate and human impact. *Anabasis articulata*, *Artemisia herb-alba*, *Asparagus stipularis*, *Gymnocarpos decander*, *Deverra tortuosa* and *Stipa capensis* are positively correlated with fine fraction (silt and clay), organic matter, salinity and elevation. The position of *Noaea mucronata* in the center of the diagram indicated their wide distribution in the core area II and its relation with the environmental variables is not clear.

The elevation correlated positively with the total numbers of plant species ( $r = 0.52$ ), relative evenness ( $r = 0.77$ ), chamaephytes ( $r = 0.56$ ) and geophytes (0.38), and negatively with concentration of dominance ( $r = - 0.73$ ) and phanerophytes (- 0.46) (Table 5). Organic matter correlated positively with total number of plant species (0.36), relative evenness ( $r = 0.54$ ), chamaephytes (0.32) and geophytes ( $r = 0.37$ ), and negatively with concentration of dominance (- 0.49) and phanerophytes (- 0.37). Therefore elevation and organic matter have the same trend. On the other hand, the high level of human impact correlated positively with phanerophytes ( $r = 0.35$ ) and negatively with species number ( $r = - 0.73$ ), relative evenness ( $r = - 0.64$ ), chamaephytes ( $r = - 0.56$ ) and geophytes ( $r = - 0.47$ ). Sand correlated positively with total cover (0.34), concentration of dominance ( $r = 0.56$ ) and phanerophytes (0.43), and negatively with species number ( $r = - 0.58$ ), relative evenness ( $r = - 0.61$ ), chamaephytes (- 0.44) and geophytes ( $r = - 0.38$ ). The soil moisture correlated positively with therophytes ( $r = 0.29$ ), and negatively with chamaephytes (- 0.30).

## DISCUSSION

The total recorded species in the Omayed Biosphere Reserve were 172 (55 annuals and 117 perennials), whereas the Core Area II contains 98 of these species (34 annuals and 64 perennials). Therefore, the Core Area II is one of the unique diverse sites in the Omayed Biosphere Reserve. The high percentage of the monoregional Mediterranean species in the present study could be interpreted in the view that study area is located in the basin of the West Mediterranean subregion of Mediterranean floristic region (Zohary, 1973). The Saharo-Arabians are associated with the Mediterranean species, as in case of biregional category, because the Saharo-Arabian region is adjacent to the Mediterranean region. Where the desert flora comes very close to the Mediterranean Sea and some species may penetrate deep into the adjacent region and its gaps, and grow there under particular condition (Eig, 1939; Drar, 1955; Zohary, 1962 and 1973).

Three major types of habitat are recognized in the Core area II (non saline depression, inland ridge and its slope and inland plateau). Each of these habitats is characterized by local physiographic variations which effectuate variation in vegetation composition and species abundance. This composition was expressed by characterizing the vegetation after application of TWINSpan technique (Hill, 1979a) into six vegetation groups named after their dominant and co-dominant species as follows: *Gymnocarpos decander* – *Artemisia herb-alba* group mainly inhabited on the north slope of the inland ridge. *Anabasis articulata* occupied the top of inland ridge and inland plateau. *Noaea mucronata* group which dominate on the intermediate stands of non saline depression and foot of inland ridge. The non saline depression supports three vegetation groups as follows: *Artemisia monosperma* - *Noaea*

*mucronata* group that occupied the sites of compact soil of non saline depression, *Artemisia monosperma* on the small hummocks of the non saline depression, and *Carduncellus eriocephalus* group on the highly degraded sites of non saline depression. The application of DCA ordination technique (Hill, 1979b) leads to clear distinction between these different vegetation groups. Most of these vegetation groups are comparable with those of the previous studies in the same region (e.g. Tadros, 1956, Ayyad, 1971; Ayyad, 1973; Ayyad and Ammar, 1974; Ayyad, and El-Ghareeb, 1974 and 1982, Ayyad, 1976; Ayyad and El-Ghonemy, 1976; Abdel Razik, 1976; Ayyad and El-Bayyoumy, 1979; El-Kenany, 1995). This vegetation is considered as a part of a larger vegetation gradient in the western Mediterranean desert of Egypt (Abdel Razik, 1976). *Artemisia monosperma* and *Carduncellus eriocephalus* groups are less comparable with the previous studies (except *Artemisia monosperma* group which recorded in the study of El-Kenany 1995). However, we consider the dominance of *Artemisia monosperma* and *Carduncellus eriocephalus* in this region as an indicator for the severe human impact (e.g. digging of irrigation canal, ploughing, cultivation of crops and grazing).

Dwarf woody scrub, represented by *Gymnocarpos decander*, *Artemisia herb-alba* and *Anabasis articulata* groups that inhabited the inland ridge and inland plateau was characterized by the highest species diversity are apparently controlled by land elevation and organic matter content. This trend is due to that the species dominate stabilize fine texture in cracks between rocks of the inland ridge (southward). Also these habitats are characterized by substrate heterogeneity such as heterogeneity of soil depth, rockiness, as well as slope degree and exposure, cracks, sand and gravels (i.e. increase of habitat niche for different species). Therefore, the species diversity increases as the fertility increase with habitat heterogeneity (see Whittaker, 1972,

Naveh and Whittaker, 1979. Abbadi and El-Sheikh, 2002). Further more; the most humid sites have the highest shrub importances (i.e. phanerophytes) and lowest species diversity, while the most xeric sites have the lowest of shrub importances and the highest diversities. This is similar to the trend outlined in Naveh and Whittaker, (1979), Tothill and Mott (1985).

The phanerophytic, psammophytic and anthropogenic species dominate the non saline depression, and their dominance is positively controlled by human impact, sand and moisture, and negatively with the elevation of land and organic matter. The high level of human disturbance will decrease the number of species due to severe disturbance occurring in non saline depression (see Grime, 1979, Kutiel and Danin 1987, Naveh and Whittaker, 1979, Kowarik, 1990). The recent abundance of *Artemisia monosperma* in the study area could be related to its adaptation to the high degree of soil disturbance including sand movements occurring in mobile and partially stabilized sandy sites (Tilman, 1982). As the range of disturbance increase, species diversity decreases but concentration of dominance increases. Because most of the species cover is accounted for by one or two species that can apparently make the best use of available resources, because of their higher competitive capacities under these conditions (Kutiel and Danin 1987, Abbadi and El-Sheikh, 2002; Scholes, *et al.* 2002).

Furthermore, from a pedogenetic point view, there is a discontinuity in the process leading to the formation of three kinds of soil substrates in the non saline depression. It is therefore, suggested that there are three different succession of vegetation groups in the non saline depression. The *Carduncellus eriocephalus* occupied the highly degraded soil as a result of clear cutting, ploughing, digging and grazing. The *Artemisia monosperma* group constitutes a low-diverse plant community

and grows on deep mobile sand with highly vital and more or less arrested sands which cover old landscape. The fixation of new blown sand (as a result of digging of irrigation canal in the area of non saline depression) starts with establishment some grasses (e.g. *Cutandia dicotoma*, *Brachypodium distichyum*, *Stipa capensis*, *Schismus barbatus* and *Stipagrostis ciliate*) which help in the germination of *Artemisia monosperma*; the increasing of density of this species results in the accumulation of sand on the ground. The same conclusions were attained by Kutiel, *et al.*, (1979). *Artemisia monosperma* - *Noaea mucronata* group represents an advanced stage of sand stabilization. A thin sand cover (2-3 mm) over the seeds enables penetration of light and protects them from desiccation; a deeper sand cover will inhibit germination. Therefore, germination occurs in places protected from the wind, such as the leeward side of existing shrubs, mound and depression between dunes because leaves of *Artemisia monosperma* are sensitive to sea spray (Zohary & Fahn 1951; Kutiel, *et al.*, 1979).

**Acknowledgment:** this paper is dedicated to the memory of Prof. Dr. Mohamed A. Ayyad, who initiated the Omayed Biosphere Reserve. This study was carried out in the frame work of the MedWetCoast project, thus we thank all the team of this project who support our study especially Prof. Dr. Rafeik El-Ghareeb, Prof. of plant ecology, Botany Department, Faculty of Science, Alexandria University. We also thank Prof Dr. Kamal H. Shaltout Prof. of plant ecology, Botany Department, Faculty of Science, Tanta University, for reading the manuscript.

## References

- Abbadi, G. A. and El-Sheikh, M. A. (2002). Vegetation analysis of Failaka Island (Kuwait). *Journal of Arid Environments*, 50: 153-165.
- Abdel Razik, M. (1976). *A study on the Vegetation Composition, Productivity, and Phenology in a Mediterranean Desert Ecosystem (Egypt)*. M. Sc. Thesis, Alexandria University. 89 pp.
- Allen, S. E., Grimshaw, H. M., Parkinson, J. A. and Quarmby, C. (1974). *Chemical Analysis of Ecological Materials*. Oxford: Blackwell Scientific Publications. 565 pp.
- Ayyad, M. A. (1971). A study of solar radiation on sloping surfaces at Alexandria. *United Arab Republic Journal Botany*, 14: 65-73
- Ayyad, M. A. (1973). Vegetation and environment of the western Mediterranean coastal land of Egypt. 1. the habitat of sand dunes. *Journal Ecology*, 61: 509-523.
- Ayyad, M. A. and Ammar, M. Y.(1974). Vegetation and environment of the western Mediterranean coastal land of Egypt. II. The habitat of Inland ridges. *Journal Ecology*, 62: 439-456.
- Ayyad, M. A. and El-Ghareeb, R. (1974) Vegetation and environment of the western Mediterranean coastal land of Egypt. II. The habitat of saline depressions of Egypt. *Bull. Institute Desert*, 24.
- Ayyad, M. A. and El-Ghareeb, R. (1982). Habitats and plant communities of the northwestern desert of Egypt. *Communications in Agrisciences and Development Research*. 7(60): 1-34.

- Ayyad, M. A. (1976). Vegetation and environment of western Mediterranean Coastal land of Egypt. IV: The habitat of non-saline depressions. *Journal Ecology*. 64: 713-722.
- Ayyad, M. A. and El-Ghonemy, A. A. (1976). Phytosociological and environmental gradients in a sector of western desert of Egypt of vegetation. *Vegetatio*. 31: 93-102.
- Ayyad, M. A. and El-Bayyoumy, M. A. (1979). On the phytosociological of sand dunes of the western Mediterranean Desert of Egypt. *Glimpses of Ecology*. P: 219-237.
- Ayyad, M. A. and El-Kady, H. F. (1982). Effect of protection and controlled grazing on the the vegetation of a Mediterranean desert ecosystem in northern Egypt. *Vegetatio*, 49: 129-139.
- Boulos, L. (1995). *Flora of Egypt: Checklist*, Al-Hadara Publishing, Cairo, 283 pp.
- Boulos, L. (1999). *Flora of Egypt*. Vol 1, Al-Hadara Publishing, Cairo, 419 pp.
- Boulos, L. (2000). *Flora of Egypt*. Vol. 2, Al-Hadara Publishing, Cairo, 352 pp.
- Canfield, R. (1941). Application of line intercept method in sampling range vegetation. *Journal Forestry*, 39: 288-394.
- Drar, M. (1955). Egypt, Eritrea, Libya and the Sudan. *Plant Ecology*, Rev. Res. UNESCO, Arid Zone Res. 6: 151-194.
- Eig, A. (1939). The vegetation of the light soils belt of the Coastal Plain of Palestine. *Palestine Journal Botany, Jerusalem Ser.* 1: 255-308.
- El-Ghaeeb, R., Ayyad, M. A. and Gaballah, M. S. (1991). Effect of protection on the nutrient concentration and uptake of some Mediterranean desert annuals. *Vegetatio* 96: 113-125.

- El-Kenany, I. T. (1995). *A Study on the Vegetation and Land-Use in Omayed Biosphere Reserve*. M. Sc. Thesis, Alexandria University. 113 pp.
- Feinbrun-Dothan, N. (1978). *Flora Palestina*, vol. 3. Israel Academy of Sciences and Humanities, Jerusalem, 481 pp.
- Feinbrun-Dothan, N. (1986). *Flora Palestina*, vol. 4. Israel Academy of Sciences and Humanities, Jerusalem, 462 pp.
- Grime, J. P. (1979). *Plant Strategies and Vegetation Processes*. J. Wiley. 222 pp.
- Hill, M. O. (1979a). *DECORANA-A FORTRAN Program for detrended correspondence analysis and reciprocal averaging*. Ithaca, NY. Cornell University, 52 pp.
- Hill, M. O. (1979b). *TWINSPAN-A FORTRAN Program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes*. Ithaca, NY. Cornell University, 90 pp.
- Kowarik, I. (1990). Some responses of flora and vegetation to urbanization in central Europe In: Sukopp, H. and Hejny, S. (Eds), *Urban Ecology*. pp. 45-74. The Hague: SPB Academic Publishers. 282 pp.
- Kutiel, P and Danin, A. (1987). Annual species diversity and above ground phytomass in relation to some soil properties in the sand dunes of the northern Sharon plains, Israel. *Vegetatio*, 70: 45-49.
- Kutiel, P., Danin, A. and Orshan, G. (1979). Vegetation of the sandy soils near caesarea, Israel. *Israel Journal of Botany*, 28: 20-35.
- Naveh, Z. and Whittaker, R. H. (1979). Structural and floristic diversity of shrublands and woodlands in north Israel and other Mediterranean areas. *Vegetatio*, 41: 171-190.

- Ranukiaer (1934). *The Life Form of Plants and Statistical Plant Geography*. Oxford: Clarendon Press, 104 pp.
- Pielou, E. C. (1975). *Ecological Diversity*. New York, Wiley Interscience. 165 pp.
- SAS (1985). *SAS User's Guide: Statistics*. Cary , NC: Institute, 956 pp.
- Scholes, R. J., Dowty, P. R., Caylor, K., Parsons, D., A., B, Frost, P., G., H., Shugart, H., H. (2002). Trends in Savanna structure and composition along an aridity gradient in the Kalahari. *Journal of Vegetation Science* 13: 419-428.
- Täckholm, V. (1974). *Student's Flora of Egypt*. Cairo, University Press, 888 pp.
- Tadros, T. M. (1956). An ecological survey of the semi-arid coastal strip of the western desert of Egypt. *Bull. Inst. Desert Egypt*, 6: 28-56.
- Ter Braak, C. J. F. (1987). The Analysis of Vegetation-Environment relationships by Canonical Correspondence Analysis (CCA). *Vegetatio* 69: 69-77.
- Ter Braak, C. J. F. (1988). *CANOCO A FORTRAN program for canonical community ordination by partial detrended correspondence analysis, principal components analysis and redundancy analysis (version 2.1)*. Agric. Math. Group. Wageninigen. 95 pp.
- Tilman, D. L. (1982). Resource competition and community structure. Princeton University Press.
- Tothill, J. C. and Mott, J. J. (1985). *Ecology and Management of the World's Savannas*. Australian Academy of Science, Canberra, Au.
- UNESCO, (1977). *Map of the World Distribution of Arid Regions*. MAP Technical Notes, 7.
- Whittaker, R. H. (1972). Evolution and measurement of species diversity. *Taxon*, 21: 213-251.

- Zohary, M. and Fahn, A. (1951). Ecological studies on East Mediterranean dune plants. *Bull. Research Counc. Israel*. 3: 38-53.
- Zohary, M. (1962). Plant Life of Palestine, Israel and Jordan. The Ronald Press, New York, 262 pp.
- Zohary, M. (1966). *Flora Palestina*, vol. 1. Israel Academy of Sciences and Humanities, Jerusalem, 346 pp.
- Zohary, M. (1972). *Flora Palestina*, vol. 2. Israel Academy of Sciences and Humanities, Jerusalem, 489 pp.
- Zohary, M. (1973). *Geobotanical Foundations of the Middle East*. Gustav Fischer Verlag. Stuttgart. 739 pp.

Table 1. Mean  $\pm$  standard deviation of species diversity and soil characters of the three habitats of core area II of Omayed Biosphere Reserve (OBR). \* =  $p \leq 0.05$ , \*\* =  $p \leq 0.01$ , \*\*\* =  $p \leq 0.001$ .

Variable	Non saline depression	Inland rocky ridge	Inland plateau	F value
<b>Soil variables:</b>				
Moisture	0.5 $\pm$ 0.4	0.3 $\pm$ 0.2	0.4 $\pm$ 0.3	0.76
Organic matter	1.2 $\pm$ 0.5	2.4 $\pm$ 0.8	1.3 $\pm$ 0.2	11.85***
Ca carbonate	22.1 $\pm$ 5.0	21.6 $\pm$ 2.0	17.4 $\pm$ 2.6	1.95
Sand	87.6 $\pm$ 5.4	72.0 $\pm$ 7.0	82.3 $\pm$ 10.0	15.68***
Silt	6.6 $\pm$ 4.4	17.6 $\pm$ 5.2	10.0 $\pm$ 5.3	15.47***
Clay	5.7 $\pm$ 3.2	10.4 $\pm$ 3.4	7.8 $\pm$ 4.9	5.60**
pH	8.2 $\pm$ 0.1	8.0 $\pm$ 0.2	8.2 $\pm$ 0.1	3.04
EC mS/cm	1.0 $\pm$ 0.1	1.7 $\pm$ 0.6	1.1 $\pm$ 0.4	8.58***
<b>Species diversity:</b>				
Total species	34.0	54.0	28.0	8.41***
Species richness	10.8 $\pm$ 1.8	19.7 $\pm$ 6.0	15 $\pm$ 0.0	14.96***
Shannon index ( $\hat{H}$ )	0.5 $\pm$ 0.1	1.1 $\pm$ 0.1	1.0 $\pm$ 0.1	7.06***
Simpson index (C)	0.30 $\pm$ 0.1	0.09 $\pm$ 0.01	0.10 $\pm$ 0.04	12.22***
Evenness	0.5 $\pm$ 0.1	0.8 $\pm$ 0.05	0.8 $\pm$ 0.1	10.54***

Table 2. Characteristics of the six vegetation groups derived after the application of TWINSpan. VG: vegetation group, A: *Gymnocarpus decander* – *Artemisia herb-alba*, B: *Anabasis articulata*, C: *Noaea mucronata*, D: *Artemisia monosperma* - *Noaea mucronata*, E: *Artemisia monosperma* and F: *Carduncellus eriocephalus* P: presence percentage, C: cover (%). ND: non saline depression, IR: inland ridges, IP: inland plateau of core area II of Omayed Biosphere Reserve (OBR).

VG	No. of stand	First and second dominant species	P	C	Habitat (%)			No. of sp.	Species richness	Relative evenness	Evenness	Conc. of domin.
					ND	IR	IP					
A	3	<i>Gymnocarpus decander</i>	100	20	100			45	27.7	1.2	0.8	0.08
		<i>Artemisia herb-alba</i>	100	12								
B	10	<i>Anabasis articulata</i>	100	22	60	40		38	15.8	0.98	0.9	0.12
		<i>Noaea mucronata</i>	100	14								
C	2	<i>Noaea mucronata</i>	100	9	50	50		20	12.5	0.8	0.7	0.25
		<i>Anabasis articulata</i>	100	5								
D	3	<i>Artemisia monosperma</i>	100	37	100			18	13.0	0.70	0.6	0.30
		<i>Noaea mucronata</i>	100	29								
E	9	<i>Artemisia monosperma</i>	100	73	100			28	10.2	0.45	0.4	0.38
		<i>Thymelea hirsuta</i>	66.7	7.9								
F	3	<i>Carduncellus eriocephalus</i>	100	49	100			8	7.3	0.60	0.7	0.30
		<i>Launaea nudicaulis</i>	100	27								

Table 3. One-way ANOVA of soil variables of the six vegetation groups of core area II of Omayed Biosphere Reserve A: *Gymnocarpos decander*– *Artemisia herb-alba*, B: *Anabasis articulata*, C: *Noaea mucronata*, D: *Artemisia monosperma* - *Noaea mucronata*, E: *Artemisia monosperma* and F: *Carduncellus eriocephalus*. \* =  $p \leq 0.05$ .

Soil variable	Vegetation group						F-value
	A	B	C	D	E	F	
Moisture	0.4	0.4	0.2	0.5	0.5	0.5	0.37
Organic matter	1.9	2.0	1.8	0.9	1.2	1.1	1.51
Ca carbonate	22.3	19.7	25.4	21.7	20.5	24.8	1.07
Sand	% 65.0	78.5	81.5	90.0	86.9	88.3	5.08*
Silt	22.3	13.1	10.0	4.3	7.8	7.0	5.22*
Clay	12.7	8.3	8.5	5.7	6.2	4.7	1.93
pH	7.9	8.1	8.3	8.3	8.1	8.3	1.67
EC mS/cm	1.6	1.6	1.2	1.1	1.0	0.9	1.58

Table 4. Interset correlation between the environmental variables and ordination axes of core area II of Omayed Biosphere Reserve (OBR). \* =  $p \leq 0.05$ , \*\* =  $p \leq 0.01$ , \*\*\* =  $p \leq 0.001$ .

Variable	Axis 1	Axis 2	Axis 3	Axis 4
pH	-0.13	0.12	0.31	-0.45**
EC	0.51***	0.11	0.24	-0.35
CaCO <sub>3</sub>	-0.19	0.15	0.39**	-0.42
Organic matter	0.48***	0.14	0.01	-0.63***
Sand	-0.48***	-0.01	0.12	-0.34*
Silt	0.62***	0.08	0.29	-0.30
Clay	0.55***	0.02	0.31	-0.44*
Moisture	-0.23	-0.03	0.22	-0.14
Elevation	0.82***	0.20	-0.22	0.06
Human impact	-0.62***	0.58***	0.11	-0.08

Table 5: Simple linear correlation coefficient (r) between community, life forms and environmental variables. \* =  $p \leq 0.05$ , \*\* =  $p \leq 0.01$ , \*\*\* =  $p \leq 0.001$ .

<b>Variable</b>	<b>Human impact</b>	<b>Elevation</b>	<b>Moisture</b>	<b>Sand</b>	<b>Organic matter</b>
<b>Community variables:</b>					
Total species	- 0.73***	0.52***	0.05	- 0.58***	0.36*
Total cover	- 0.31*	- 0.24	0.03	0.34*	- 0.17
Shannon index ( $\hat{H}$ )	- 0.64***	0.77***	- 0.01	- 0.61***	0.54***
Simpson index (C)	0.26	- 0.73***	0.05	0.56***	- 0.49**
<b>Life Form:</b>					
Phanerophytes	0.59***	- 0.46**	0.04	0.43**	- 0.37*
Chamaephytes	- 0.56***	0.56***	- 0.30*	- 0.44**	0.32*
Hemicryptophytes	- 0.07	0.21	0.01	- 0.05	0.09
Geophytes	- 0.47**	0.38**	0.11	- 0.38**	0.37*
Therophytes	0.18	- 0.37*	0.29*	0.17	- 0.13

Appendix 1: Mean cover values (%) and total presence % (p) of the recorded species in the six vegetation groups derived after application of TWINSPAN. Life forms are: Ph: phanerophytes, Ch, chamaephytes, He: hemicryptophytes, Ge: geophyte, Th: therophytes. Chorotypes are: Me: Mediterranean, SA: Saharo-Arabian, IT: Irano –Turanian, SU: Sudanian, ES: Euro-Siberian, COSM: cosmopolitan

Species	Life Form	Chorotype	Vegetation group						Presence P %
			A	B	C	D	E	F	
<i>Anabasis articulata</i> (Forsk.) Moq.	Ph	SA,IT	3.0	21.5	5.1	6.3	4.0	3.2	76.7
<i>Asphodelus brevicaulis</i> (Bertol.) J.Gay	Ge	ME	2.0	4.7	4.0	4.5	3.5		76.7
<i>Noaea mucronata</i> (Forsk.) Asch.&Sch	Ch	IT,ME	11.2	13.6	9.3	28.5	1.3		76.7
<i>Cutandia dicotoma</i> (Forsk.) Trab.	Th	SA,IT	1.8	2.4	2.5	0.7	0.8	1.6	73.3
<i>Gymnocarpus decander</i> Forssk.	Ch	SA	20.3	10.8	2.6	3.2	1.9		73.3
<i>Helianthemum lippii</i> (L.) Dum. Cours	Ch	SA,SU	2.0	5.0		2.0	1.9		66.7
<i>Thymelaea hirsuta</i> (L.) Endl.	Ph	ME,SA	8.4	5.4	5.2	2.8	7.9		63.3
<i>Artemisia monosperma</i> Delile	Ph	SA,ME			28.5	36.7	72.5	21.0	53.3
<i>Atractylis carduus</i> (Forsk.) C. Chr.	Ch	ME,SA	0.4	1.8		0.3	3.1		53.3
<i>Echiochilon fruticosum</i> Desf.	Ch	SA	0.2	4.1		2.4	1.5		43.3
<i>Echinops spinosissimus</i> Turra	Ch	ME,SA	2.0	1.4	2.3		0.1		40.0
<i>Scorzonera undulata</i> Vahl	Ge	–	1.3	3.6	5.3				46.0
<i>Deverra tortuosa</i> (Desf.) DC.	Ch	–	4.5	7.5	5.1				36.0
<i>Stipagrostis ciliata</i> (Desf.) de Winter	Ge	SA	1.1	1.4		1.0	0.2		36.0
<i>Artemisia herb-alba</i> Asso	Ch	IT	11.6	2.4	15.3				33.3
<i>Adonis dentate</i> Delile	Th	IT,SA,ME				1.4	1.8		33.3
<i>Launaea nudicaulis</i> (L.) Hook. f.	He	SA,SU,IT	1.0	0.2			0.2	27.4	30.0
<i>Stipa capensis</i> Thunb.	Th	IT,SA,ME	0.7	0.9	1.0				26.7
<i>Schismus barbatus</i> (L.) Thell.	Th	ME,IT,SA	0.9	0.2	3.5	0.7	0.7		36.7
<i>Ifloga spicata</i> (Forsk.) Sch. Bip.	Th	SA,ME	0.1	0.7		0.6	0.2		26.7
<i>Lotus creticus</i> L.	He	ME		0.3			0.5		23.3
<i>Carduncellus eriocephalus</i> Boiss.	Ch	SA		0.1		0.3	0.3	49.0	23.3
<i>Plantago albicans</i> L.	He	ME,SA	0.7	1.8			0.1		23.3
<i>Anabasis oropediorum</i> Maire	Ch	ME		5.5	0.2				23.3
<i>Lycium europaeum</i> L.	Ph	ME		1.1	0.2		1.1		23.3
<i>Bassia muricata</i> (L.) Asch.	Th	SA,IT			3.6	2.1	0.5		20.0
<i>Filago desertorum</i> Pomel	Th	SA,IT	0.3	0.1		0.1	0.4		20.0
<i>Spergularia marina</i> (All.) Chiov.	He	ES,ME,IT	0.7	1.6					20.0
<i>Allium erdellii</i> Zucc.	Ge	ME,IT	0.8	0.1	0.3				16.7
<i>Asparagus stipularis</i> Forssk.	Ch	ME,SA	1.6	0.4					16.7
<i>Plantago crypsoides</i> Forssk.	Th	-	0.8	0.5	0.5		0.3		16.7
<i>Brachypodium distachyum</i> (L.) Link	Th	ME,IT,SA	0.5				0.9		16.7
<i>Dactylis glomerata</i> L.	Ge	ME,IT,ES	4.2	0.2					13.3
<i>Thymus capitatus</i> (L.) Link	Ch	SA	0.2	0.1	2.3				13.3
<i>Aegilops kotschy</i> Boiss.	Th	IT,SA	0.8	0.5					10.0
<i>Hippocrepis areolata</i> Desv.	Th	SA	0.8	0.1					10.0
<i>Launea tenuiloba</i> (Boiss.) Kuntze	Th	ME						3.2	10.0
<i>Centaurea calcitrapa</i> L.	Th	SA						4.8	10.0
<i>Reaumuria hirtella</i> Jaub. & Spach	Ch	SA,IT	1.3						10.0
<i>Crucianella aegyptiaca</i> L.	Th	ME	1.0						6.7
<i>Vaccaria hispanica</i> (Mill) Rauschert	Th	ME,IT,ES	1.6						6.7
<i>Kickxia aegyptiaca</i> (L.) Nabelek	Ch	ME,SA,IT		0.3					6.7
<i>Salsola tetrandra</i> Forssk.	Ch	SA		0.2					6.7
<i>Convolvulus lanatus</i> Vahl	Ch	SA					0.8		6.7
<i>Launaea resedifolia</i> (L.) Kuntze	He	ME,SA	0.4						6.7
<i>Medicago minima</i> (L.) L.	Th	ES,ME,ITSA	0.3						3.3
<i>Medicago truncatula</i> Gaertn.	Th	ME,ES	0.4						3.3
<i>Spergularia diandra</i> (Guss.) Boiss.	Th	ME,IT,SA	0.4						3.3
<i>Sencio glaucus</i> L.	Th	SA,IT	0.5						3.3

Appendix 1. Cont.

Species	Life Form	Chorotype	Vegetation Group						Presence P %
			A	B	C	D	E	F	
<i>Fumana thymifolia</i> (L.) Webb	Ch	ME	0.6						3.3
<i>Carrichtera annua</i> (L.) DC	Th	SA	0.2						3.3
<i>Teucrium polium</i> L.	He	ME,IT	1.0						3.3
<i>Salvia aegyptiaca</i> L.	Ch	SA,SU	0.2						3.3
<i>Phlomis floccosa</i> D. Don	Ph	–	2.1						3.3
<i>Phagnalon rupestre</i> (L.) DC.	Ch	ME,IT	0.3						3.3
<i>Prasium majus</i> L.	Ch	ME	0.6						3.3
<i>Reichardia tingitana</i> (L.) Roth	Th	SA,IT	0.2						3.3
<i>Gynandris sisyrinchium</i> (L.) Parl.	Ge	ME,IT			2.0				3.3
<i>Centaurea glomerata</i> Vahl	Th	ME		0.1					3.3
<i>Lobularia libyca</i> (Viv.)C.F.W.Meissn	Th	SA		0.3					3.3
<i>Salvia lanigera</i> Poir.	Ch	ME,SA		0.1					3.3
<i>Limonium tubiflorum</i> (Delile) Kuntze	Ch	–		0.2					3.3
<i>Salsola kali</i> L.	Th	COSM				0.1			3.3
<i>Ebenus armitagei</i> Schweinf.&Taub.	Ch	ME					0.7		3.3
<i>Carthamus lanatus</i> L.	Ch	–					0.1		3.3
<i>Traganum nudatum</i> Delile	Ch	SA,SU					0.3		3.3
<i>Cynodon dactylon</i> (L.) Pers.	Ge	TR						0.5	3.3
<b>Species with non-significant cover:</b>									
<i>Attractylis cancellata</i> L.	Ch	ME,SA	r	r	r	r			
<i>Avena fatua</i> L.	Th	COSM	r	r	r	r			
<i>Bupleurum lancifolium</i> Hornem	Th	ME,IT	r	r					
<i>Erodium laciniatum</i> (Cav.)Willd.	Th	ME	r					r	
<i>Linaria albiflora</i> (Sm.) Spreng.	Th	IT,ME			r				r
<i>Medicago lanciniata</i> (L.) Mill.	Th	SA						r	
<i>Ononis serrata</i> Forssk.	Th	ME,SA,ES				r	r	r	
<i>Silene villosa</i> Forssk.	Th	SA	r			r	r		
<i>Astragalus trigonus</i> DC.	Ch	ME		r					
<i>Eryngium creticum</i> Lam.	Ch	ME,IT							
<i>Herniaria hemistemon</i> J. Gay	He	SA	r	r					
<i>Multikiopsis ciliata</i> (Forssk.) I.M.Johnst	Ch	SA,SU,ME					r		
<i>Stipagrostis plumosa</i> (L.) Munro ex T	Ge	SA,IT,SU	r				r	r	
<i>Rumex pictus</i> Forssk.	Th	ME,SA							r
<i>Astragalus peregrinus</i> Vahl	Th	SA							r
<i>Cutandia memphitica</i> (spreng.) K.	Th	SA							r
<i>Mesembryanthemum nodiflorum</i> L.	Th	ME,SA,ES							r
<b>Species recorded outside of the sampled stands:</b>									
<i>Bupleurum semicompositum</i> L.	Th	ME,IT,SA							
<i>Arygrolobium uniflorum</i> (Decne.) Jaub. & Spach	He	–							
<i>Calligonum polygonoides</i> L.	Ch	SA							
<i>Helianthemum sp.</i>	Ch	SA,ME							
<i>Helianthemum stipulatum</i> (Forssk.)C.Chr.	Ch	SA,ME							
<i>Limonium pruinatum</i> (L.) Chaz.	Ch	SA							
<i>Lygeum spartum</i> Loeffl. Ex L.	Ge	–							
<i>Ornithogalum trichophyllum</i> Boiss.&Heldr.	Ge	SA,IT							
<i>Stipa sp</i>	Ge	–							
<i>Stipa lagascae</i> Roem. & Schult.	Ge	ME,IT							

Fig. 1. Location map showing the study area and the sampled stands (1-30) of Core Area II of Omayed Biosphere Reserve.

Fig. 2. Life form spectrum of the Core Area II in relation to types of habitat.

Fig. 3. The relationship between the six vegetation groups generated after application of TWINSpan classification, DCA and CCA ordinations.

