Ecologia mediterranea

Vegetation along an elevation gradient in Al-Jabal Al-Akhdar, Libya

Yassin M. Al-Sodany, M. N. Shehata, Kamel H. Shaltout

Résumé

Le jbel Al-Akhdar représente une région de montagne située au nord-est de la Libye, en Cyrénaïque. Le secteur d'étude s'étend selon un transect nord-sud d'environ 30 kilomètres, entre El-Hamamah (près du niveau de la mer : 33 º 53' N et 21 º 39' E) et El-Bydda au sud (600 m au dessus du niveau de la mer : 33 º 17' N et 21 º 50' E). Ce secteur se caractèrise par une variation physiographique importante qui conduit à distinguer beaucoup d'habitats tels que les étendues sablonneuses et salées de la côte, les dunes de sable, les escarpements et les collines de sable, et le plateau interne comportant des terrasses et des oueds. 165 relevés ont été effectués pour analyser l'organisation de la végétation de ce secteur. 119 espèces végétales ont été recensées (43 annuelles et 76 pérennes) dont six espèces endémiques. Les composées ont la contribution la plus élevée vis à vis de toute la flore, suivies par les graminées et les légumineuses. L'application de l'analyse bi-directionnelle d'espèces indicatrices (TWINSPAN) aboutit à l'agglomération de 30 groupes de végétation au niveau sept et six : la communauté à Juniperus phoenicea – Sarcopoterium spinosum qui occupe un gradient altitudinal important, la communauté à Crucianella maritima – Suaeda vermiculata des collines côtières soumises aux influences marines, la communauté à Retama raetam des étendues sablonneuses côtières, la communauté à Pancratium maritimum – Ammophila arenaria des dunes de sable, et la communauté à Cichorium spinosum et Limoniastrum monopetalum des étendues sablonneuses et salées de la plaine côtière. L'application de l'analyse de correspondance de type DECORANA indique une ségrégation correcte entre ces divers groupes de communautés. La communauté à Juniperus phoenicea – Sarcopoterium spinosum (i. e. les matorrals méditerranéens) constitue le type de végétation le plus fréquent dans la zone d'étude ; ces matorrals se caractérisent par une augmentation de la diversité et du recouvrement parallèlement avec l'altitude, et ils entrent au contact des forêts méditerranéennes dans les secteurs sub-humides de plus haute altitude.

Abstract

Al-Jabal Al-Akhdar is an upland region which lies at the northeast part of Libya, in Cyrenaic. The study area is an N-S transect of about 30 km between El-Hamamah (near the sea level : 33 º 53 ´ N and 21 º 39 ´ E) to El-Bydda in the south (600 m above the sea level : 33 º 17 ´ N and 21 º 50 ´ E). This area is characterized by a wide physiographic variation that leads to distinguish of many habitats such as coastal saline sand flats, sand dunes, sand flats and hills, and inland plateau with terraces and wadis. 165 stands were sampled to analyze the vegetation of this area. 119 plant species were recorded (43 annuals and 76 perennials) including six endemic species. The composites have the highest contribution to the total flora, followed by the grasses and legumes. The application of two-way indicator species analysis (TWINSPAN) resulted in agglomerating of 30 vegetation groups at the level seven and six major ones at the levels three and two of this classification : Juniperus phoenicea – Sarcopoterium spinosum that occupies a wide elevation gradient, Crucianella maritima – Suaeda vermiculata along the seaward direction of the coastal hills, Retama raetam in the coastal sand flats, Pancratium maritimum – Ammophila arenaria in the coastal sand dunes, Cichorium spinosum and Limoniastrum monopetalum in the saline sand flats of the coastal plain. The application of the detrended correspondence analysis (DECORANA) indicates reasonable segregation between these vegetation groups. Juniperus phoenicea – Sarcopoterium spinosum group is the most prominent vegetation type in the study area (i. e. Mediterranean matorrals) where its diversity and cover increases with elevation reaching the Mediterranean forests at the highest elevated sub-humid zones.

Vegetation along an elevation gradient in Al-Jabal Al-Akhdar, Libya

Organisation de la végétation le long d'un gradient altitudinal dans le Jbel Al-Akhdar, Libye

Y. M. Al-Sodany[1], *M. N. Shehata*[2] *& K. H. Shaltout*[3]

1. Biological & Geological Sciences Department, Faculty of Education at Kafr El-Sheikh, Tanta University, Kafr El-Sheikh, Egypt
2. Botany Department, Faculty of Science at Banha, Zagazig University, Banha, Egypt
3. Botany Department, Faculty of Science, Tanta University, Tanta, Egypt

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Key-words

Mediterranean region, Libya, Cyrenaic, matorrals, vegetation classification, ordination, plant diversity, phytogeography.

Résumé

Le jbel Al-Akhdar représente une région de montagne située au nord-est de la Libye, en Cyrénaïque. Le secteur d'étude s'étend selon un transect nord-sud d'environ 30 kilomètres, entre El-Hamamah (près du niveau de la mer : 33º 53'N et 21º 39'E) et El-Bydda au sud (600 m au-dessus du niveau de la mer : 33º 17'N et 21º 50'E). Ce secteur se caractèrise par une variation physiographique importante qui conduit à distinguer beaucoup d'habitats tels que les étendues sablonneuses et salées de la côte, les dunes de sable, les escarpements et les collines de sable, et le plateau interne comportant des terrasses et des oueds. 165 relevés ont été effectués pour analyser l'organisation de la végétation de ce secteur. 119 espèces végétales ont été recensées (43 annuelles et 76 pérennes) dont six espèces endémiques. Les composées ont la contribution la plus élevée vis à vis de toute la flore, suivies par les graminées et les légumineuses. L'application de l'analyse bi-directionnelle d'espèces indicatrices (TWINSPAN) aboutit à l'agglomération de 30 groupes de végétation au niveau sept et six : la communauté à Juniperus phoenicea – Sarcopoterium spinosum qui occupe un gradient altitudinal important, la communauté à Crucianella maritima – Suaeda vermiculata des collines côtières soumises aux influences marines, la communauté à Retama raetam des étendues sablonneuses côtières, la communauté à Pancratium maritimum – Ammophila arenaria des dunes de sable, et la communauté à Cichorium spinosum et Limoniastrum monopetalum des étendues sablonneuses et salées de la plaine côtière. L'application de l'analyse de correspondance de type DECORANA indique une ségrégation correcte entre ces divers groupes de communautés. La communauté à Juniperus phoenicea – Sarcopoterium spinosum (i.e. les matorrals méditerranéens) constitue le type de végétation le plus fréquent dans la zone d'étude ; ces matorrals se caractérisent par une augmentation de la diversité et du recouvrement parallèlement avec l'altitude, et ils entrent au contact des forêts méditerranéennes dans les secteurs sub-humides de plus haute altitude.

Mots-clés

Région méditerranéenne, Libye, Cyrénaïque, matorrals, classification de la végétation, ordination, diversité végétale, phytogéographie.

INTRODUCTION

Numerous studies had been published on the flora of Libya, but few have dealt with its vegetation. Earlier studies are those of Maire (1952-1977), Keith (1965), Boulos (1971) on the wild trees and shrubs of Libya and Boulos (1972) that presented a bibliography on the flora and vegetation of this country. On the other hand, several check-lists of Libyan flora have been published such as Boulos (1977, 1979a, b). Greuter *et al.* (1984, 1986, 1989) made a partial inventory of vascular plants of the circum-Mediterranean countries including the flora of Libya. Scholz (1974) made an exhaustive study on the grasses of Libya, Ali and Jafri (1976), Jafri and El-Gadi (1978), Pratov and El-Gadi (1980), Qaiser and El-Gadi (1984) and El-Gadi (1988) studied the floristic composition of the pasture zone of the Libyan Jamahiraya. More recently, Brullo and Furanari (1994) have performed a detailed phytosociological analysis of the vegetation of A-Jabal Al-Akhdar; Edrawi and El-Naggar (1995) published a note on the natural vegetation of Libya, whereas Ebrahem (1999) studied the vegetation and flora of a sector from Tobruk to Egyptian border and El-Kady (2000) studied the vegetation along Slouk-Musus road in southeastern Benghazi.

The present study aims at analyzing the vegetation along a 30 km N-S transect in Al-Jabal Al-Akhdar in the northeast of Libya using multivariate analysis and identifying the plant communities that characterize the different habitats and elevations. It assesses the effects of the elevation and environmental factors on the species diversity of the identified plant communities in the study area.

The study area

Al-Jabal Al-Akhdar uplands represent a plateau formed as a result of tectonic elevation of a primary plain of marine accumulation. The maximum absolute height of the upland is 878 m. Due to its morphometric features, it is attributed to the type of low plateaux and partially, to those of a medium height (Chemekov *et al.*, 1972). The study area is a N-S transect of about 30 km between El-Hamamah (near the sea level: 33º 53´ N and 21º 39´ E) to El-Bydda (600 m above the sea level: 33º 17´ N and 21º 50´ E) passing through El-Wesaitah (300 m above the sea level: 33º 25´ N and 21º 40´ E). This area is characterized by a wide physiographic variation such as the coastal plain, coastal hills, inland plateau and wadis (see Shishov, 1980). The coastal plain extends for about 1 km from the Mediterranean and composed of marine accumulation and three main habitats can be distinguished: saline sand flats, sand dunes (up to 50 m high) and sand flats. The coastal hills (up to 100 m high) are generally confined to marginal parts of the coastal plain. It is possible to distinguishe a seaward direction where the soil is shallow and the rocky substratum, sometimes is not covered by any soil except in notches and crevices, and a leeward direction which is covered by a relative thin mantle of alluvial deposits and slightly dissected by water runnels.

The inland plateau was formed as a result of tectonic elevation of the primary plain of marine accumulation. The marginal parts of the plateau have a deep erosional dissection which adds to the relief features of the mountainous. The plateau appears in the form of three steps (terraces): the first is up to 400 m above the sea level at Ras El-Hilal, the second up to 600 m above at El-Bydda and the third one up to 880 m at Slentah. These terraces are characterized by considerable thickness of alluvial deposits, and deeply dissected by several wadis, runlets and dells. Wadis which are confined to the different parts of the plateau extend in the south–north direction and are covered with shallow sandy loam soil. They can be distinguished into south–east and north-east facing slopes, and wadi beds. Under such conditions, many valleys are developed. These valleys are characterized by irregularity and sheerness, but others are chinks-like, narrow and have

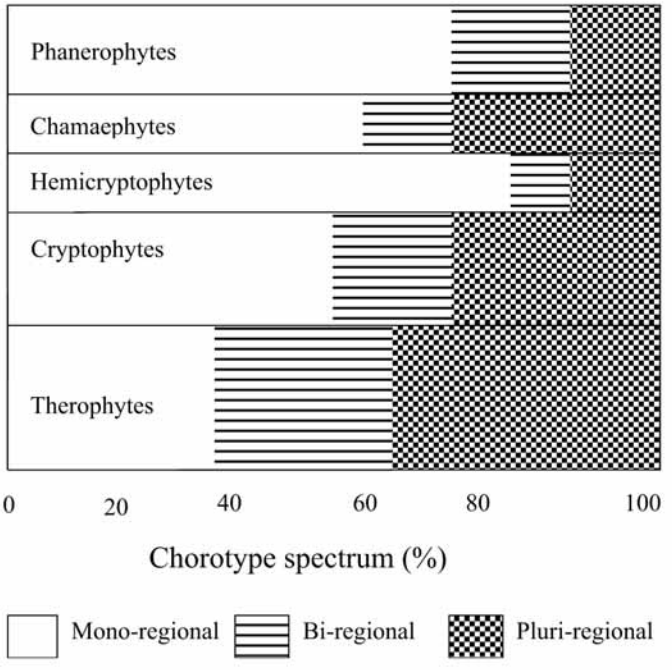

Fig. 1. Layer diagram of life form and chorotype spectra of the vegetation of the study area in Al-Jabal Al-Akhdar.

V-shaped. The depth of valley reaches 300 m and the slopes may be strongly developed vertically or often very steep. The fluffy cover on the slopes is thin, rock outcrops and structural terraces are widespread.

The study area belongs to the Mediterranean climate in the belt of subtropical alternate atmospheric circulation. The calculation of aridity index indicates that three types of bioclimates exist in the study area: an arid bioclimate in the littoral plain (Q = 1.3), a semi-arid bioclimate characterizing the lower terrace (Q = 2.0) and a sub-humid bioclimate for the upper terrace (Q = 2.8). The annual mean temperatures decrease from 19.9 °C at El-Hamamah (sea level) to 16.4 °C at El-Bydda (600 m). The annual rainfalls increase in the same direction from 323.6 to 567.1 mm/year; the wind velocity from 42.7 km/hr to 72.7 km/hr; and evaporation from 5.9 mm/day to 10.5 mm/day, while the relative humidity decreases in the same direction from 73 % to 68 % (table 1).

METHODS

One hundred and sixty-five stands were selected to represent the variation in three elevations (0 m, 300 m and 600 m above sea level), four main habitats which distinguish into microhabitats as follows (coastal plain: saline sand flats, sand dunes and sand flats; coastal hills: seaward and leeward slopes; inland plateau: first and second terraces; and wadis: north-east and south-east facing slopes and wadi beds) and prevailing plant communities in the study area. The area of the stand was about 150 m x 150 m. In each stand, the plant species were recorded. Nomenclature is according to Ali and Jafri (1976) and Täckholm (1974), and the Latin names were updated following Boulos (1977, 1979a, b and 1995). The species cover was estimated quantitatively using the line intercept method by laying out 5 parallel lines (each of 150 m long) in each stand (Canfield, 1941).

Two-way indicator species analysis (TWINSPAN), as a classification technique, and detrended correspondence analysis (DECORANA), as an ordination one, were used to analyze the data of the cover estimates of 119 species in 165 stands according to the computer programs of Hill (1979 a, b). The setup parameters for TWINSPAN program were as follow: the maximum number of indicators per division = 7, the maximum level of division = 8 and the minimum group size for division = 5.

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 number of species in a certain vegetation group and its alpha diversity. Relative evenness ($\sum$: Shannon-Weiner index) and the relative concentration of dominance (C: Simpson's index) were expressed according to these equations:

$\sum = - \Sigma^{s} Pi \, (Log \, Pi)$, $C = \Sigma^{s}(Pi)$

where s is the total number of species and Pi is the relative importance value (relative cover) of the i th species (Pielou, 1975; Magurran, 1988).

Three soil samples were collected as profiles (0-50 cm) from each sampled stand for estimating their physical and

Metereological variables			El-Hamamah		El-Wesaitah		El-Bydda	
			Lat.	Long.	Lat.	Long.	Lat.	Long.
			33° 53' (N)	21° 39' (E)	33° 25' (N)	21° 40' (E)	33° 17' (N)	21° 50' (E)
			Range	Mean	Range	Mean	Range	Mean
Altitude	m (a.s.l.)			0		300		600
Temperature	Min.	°C	10.7 – 23.2	16.4	5.2 – 16.1	10.4	6.1 – 19.9	12.0
	Max.		17.5 – 29.1	23.5	15.8 – 31.6	24.4	12.6 – 28.0	20.8
	mean		14.1 – 26.2	19.9	10.5 – 23.9	17.4	9.4 – 23.2	16.4
Total rainfall	mm/yr		----	323.6	----	417.5	----	567.1
Relative humidity	%		67.0 – 80.0	73.0	57.0 – 70.0	65.0	56.0 – 80.0	68.0
Wind velocity	km/hr		29.9 – 57.8	42.7	39.1 – 62.1	50.4	63.2 – 88.6	72.7
Evaporation	mm/day		----	5.9	----	8.8	----	10.5

Table 1. Long-term annual averages (1970-1990) of the metereological data of 3 stations within Al-Jabal Al-Akhdar area (data obtained from metereological stations at Shahat: personal communication).

chemical properties. Fine fractions (<0.09 mm) were estimated using a series of sieves and moisture content of soil was determined by drying 1 gm soil in oven at 105 °C. Bicarbonates were estimated by titration against HCl using methyl orange as indicator, chlorides by titration against silver nitrate using 5% potassium chromate as indicator, and sulphates using the gravimetric with ignition of residue method. Soil-water extracts (1:5) were prepared for the estimation of electrical conductivity (EC in mS/cm) using electric conductivity meter, and soil reaction (pH) using pH-meter. Flame photometer was used for the determination of Na, K and Ca. Mg was determined using atomic absorption (Allen *et al.*, 1989).

The relationships between the community and soil variables were tested using simple linear correlation coefficient (r). One way analysis of variance was applied to assess the significance of variations in soil and community variables in relation to the vegetation groups identified after TWINSPAN. Simple linear regressions were calculated to predict the relationship between the elevation on one hand, and species diversity and cover on the other hand (SAS, 1985).

RESULTS

One hundred and nineteen species were recorded in the study area: 43 annuals (36.1%) and 76 perennials (63.9%). These species belong to 44 families and 105 genera. The composites and grasses have the highest contribution to the total flora (each of 13.5%), followed by the legumes (10.1% of the total species). Ten species were recorded in more than 70% of the studied habitats: *Asphodelus ramosus*, *Cynodon dactylon*, *Juniperus phoenicea*, *Marrubium vulgare*, *Medicago rigidula*, *Phlomis floccosa*, *Pistacia lentiscus*, *Poa annua*, *Poa bulbosa* and *Sarcopoterium spinosum*. On the other hand, six species were recorded in only one habitat: *Cichorium spinosum*, *Eleocharis palustris*, *Juncus rigidus* and *Tamarix africana* in the saline sand flats, and *Lycium europaeum* and *Lycium shawii* in the sand flats (appendix 1). Regarding the life form spectra (fig. 1), therophytes have the highest contribution (36.1%), followed by cryptophytes (19.3%), phanerophytes (17.6%), chamaephytes (13.5%) and hemicryptophytes (13.5%). Considering the global floristic regions, most of the species belong to the Mediterranean (55 mono-regionals including 7 endemics + 19 bi-regionals + 31 pluri-regionals including 6 cosmopolitans). In general, 59 species are mono-regionals (49.6% of the total species), 23 bi-regionals (19.3%) and 31 pluri-regionals (26.1%) (fig. 1). The seven endemic species are: *Arbutus pavarii*, *Arum cyrenaicum*, *Bellis sylvestris* var. *cyrenaica*, *Cyclamen rholfsianum*, *Cynara cyrenaica*, *Onopordum cyrenaicum* and *Romulea cyrenaica*.

The application of the two-way indicator species analysis (TWINSPAN) to the data set of cover estimates of 119 species in 165 stands, resulted in agglomerating of 30 vegetation groups at the level seven and 6 major ones at the levels three and two of this classification (fig. 2A). The application of the detrended correspondence analysis (DECORANA) indicates reasonable segregation between these vegetation groups (fig. 2B). They are named according to their dominant species as follows (table 2): *Juniperus phoenicea – Sarcopoterium spinosum* group (I) that occupies a wide elevation gradient, *Crucianella maritima – Suaeda vermiculata* group (II) along the seaward direction of the coastal hills, *Retama raetam* group (III) in the coastal sand flats, *Pancratium maritimum – Ammophila arenaria* group (IV) in the coastal sand dunes, *Cichorium spinosum* and *Limoniastrum monopetalum* groups (V, VI) in the saline sand flats of the coastal plain.

Juniperus phoenicea - Sarcopoterium spinosum group (I) had the highest total number of species (113 species), species richness (22.3 species/stand), species turnover (5.1) and relative evenness (2.25), but the lowest relative concentration of dominance (0.01) (table 3). On the other hand, *Cichorium spinosum* and *Limoniastrum monopetalum* groups (V, VI) had the lowest total number of species (11 species) and relative evenness (0.99). *Pancratium maritimum - Ammophila arenaria* group (IV) had the lowest species richness (5.0 species / stand) and the highest relative concentration of dominance (0.13).

The soil of saline sand flats had the highest values of moisture content (8.60 %), EC (2.40 mS / cm), pH (8.70), sodium (0.95 mg / 100 gm), calcium (1.87 mg / 100 gm) and magnesium (0.65 mg / 100 gm), but the lowest of bicarbonates (0.19 %). The soil of the coastal sand flats had the highest of fine fraction (59.4 %), bicarbonates (0.59 %) and chlorides (5.50 %) (table 4). On the other hand, the soil of south-east facing slopes of the wadis had the lowest of pH (7.43), chlorides (0.28 %), sulphates (0.24%), sodium (0.08 mg / 100 gm) and magnesium (0.15 mg / 100 gm), while that of seaward direction of the coastal hills had the lowest of fine fractions (1.40%), moisture content (1.48 %) and EC (0.39 mS / cm). The soil of leeward direction of the coastal hills is characterized by the lowest value of potassium (0.02 mg / 100 gm) and that of the wadi beds had the highest of potassium (0.50 mg / 100 gm) and the lowest of calcium (0.25 mg / 100 gm).

VG	N	Total Sp.	G/P (%)	Habitat type										First dominant species	P (%)	C (%)	Second dominant species	P (%)	C (%)
				Coastal plain			Coastal hill		Plateau		Wadi								
				SS	SD	SF	SW	LW	FT	ST	NE	SE	WB						
I	130	113	81.3			8		12	12	12	12	35	12	*Juniperus phoenicea*	80	48	*Sarcopoterium spinosum*	73	42
II	6	17	3.8				100							*Crucianella maritima*	100	14	*Suaeda vermiculata*	83	19
III	7	16	4.4			71	29							*Retama raetam*	71	69	*Thymelaea hirsuta*	71	30
IV	12	14	7.5		83		17							*Pancratium maritimum*	75	33	*Ammophila arenaria*	67	29
V	5	11	3.1	100										*Cichorium spinosum*	100	72	*Limoniastrum monopetalum*	60	18
VI	5	11	3.1	100										*Limoniastrum monopetalum*	100	63	*Tamarix africana*	80	27

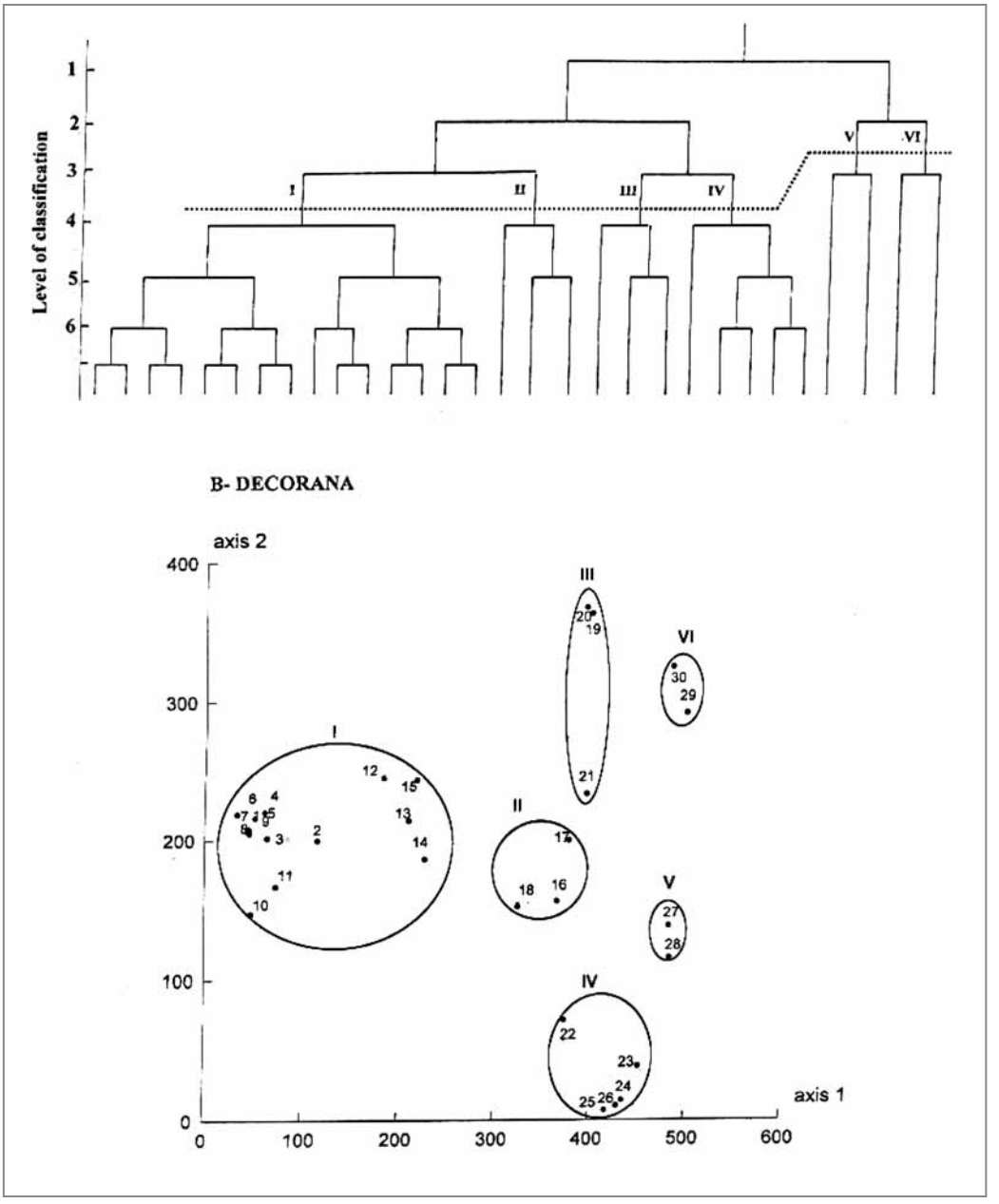

Fig. 2. The relationship between the 6 vegetation groups generated after application of TWINSPAN (A) and their cluster centroids on the first and second axes of DECORANA (B). The vegetation groups are: I: Juniperus phoenicea – Sarcopoterium spinosum, II: Crucianella maritima – Suaeda vermiculata, III: Retama raetam, IV: Pancratium maritimum – Ammophila arenaria, V: Cichorium spinosum, VI: Limoniastrum monopetalum.

Table 2. Characteristics of the 6 vegetation groups (VG) derived after the application of TWINSPAN on the vegetation of Al-Jabal Al-Akhdar area. N: number of stands, G/P: the percentage of the stands representing each vegetation group in relation to the total sampled stands, P: presence of species (%), C: absolute cover of species (m /100 m). The vegetation groups are: I: Juniperus phoenicea – Sarcopoterium spinosum, II: Crucianella maritima – Suaeda vermiculata, III: Retama raetam, IV: Pancratium maritimum – Ammophila arenaria, V: Cichorium spinosum, VI: Limoniastrum monopetalum. The habitats of coastal plain are: SS: saline sand flats, SD: coastal sand dunes, SF: sand flats; those of coastal hill are: SW: seaward slope and LW: leeward slope; those of the plateau are: FT: first terrace and ST: second terrace; and those of wadis are SE: south-east slope, NE: north-east slope and WB: wadi bed.

	Soil variables									
Community variables	Fine fraction	Moisture content	EC	pH	Cl	SO_4	Na	K	Ca	Mg
Total species	0.38	0.18	0.04	0.15	0.71*	-0.53	0.67*	0.47	-0.54	0.80
Species richness	0.50	0.35	0.19	0.32	-0.65*	-0.42	-0.46	0.73*	-0.48	0.36
Species turnover	-0.36	-0.37	-0.36	-0.70*	0.33	0.64*	-0.14	-0.65*	0.23	-0.36
Relative conc. of dominance (C)	-0.46	-0.26	-0.32	-0.47	0.19	0.96***	0.11	-0.29	0.15	0.15
Relative evenness (H')	0.46	0.23	0.18	0.32	-0.47	-0.82**	-0.40	0.38	-0.38	0.12

*Table 5. Matrix of simple linear correlation coefficients between the soil and community variables of the Al-Jabal Al-Akhdar area. Significant r values are indicated as follows: * P ≤ 0.05, ** P ≤ 0.01, *** P ≤ 0.001.*

Table 3. Variation in some diversity indices calculated for the 6 vegetation group and the 10 types of habitat identified in Al-Jabal Al-Akhdar area. The vegetation groups are: I: Juniperus phoenicea – Sarcopoterium spinosum, II: Crucianella maritima – Suaeda vermiculata, III: Retama raetam, IV: Pancratium maritimum – Ammophila arenaria, V: Cichorium spinosum, VI: Limoniastrum monopetalum. The habitats of coastal plain are: SS: saline sand flats, SD: coastal sand dunes and SF: sand flats; those of coastal hill are SW: seaward slope and LW: leeward slope; those of plateau are FT: first terrace and ST: second terrace; and those of wadis. are SE: south-east slope, NE: north-east slope, and WB: wadi bed.

Component		Total species	Species richness	Species turnover	Relative conc. of dominance (C)	Relative evenness (H')
Vegetation group						
I		113	22.3	5.1	0.01	2.25
II		17	7.8	2.2	0.08	1.174
III		16	5.3	3.0	0.09	1.13
IV		14	5.0	2.8	0.13	1.00
V		11	5.4	2.0	0.11	0.99
VI		11	5.7	1.9	0.11	0.99
Total mean		30.3	8.6	2.8	0.09	1.25
S. D.		40.6	6.8	1.2	0.04	0.49
Habitat						
Coastal plain	SS	13	5.3	1.9	0.12	0.99
	SD	6	2.4	4.2	0.36	0.52
	FP	20	6.1	2.5	0.07	1.23
Coastal hill	SW	18	7.1	1.4	0.12	1.04
	LW	67	21.2	0.7	0.04	1.52
Plateau	FT	91	49.1	0.3	0.05	1.51
	ST	91	53.7	0.5	0.05	1.69
Wadi	SE	80	21.7	3.7	0.06	1.50
	NE	52	27.8	0.5	0.07	1.36
	WB	52	27.9	0.5	0.08	1.34
Total mean		49	22.2	1.6	0.10	1.27
S. D.		33.0	18.1	1.4	0.09	0.34

The calculation of simple linear correlation coefficients between the soil and community variables (table 5) indicated that sulphate had highly positive correlations with relative concentration of dominance ($r = 0.96$, $p < 0.001$), and negative correlation with relative evenness ($r = -0.82$, $p < 0.01$). The correlation between the elevation and species diversity indicated significant positive correlation with total number of species ($r = 0.84$, $p < 0.01$), relative evenness ($r = 0.71$, $p < 0.05$) and species richness ($r = 0.90$, $p < 0.001$) (fig. 3A). On the other hand, the correlation between the elevation and plant cover indicated a significant positive correlation with the total cover

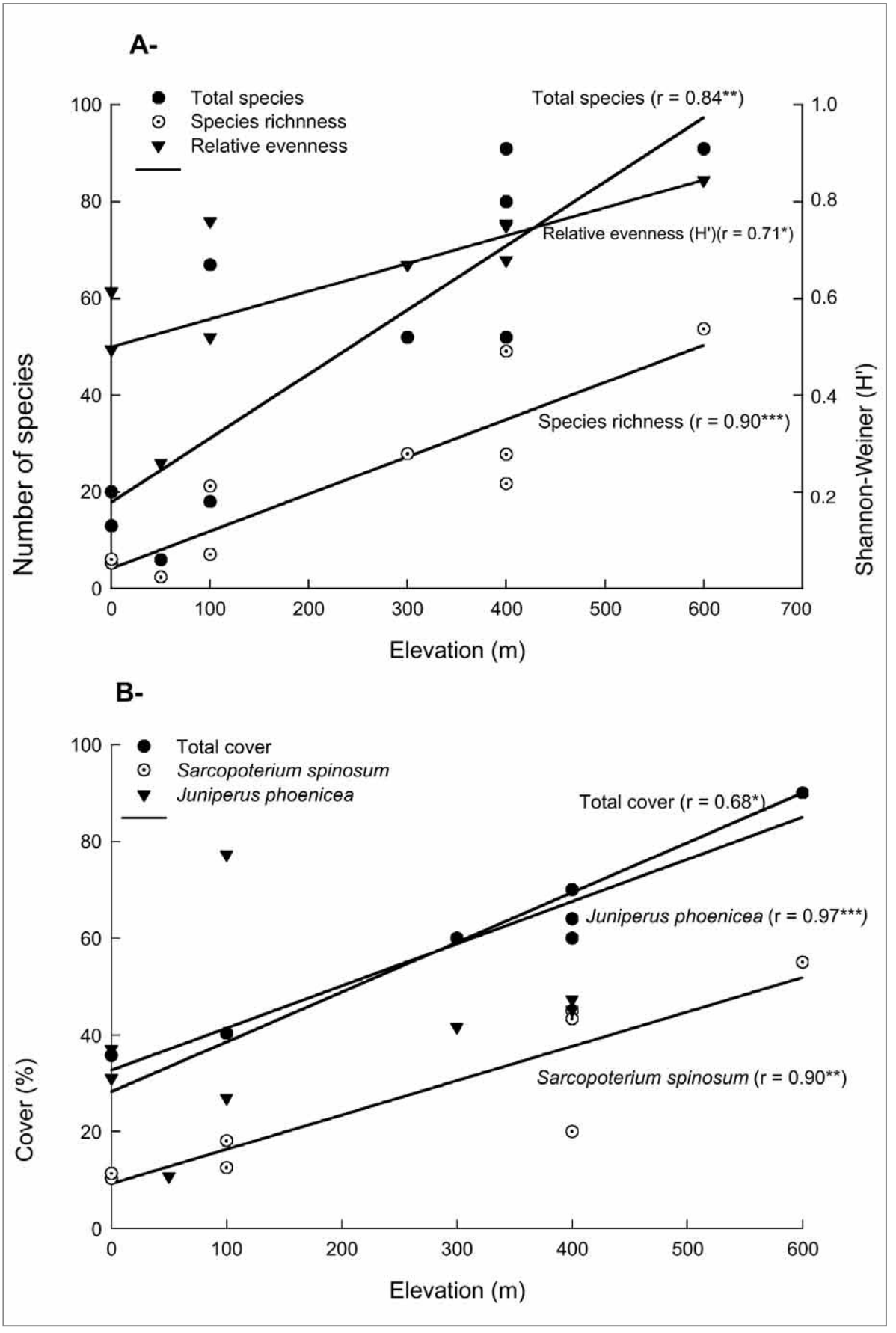

Fig. 3. Simple linear regression between the elevation and species diversity of the vegetation (A) and simple linear regression between the elevation and the total cover and cover of some species (B) of the study area in Al-Jabal Al-Akhdar.

Soil variables		Habitat type										Total mean	F-value
		Coastal plain			Coastal hill		Plateau		Wadis				
		SS	SD	SF	SW	LW	FT	ST	SE	NE	WB		
Fine fractions	(%)	36.40	10.30	59.40	1.40	21.30	65.70	45.50	20.47	41.50	50.20	32.76	5.96
Moisture content		8.60	2.70	3.50	1.48	3.60	5.10	6.70	3.10	4.20	5.60	4.23	4.17
EC	(mS/cm)	2.40	0.49	1.40	0.39	0.99	1.60	1.40	0.57	0.89	1.30	1.05	9.88*
pH		8.70	7.50	8.40	7.60	8.30	8.70	8.10	7.43	8.70	8.60	8.08	1.22
HCO_3	(%)	0.19	0.29	0.59	0.27	0.43	0.42	0.46	0.32	0.50	0.37	0.37	0.72
Cl		5.47	2.05	5.50	1.50	0.88	0.22	0.62	0.28	0.69	0.78	1.55	162.52***
SO_4		1.33	5.53	0.72	0.25	0.27	0.47	0.64	0.24	0.37	0.34	0.89	150.44***
Na	mg/ 100gm	0.95	0.51	0.83	0.64	0.55	0.40	0.49	0.08	0.45	0.59	0.47	72.82**
K		0.24	0.07	0.05	0.04	0.02	0.50	0.40	0.04	0.30	0.50	0.19	27.15**
Ca		1.87	0.63	0.97	0.37	0.50	0.35	0.48	0.35	0.45	0.25	0.58	17.25*
Mg		0.65	0.32	0.50	0.19	0.25	0.59	0.61	0.15	0.30	0.49	0.36	6.91

*Table 4. Means of some characters of soil samples representing the main habitats in Al-Jabal Al-Akhdar area. The habitats of coastal plain are SS: saline sand flats, SD: coastal sand dunes and SF: sand flats; those of coastal hill are SW: seaward slope and LW: leeward slope; those of plateau are FT: first terrace and ST: second terrace; and those of wadis are SE: south-east slope, NE: north-east slope, and WB: wadi bed. *: P ≤ 0.05, **: P≤ 0.01 and ***: P ≤ 0.001 according to F-test.*

($r = 0.68$, $p < 0.05$) and the cover of *Juniperus phoenicea* ($r = 0.97$, $p < 0.001$) and *Sarcopoterium spinosum* ($r = 0.90$, $p < 0.001$) (fig. 3B).

DISCUSSION

The composites and grasses followed by the legumes had the highest contribution to the flora of the present study. This trend is similar to that of the pasture zone in north Libya, as well as the total Libyan flora (Qaiser & El-Gadi, 1984). Regarding the biological spectrum in the present study, therophytes are the most frequent (36.7%), followed by the cryptophytes (19.2%) and phanerophytes (17.6%). This resembles the biological spectrum of some Mediterranean territories (Archibold, 1995), but greatly differs from that of Egyptian Mediterranean region where the therophytes contribute 58.7% and the phanerophytes 3.2% (Hassib, 1951). Therophytes are particularly well adapted to the seasonal region of mild moist winters and dry summers, and often account for 40-50% of the species present in the Mediterranean region. Cryptophytes are also well adapted to the Mediterranean climate where they survive the dry summer below ground as bulbs, corms or rhizomes, and produce leaves and flowers during the winter and spring (Raven, 1973). The phanerophytes are mainly represented in the present study by evergreen sclerophyllus shrubs (1-3 m in height) where they dominate the plant cover, although they were represented by relatively low number of species comparing with the therophytes and cryptophytes. This life form gives the landscape of Al-Jabal Al-Akhdar its special beauty and charm (Boulos, 1971).

From the phytogeographical viewpoint, the Mediterranean elements are the most represented chorotype taking the following sequence: mono-regionals > bi-regionals > pluri-regionals. The Saharo-Arabian elements come in the second order, while the other elements show a minor representation. There are no doubts about the existence of biogeographical links between Mediterranean, Saharo-Arabian and Irano-Turanian elements. Relics of the Mediterranean flora also persist in the high mountains of the Sahara (see Quézel, 1978; Di Castri, 1981). On the other hand, the occurrence of many common western Mediterranean elements (e.g. *Viburnum tinus, Rhamnus lycioides, Olea europaea, Myrtus communis, Rosmarinus officinalis, Cichorium spinosum, Quercus coccifera* and many others) indicate more affinities with the flora of Crete and west Mediterranean region rather than the much closer east Mediterranean territory (Zohary, 1973; Qaiser & El-Gadi, 1984).

Al-Jabal Al-Akhdar could be considered the center of endemic species in Libya. Among 134 endemic species in the Libyan flora, approximately 50% of them are found in Al-Jabal Al-Akhdar (Qaiser & El-Gadi, 1984; Beentje *et al*., 1994). Of the 59 endemics recorded in this region (Qaiser & El-Gadi, 1984), only 7 ones were recorded in the studied area. The concentration of the endemic species in Al-Jabal Al-Akhdar could be due to its peculiar physiography and climate comparing with most of the country. It is surrounded by the sea from the north and west sides, and by the desert from the south and east sides. These physiographic and climatic barriers have provided an excellent ecological refugia and contributed to restriction of many endemic taxa.

Six vegetation groups were generated after the application of the multivariate analysis (Hill 1979, a, b) to the cover estimates of 119 species in 165 stands (four groups mainly inhabit the coastal plain habitats and one inhabits the hilly and upland terrain). Two of the coastal plain groups inhabit the saline sand flats (*Cichorium spinosum* and *Limoniastrum monopetalum* groups), two inhabit the sand dunes and flats (*Pancratium maritimum – Ammophila arenaria* and *Retama raetam*), and one inhabits the seaward slopes of the coastal hills (*Crucianella maritima – Suaeda vermiculata*). Comparable groups (except that of *Cichorium spinosum*) were identified in the habitats of the coastal plain in the adjacent Egyptian Mediterranean region (Ayyad, 1973; Ayyad & El-Ghareeb, 1982; Shaltout & El-Ghareeb, 1992; Shaltout & Ayyad, 1994). The species diversity of these groups is low (5.0 – 7.8 species / stand) and resemble those of the inland desert along Slouk – Msus road south (3.7 – 8.6 species / stand) of Al-Jabal Al-Akhdar region (El-Kady, 2000), in spite of the low floristic similarity between both regions.

The group of *Juniperus phoenicea – Sarcopoterium spinosum* mainly inhabits the hilly and upland terrain, including the terraces and wadis of Al-Jabal Al-Akhdar plateau. This group is the most prominent vegetation type (i.e. Mediterranean matorrals) in the study area where its diversity and cover increases at high elevations reaching the Mediterranean forests at the sub-humid zones of rainfall ranges between 600 and 800 mm/year (*sensu* Le Houérou, 1984). A sub-group is splitted from this major group at level four of classification and characterized by *Sarcopoterium spinosum* shrub which could be considered as a degraded stage of forest or matorral extending predominantly at relatively low elevations, between 300 and 400 m, where it tends to become a disclimax similar to the phryganas of Greece and the "bathas" of the near east (Zohary, 1973; Le Houérou, 1984; Dallman, 1998).

The communities of wadis in Al-Jabal Al-Akhdar area are completely different to those of wadis of the western Mediterranean region of Egypt. Most of the recorded species in the study area were not recorded in the wadis of the western Mediterranean region of Egypt (Kamal & El-Kady, 1993). This may be due to the fact that the wadis of the western Mediterranean region of Egypt are relatively shallow and are geologically more recent. The shallow wadis differ from mature great ones of the study area in several aspects. Those of the study area are characterized by their wide and deep with developed prominent valleys. These valleys are characterized by irregularity and sheerness, but others are chinks-like, narrow and have V-shaped. The depth of valley reaches to 300 mm and the slopes may be strongly developed vertically or often steep.

This spot of Libyan Mediterranean vegetation which approximates an area of 500 km^2 (Azzawm, 1995) is considered as a unique vegetation type inside an extending gap between south pasture and the western border of Libya in which the Saharo-Arabian belt closely approaches the Mediterranean coast (Zohary, 1973; Brullo & Furnari, 1994; Mady *et al*., 2002). Generally much of the matorrals has been heavily grazed for thousands of years. Unfortunately, this vegetation type in Libya has been subjected to severe disturbance for changing it into agricultural land through the "Agricultural Project of Al-Jabal Al-Akhdar" (Azzawam, 1995). Recent efforts have been done by the governmental authorities for stopping the clearance of the natural vegetation in this region, and rehabilitating some places which are not suitable for agricultural purposes. International efforts should be done for declaring this region as a "Biosphere Reserve".

References

ALI, S.I. & JAFRI, S.M.H. 1976. *Flora of Libya*. Vols 1-24. Department of Botany, El-Faateh Univ., Tripoli.

ALLEN, S., GRIMSHAW, H.M., PARKINSON, J.A. & QUARMBY, C. 1989. *Chemical analysis of ecological materials*. Blackwell Sci. Publ., London. 565 p.

ARCHIBOLD, O.W. 1995. *Ecology of World vegetation*. Chapman & Hall, London. 510 p.

AYYAD, M.A. 1973. Vegetation and environment of the western Mediterranean coastal land of Egypt. I. The habitat of sand dunes. *J. Ecol.*, 61: 509-525.

Ayyad, M.A. & El-Ghareeb, R.E. 1982. Salt marsh vegetation of the Western Mediterranean desert of Egypt. *Vegetatio,* 49: 3-19.

AZZAWAM, S.M. 1995. *Al-Jabal Al-Akhdar: A study in physical geo-*

graphy. Publication of University of Qar Younis of Benghazi, Libya. 139 p. (in Arabic).

BEENTJE, H.J., ADAMS, B. & DAVIS, S.D. 1994. Regional overview: Africa. In: Davis, S.D., Heywood, V.H. & Hamilton, AC. (eds.). *Centres of plant diversity*. Oxford.

BOULOS, L. 1971. The flora of Libya project. *Mitt. Bot. Staatssamml. München*, 10: 14-16.

BOULOS, L. 1972. Our present knowledge on the flora and vegetation of Libya. *Webbia*, 26: 365-400.

BOULOS, L. 1977. A check-list of the Libyan flora. 1. Introduction and Adiantaceae – Orchidaceae. *Public. Cairo Univ. Herb.*, 7/8: 115-141.

BOULOS, L. 1979a. A check-list of the Libyan flora: 2. Salicaceae to Neuradaceae. *CODEN: CNDLAR*, 34: 21-48.

BOULOS, L. 1979b. A check-list of the Libyan flora: 3. Compositae. *CODEN: CNDLAR*, 34: 307-332.

BOULOS, L. 1995. *Flora of Egypt: Checklist*. Al-Hadara Publications, Cairo. 283 p.

BRULLO, S. & FURNARI, F. 1994. La vegetazione del Gebel el-Akhdar (Cirenaica settentrionale). *Boll. Acc. Gioenia Sci. Nat.*, 27: 197-412.

CANFIELD, R. 1941. Application of the line-intercept method in sampling range vegetation. *J. Forestry*, 39: 288-394.

CHEMEKOV, YU F., GANESHIN, G.C., SOLOVIEV, V.V., BOITSOV, M.N., SELIVERSTOV, YU.P., & PLOTNIKOVA, T.I. 1972. *Manual on geomorphological investigations*. "Nedra" Publishing House, Leningrad.

DALLMAN, P.R. 1998. *Plant life in the World's Mediterranean climates*. California Native Plant Society. University of California Press, Berkeley. 258 p.

DI CASTRI, F. 1981. Mediterranean-type shrublands of the World. In: F. di Castri, D.W. Goodall and R.L. Specht (eds.). *Mediterranean-type shrublands*. Elsevier Scientific Publishing Company, Amsterdam, 1-52.

EBRAHEM, M.E. 1999. *Vegetation and flora of a sector along Mediterranean coast of Libya from Tobruk to Egyptian border*. M. Sc. Thesis, Fac. Sci., Univ. Qar Younis, 165 p.

EDRAWI & EL-NAGGAR. 1995. Natural plant life of Libya. *Assuit J. Environ. Studies*, 9: 149-160. (in Arabic).

EL-GADI, A.A. 1988. *Flora of Libya*. Vol. 145. Department of Botany, El-Faateh Univ., Tripoli.

EL-KADY, H.F. 2000. Vegetation analysis along Slouk-Msus road in southeastern Benghazi, Libya. *El-Minia Sci. Bull.*, 13: 61-71.

GREUTER, W., BURDET, H. & LONG, G. (EDS). 1984, 1986, 1989. *Med-Checklist. A critical inventory of vascular plants of the circum-Mediterranean countries*. Conservatoire et Jardin Botaniques de la Ville de Genève, Genève.

HASSIB, M. 1951. Distribution of plant communities in Egypt. *Bull. Fac. Sci. Fouad I Univ.*, 29: 59-261.

HILL, M.O. 1979a. *DECORANA – a FORTRAN program for detrended correspondence analysis and reciprocal averaging*. Cornell Univ., Ithaca, N.Y. 90 p.

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*. Cornell University, Ithaca, N.Y. 52 p.

JAFRI, S.M. & EL-GADI, A. 1978. *Flora of Libya*. Vols. 25-144. Department of Botany, El-Faateh Univ., Tripoli.

KAMAL, S.A. & EL-KADY, H.F. 1993. Vegetation analysis of some wadis in the Egyptian Mediterranean desert. *Feddes Repert.*, 104: 537-545.

KEITH, H.G. 1965. *A Preliminary check-list of Libyan flora*. 2 vols. The Government of Libyan Arab Republic, Ministry of Agriculture and Agrarian Reform, Tripoli.

LE HOUÉROU, H.N. 1984. An outline of the bioclimatology of Libya. *Bull. Soc. Bot. Fr., 131, Actual bot.*, (2/3/4): 157-178.

MADY, M.I., SHALTOUT, K.H. & SHARAF EL-DIN, A. 2002. Flora of the coastal sand dunes of Gaza strip, Palestine. *Proc. 2nd Int. Conf. Biol. (ICBS), Fac. Sci., Tanta Univ.*, 2: 64-78.

MAGURRAN, A.E. 1988. *Ecological diversity and its measurement*. Princeton Univ. Press, Princeton, New Jersey. 179 p.

MAIRE, R. 1952-1977. *Flore de l'Afrique du Nord, vol. 1-14*. Encyclopédie Biologique Lechevalier, Paris.

PIELOU, E.C. 1975. *Ecological diversity*. A Willy-Interscience Publ. 165 p.

PRATOV, U. & EL-GADI, A. 1980. On floral composition of the pasture zone of the Libyan Jamahiriya. *Libyan J. Sci.*, 10B: 19-43.

QAISER, M. & EL-GADI, A. 1984. A critical analysis of the flora of Libya. *Libyan J. Sci.*, 13: 31-40.

QUÉZEL, P. 1978. Analysis of the flora of Mediterranean and Saharan Africa. *Ann. Missouri Bot. Gard.*, 65: 479-534.

RAVEN, P.H. 1973. The evolution of Mediterranean floras. In F. di Castri & H.A. Mooney (eds.). *Mediterranean type ecosystems: origin and structure*. Springer, New York, 213-224.

SAS 1985. *SAS / STAT User's Guide*. SAS Institute Incorporation, Cary. NC. 956 p.

SCHOLZ, H. 1974. Liste der grase Libyens. *Willdenowia*, 7: 419-458.

SHALTOUT, K.H. & EL-GHAREEB, R. 1992. Diversity of the salt marsh plant communities in the western Mediterranean region of Egypt. *J. Univ. Kuwait (Sci.)*, 19: 75-83.

SHALTOUT, K.H. & AYYAD, M.A. 1994. Phytosociological behavior of *Thymelaea hirsuta* (L.) Endel. in Egypt. *Flora*, 189: 193-199.

SCHISHOV, L.L. 1980. *Soil Studies in the Eastern Zone of the Socialist People's Libyan Arab Jamahiriya*. Soil-Ecological Expedition V/O "Selkhozpromexport", Tripoli. 392 p.

TÄCKHOLM, V. 1974. *Students Flora of Egypt*. Cairo Univ. Press, Cairo. 888 p.

ZOHARY, M. 1973. *Geobotanical foundations of the Middle East*. Gustav Fischer Verlag, Stuttgart. 739 p.

Appendix 1. Characteristics of the recorded plant species in Al-Jabal Al-Akhdar area.

The floristic categories are: ME: Mediterranean, COSM: cosmopolitan, SA: Saharo-Arabian, TR: tropical, SU: Sudanian, ES: Euro-Sibarian, IT: Irano-Turanian. The vegetation groups are: I: *Juniperus phoenicea – Sarcopoterium spinosum*, II: *Crucianella maritima – Suaeda vermiculata*, III: *Retama raetam*, IV: *Pancratium maritimum – Ammophila arenaria*, V: *Cichorium spinosum*, VI: *Limoniastrum monopetalum*. The habitats of coastal plain are SS: saline sand flats, SD: coastal sand dunes and SF: sand flats; those of coastal hill are SW: seaward slope and LW: leeward slope; those of plateau are FT: first terrace and ST: second terrace; and those of wadis are SE: south-east slope, NE: north-east slope, and WB: wadi bed.

Species	Family	Floristic category	Vegetation groups	Habitats
Phanerophytes (*sensu lato*)				
Arbutus pavarii Pamp.	Ericaceae	Endemic	I	LW,FT,ST,SE,NE,WB
Callicotome villosa (Poir.) Link in Schrad	Leguminosae	ME	I	LW,FT,ST,SE,NE,WB
Ceratonia siliqua L.	Caesalpiniaceae	ME	I	FT,ST,SE,WB
Cupressus sempervirens var. *horizontalis* (Mill.) Gord.	Cupressaceae	Endemic	I	FT,ST,SE,NE,WB
Euphorbia characias L.	Euphorbiaceae	ME	I	LW,FT
Euphorbia dendroides L.	Euphorbiaceae	ME	I	FT, ST
Juniperus phoenicea L.	Cupressaceae	ME	I, III	SF,LW,FT,ST,SE,NE,WB
Lycium europaeum L.	Solanaceae	ME	I, III	SF
Lycium shawii Roemer & Schultes	Solanaceae	SA+SU	I, III	SF
Myrtus communis L.	Myrtaceae	ME+IT+ES	I	FT,ST,SE,NE,WB
Olea europaea L.	Oleaceae	ME	I	FT,ST,SE,NE,WB
Phlomis floccosa D. Don	Labiatae	ME+IT	I, II	All habitats except SS,SD
Pinus halepensis Mill.	Pinaceae	ME	I	FT,SE,NE,WB
Pistacia lentiscus L.	Anacardiaceae	ME	I, III	SF,LW,FT,ST,SE,NE,WB
Quercus coccifera L.	Fagaceae	ME	I	LW,FT,ST,SE,NE
Retama raetam (Forssk.) Weeb	Leguminosae	ME+IT+SA	I, III, IV	SD,SF
Rhamnus lycioides subsp. *oleoides* (L.) Jahand. & Maire	Rhamnaceae	ME	I	LW,FT,ST,SE,NE
Rhus tripartita (Bernard. da Ucria) Grande	Anacardiaceae	ME+IT+SA	I	LW,FT,ST,SE,NE,WB
Rosmarinus officinalis L.	Labiatae	ME	I	LW,FT,ST
Tamarix africana Poir.	Tamaricaceae	ME+SA	I, V, VI	SS
Thymelaea hirsuta (L.) Endl.	Thymelaeaceae	ME+SA	I, II, III, V, VI	SS,SF,SW,LW
Viburnum tinus L.	Caprifoliaceae	ME	I	FT,ST
Chamaephytes				
Centaurea ragusina L.	Compositae	ME	I, II, III, IV	SD,SW,LW,FT,ST
Cichorium spinosum L.	Compositae	ME	V, VI	SS
Cistus incanus L.	Cistaceae	ME	I	LW,FT,ST,SE,NE
Conyza bonariensis (L.) Cronquist	Compositae	COSM	I	LW,FT,ST,SE
Ecballium elaterium A. Rich.	Cucurbitaceae	ME	I	FT,ST
Fumana thymifolia (L.) Sp.	Cistaceae	ME	I	FT,ST,SE
Globularia alypum L.	Globulariaceae	ME+SA	I	FT,ST,SE,NE,WB
Helianthemum salsifolium (L.) Mill	Cistaceae	ME+IT+ES	I	LW,FT,ST,SE
Helianthemum stipulatum (Forssk.) Christens.	Cistaceae	ME+SA+SU	I	LW,FT,ST,SE
Helichrysum stoechas (L.) Moench. Meth.	Compositae	ME	I	FT,ST,SE,NE,WB
Limoniastrum monopetalum (L.) Boiss.	Plumbaginaceae	ME	I, III, V. VI	SS,SF
Malva sylvestris L.	Malvaceae	ME+IT+ES	I	LW,FT,ST,NE,WB
Sarcopoterium spinosum (L.) Spach.	Rosaceae	ME	I, II, V	All habitats except SD
Suaeda vermiculata Forssk. ex J.F. Gmel.	Chenopodiaceae	SA+SU	I, II, III, IV, VI	SS,SF,SW
Thymus capitatus (L.) Link	Labiatae	ME	I	FT,ST
Withania somnifera (L.) Dunal	Solanaceae	ME+IT+TR	I	FT,ST,SE,NE

Hemicryptophytes				
Ajuga iva (L.) Schreb.	Labiatae	ME	I	LW,FT,ST
Anchusa undulata L.	Boraginaceae	ME	I	LW,FT,ST,SE,NE,WB
Asteriscus spinosus (L.) Sch. Bip.	Compositae	ME	I	LW,FT,ST,SE,NE,WB
Bellis sylvestris var. *cyrenaica* Beg.	Compositae	Endemic	I	LW,FT,ST,SE,NE,WB
Convolvulus arvensis L.	Convolvulaceae	COSM	I	LW,FT,ST,SE,NE,WB
Cressa cretica L.	Convolvulaceae	ME+IT+TR	II, III, IV, V, VI	SS,SF,SW
Crucianella maritima L.	Rubiaceae	ME	II, III, IV	SF,SW
Marrubium vulgare L.	Labiatae	ME+IT	I, II, IV	SF,SWLW,FT,ST,SE,NE
Medicago marina L.	Leguminosae	ME	I, II, III, IV, V	SS,SF,SW,LW
Piptatherum miliaceum (L.) Coss.	Gramineae	ME+IT+SA	I	LW,FT,ST
Reichardia picroides (L.) Roth.	Compositae	ME	I	LW,FT,ST,SE,WB
Satureja thymbra L.	Labiatae	ME	I	FT,ST,SE
Stachys tournefortii Poiret	Labiatae	ME	I	LW,FT,ST,SE,WB
Thapsia garganica L.	Umbelliferae	ME	I	LW,FT,ST,SE,NE,WB
Tolpis virgata (Desf.) Bertol.	Compositae	ME	I	FT,ST,SE
Cryptophytes				
Ammophila arenaria (L.) Link.	Gramineae	ME	III, IV	SD,SF,SW
Arum cyrenaicum Hurby	Araceae	Endemic	I	LW,FT,ST,SE,NE,WB
Asparagus aphyllus L.	Liliaceae	ME	I	FT,ST
Asphodelus ramosus L.	Liliaceae	ME	I	SF,LW,FT,ST,SE,NE,WB
Barlia robertiana (Loisel.) Greuter	Orchidaceae	ME	I	FT,ST,NE,WB
Bellevalia mauritanica Pomel	Liliaceae	ME+IT+SA	I	LW,FT,ST,SE,NE,WB
Cyclamen rholfsianum Aschers.	Primulaceae	Endemic	I	LW,FT,ST,SE,NE,WB
Cynodon dactylon (L.) Pers.	Gramineae	COSM	II, IV, V, VI	All habitats except SF
Dactylis glomerata L.	Gramineae	ME+IT+ES	I	LW,FT,ST,SE,NE,WB
Eleocharis palustris L. Roem & Schult	Cyperaceae	ME+IT+ES	I, V, VI	SS
Gagea fibrosa (Desf.) Schult. & Schult.	Liliaceae	ME+SA	I	FT,ST,SE
Gagea trinervia (Viv.) Greuter	Liliaceae	ME	I	LW,FT,ST,SE,NE,WB
Gladiolus italicus Mill.	Iridaceae	ME+IT	I	LW,FT,ST
Juncus rigidus Desf.	Juncaceae	ME+IT+ES	V, VI	SS
Oxalis pes-caprae L.	Oxalidaceae	TR	I	LW,FT,ST
Pancratium maritimum L.	Amaryllidaceae	ME	I, II, III, IV, V, VI	SS,SD,SF,SW
Polygonum maritimum L.	Polygonaceae	ME+ES	I, II, III	SW,LW,FT,ST
Ranunculus asiaticus L.	Ranunculaceae	ME+IT	I	LW,FT,ST,SE,WB
Ranunculus paludosus Poir.	Ranunculaceae	ME+ES	I	LW,FT,ST,SE,WB
Romulea cyrenaica Beguinot	Iridaceae	Endemic	I	FT,ST,SE,NE
Scirpus maritimus L.	Cyperaceae	COSM	I, VI	SS,SF
Smilax aspera L.	Liliaceae	ME	I	FT,ST
Urginea maritima (L.) Baker	Liliaceae	ME	I	LW,FT,ST,SE,NE,WB
Therophytes				
Aegilops kotschyi Boiss.	Gramineae	IT+SA	I	FT,ST,SE
Ammi majus L.	Umbelliferae	ME+IT+ES	I	FT,ST
Avena barbata Pott ex Link in Schrad.	Gramineae	ME+IT+ES	I	FT,ST,SE
Beta vulgaris L.	Chenopodiaceae	ME+IT+ES	I	LW,FT,ST,SE,NE,WB
Biscutella didyma L.	Cruciferae	ME+IT	I	LW,FT,ST,SE,NE,WB
Brassica deserti Danin & Hedge	Cruciferae	SA	I	FT,ST,SE

Briza maxima L.	Gramineae	ME	I	FT,ST,SE,WB
Bromus alopecuros Poir.	Gramineae	ME	I	LW,FT,ST,SE,NE,WB
Bromus rubens L.	Gramineae	ME+IT+SA	I	LW,FT,ST,SE,NE,WB
Carduus argentatus L.	Compositae	ME+IT	I	FT,ST,SE,NE,WB
Carthamus lanatus L.	Compositae	ME	I	FT,ST,SE,NE,WB
Chenopodium ambrosioides L.	Chenopodiaceae	COSM	I	SF,LW,FT,ST,WB
Chrozophora tinctoria (L.) Adjuss	Euphorbiaceae	ME+IT	I	FT,ST,NE,WB
Conyza aegyptiaca (L.) Dryand.	Compositae	SA	I	FT,ST,SE,NE,WB
Crepis libyca (Pamp.) Shab.	Compositae	Endemic	I	LW,FT,ST,SE
Cynara cyrenaica Maire & Barratte	Compositae	Endemic	I	FT,ST,SE,NE,WB
Cynosurus coloratus Lehm. ex Nees	Gramineae	ME	I	SF,LW,FT,ST
Euphorbia helioscopia L.	Euphorbiaceae	ME+IT+ES	I, II, IV	SW,LW,FT,ST,SE
Euphorbia peplis L.	Euphorbiaceae	ME+IT+ES	I	LW,FT,ST
Fedia cornucopiae (L.) Gaetner	Valerianaceae	ME	I	LW,FT,ST,WB
Hordeum murinum L.	Gramineae	ME+IT	I	LW,FT,ST,SE,NE,WB
Lathyrus aphaca L.	Leguminosae	ME+IT+ES	I	LW,FT,ST,SE,WB
Lotus ornithopodioides L.	Leguminosae	ME+ES	I	FT,ST,SE
Lotus tetragonolobus L.	Leguminosae	ME	I	LW,FT,ST,SE,NE,WB
Medicago rigidula (L.) All.	Leguminosae	ME+IT	I, II	SW,LW,FT,ST,SE,NE,WB
Onobrychis crista-galli (L.) Lam.	Leguminosae	IT+SA	I	FT,ST,SE,WB
Ononis pendula Desf.	Leguminosae	ME	I, II, III	SW,LW,FT,ST,SE,NE,WB
Onopordum cyrenaicum Maire & Weill.	Compositae	Endemic	I	LW,FT,ST,SE,NE,WB
Plantago arenaria Waldst. & Kit.	Plantaginaceae	ME	I	LW,FT,ST
Plantago lagopus L.	Plantaginaceae	ME+IT	I	LW,FT,ST
Poa annua L.	Gramineae	ME+IT+ES	I, II, IV	All habitats except SS,SF
Poa bulbosa L.	Gramineae	ME+IT+ES	I, II, IV	SW,LW,FT,ST,SE,NE,WB
Polypogon monspeliensis (L.) desf.	Gramineae	COSM	I	LW,FT,ST,SE
Rapistrum rugosum (L.) All.	Cruciferae	ME+IT+ES	I	FT,ST
Rumex simpliciflorus Murb.	Polygonaceae	—	I	LW,FT,ST,SE,NE,WB
Scorpiurus muricatus L.	Leguminosae	ME+IT	I	LW,FT,ST,SE,WB
Solanum nigrum L.	Solanaceae	SA	I	FT,ST,SE,NE,WB
Sonchus oleraceus L.	Compositae	COSM	I	FT,ST
Trifolium tomentosum L.	Leguminosae	ME+IT+ES	I	FT,ST,SE,NE,WB
Trisetaria macrochaeta (Boiss.) Maire	Gramineae	SA	I	LW,FT,ST,SE,WB
Trisetaria linearis Forssk.	Gramineae	ME+SA	I	LW,FT,ST
Urtica urens L.	Urticaceae	ME+IT+ES	I	LW,FT,ST,SE,NE,WB
Vicia laxiflora Brot.	Leguminosae	ME	I	LW,FT,ST,SE