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Egypt. J. Bot., **Vol. 61,** No. 1, pp. 191-201 (2021)

Egyptian Journal of Botany

http://ejbo.journals.ekb.eg/

Impact of Edaphic Factors on Vegetation Composition in Al-Jabal Al-Akhdar, Libya

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AL JABAL Al Akhdar region is a typical mountainous ecosystem, North East Libya characterized by unique environment in the Middle East. The aim of this study was to examine the spatial pattern of vegetation composition and its relationship with environmental variables in Al Jabal Al Akhdar. Vegetation sampling was carried out using 63 stands on studied seven wadis, distributed at Al Jabal Al Akhdar. The results showed that the study area is the home of 91 species, belonging to 85 genera and 44 families. Twelve of the recorded species are endemic and endangered plants. Application of TWINSPAN program and (DCA) resulted in identification of seven vegetational groups (from A to G) at cut level three of the TWINSPAN classification. Using Canonical Correspondence Analysis (CCA) against the soil variables revealed that the most important correlation of environmental variables with species distribution in Al Jabal Al Akhdar are chloride content, pH value, silt content and major cations (Na^+ , Ca^{+2}, Mg^{+2} and K^+).

Keywords: Al Jabal Al Akhdar, Edaphic factors, Floristic composition, Libya, Life forms, Multivariate analysis.

Introduction

Libya comprises three major provinces: Tripolitania, Cyrenaica and Fezzan. Cyrenaica holds Al-Jabal Al-Akhdar which is true to its name, green and also the most vegetated part of the country (Johnson, 1973).

Al-Jabal Al-Akhdar region at the north east of Libya has considerable potential for agricultural activities since the natural resources are promising. Out of the diverse flora of Al-Jabal Al-Akhdar ecosystem, the species that are used economically and therapeutically cover about 500,000 ha, of which about one-third has been converted to growing crops. The actual area of Al-Jabal Al-Akhdar forests which is used productively is about 320,000 ha (Al-Idrissi et al., 1996).

These natural forests degraded as a result of various reasons that leading to a serious disruption in the fragile ecosystem balance especially in Al-Jabal Al-Akhdar (Eldoumi et al., 2002). Because of grazing value of some plants, the locals graze their livestock (sheep and goats) using wild pants like *Pistacia lentiscus* and *Arbutus pavarii*. The endemic species *Arbutus pavarii* has grazing value of 45%. Because of its endemism, this rare plant is really endangering and classified as one of the red list of International Union for Conservation of Nature (IUCN, 2013). In addition, extra trampling of animals might cause damage of ecosystem in the area. Consequently, the vegetation could not tolerate this disturbance or recover again (Elshatshat & Mansour, 2014).

Although this region is one of the important areas of wildlife in Libya, it suffers from extreme biodiversity destruction and degradation. Accordingly, it is important now to begin extensive environmental studies and conservation programs, including not only soil and biodiversity conservation but also beauty conservation

[#]Corresponding author email: shomabotany@yahoo.com
Received 4/2/2019; Accepted 14/10/2020
DOI: 10.21608/ejbo.2020.7969.1288
Edited by Prof. Dr. Fawzy M. Salama, Faculty of Science, Assuit University, Assuit, Egypt.

and attention to local inhabitants who play an important role in the ecological system throughout the whole area (El-Barasi & Manam, 2013).

Under arid conditions in Libya, soils are generally shallow and less developed with inadequate vegetative cover as a result of low annual precipitation accompanied with high temperature. On the other hand, the chance of salinity or alkalinity; due to the lack of enough water for leaching excessive salts from the soil solum, is high. All these factors lead to instability of soil aggregates, and hence the soil erodibility hazards are more likely in comparison with soils in semiarid and humid regions (Cerda, 1998).

This study aimed to assess the current state of the natural plant cover (vegetation) in Al-Jabal Al-Akhdar region of Libya. It is recognized that there are undoubtedly many reasons for degradation in the natural vegetation such as the nature of the soil, the extreme weather, alongside human land-use. Many assumptions are often made in terms of landscape change, desertification and climate change but the role of local inhabitants and their impacts may outweigh other influences.

The study area

Libya, a North African country, lies along the southern coast of the Mediterranean, approximately between latitude 18° and 33° North, and 9° and 25° East. Al-Jabal Al-Akhdar region is located between latitude 32° and 33° North and 20° to 23° East. The stands were selected at seven sites in Al-Jabal Al-Akhdar region at three different levels: twenty one stands in downstream, twenty one in midstream and twenty one in upstream (Table 1, Fig. 1).

Topography and geomorphology

Al-Jabal Al-Akhdar upland represents a plateau formed from tectonic lifting up of a primary plain of marine deposits, with the maximum altitude of the upland being 855.5 m in the Sidi Ahmad Al-Hemery region. It also contains coastal hills, coastal plain, inland plateau and valleys (Azzawam, 1984; Zunni et al., 1996). The plateau has three terraces: the first is up to 11.2m above sea level in the Susah region, the second up to 624m a.s.l. in El-Beida region and the third one up to 855.5m a.s.l. in the Sidi Ahmad Al-Hemery region. The depth of the valleys reaches 300m and the slopes may be strongly developed vertically and can often be very steep (Azzawam, 1984; Eldoumi et al., 2002; Al-Sodany et al., 2003).

Climate

The climatic data were obtained from some stations, chosen to match with the seven studies wadis (Table 2). The distinctive features of the climate of the study area are a concentration of rainfall during cool winter season and a very marked summer drought. The lowest mean minimum air temperature was in Jardas Jerrari and Sidi Ahmad Al-Hemery sites (13°C and 14°C, respectively), while the highest was in Al-Marj-Al-Baida motorway site (22.4°C). The relative humidity values ranged between 50% in Sidi Ahmad Al-Hemery sites and 73% in Susah site. The total rainfall varied between 285.3mm yr^{1-} and 578mm yr^{-1} in Jardas Jerrari and Sidi Ahmad Al-Hemery, respectively**.**

Materials and Methods

The present study represented by seven main wadis: Al-Marj-Al-Baida motorway, El-Beida (Belghra), Jardas Jerrari, Shahat, Sidi Ahmad Al-Hemery, Susah and Wadi El-Kouf. The field studies were conducted through regular visits during two successive years 2015–2016. Sixty three georefrenced stands were *in situ* surveyed with a global positioning system.

TABLE 1. Study sites: Location and habitat types in the seven studied wadis in Al-Jabal Al-Akhdar region.

Site	Elevation (m a.s.l*)	Location		Habitat
1- Al-Marj-Al-Baida motorway	425.5	32°29’ 1.00 “N	20°57’ 10.60”E	North-west slope
2- El-Beida (Belghra)	624	32° 45′ 59 ″ N	21° 44′ 30″ E	North-east slope
3- Jardas Jerrari	691	32° ‘3 1 33 “ N	21° ‘47 15” E	Southern dry slope
4- Shahat	351.4	32°50’ 43.60”N	21°35’ 14.50”E	Northern slope
5- Sidi Ahmad Al-Hemery	855.5	32°37’ 55.10 “N	21°47’ 22.70”E	Mountain top
6- Susah	11.2	32°53’ 45.31”N	21°35’ 50.17”E	Coastal plain
7- Wadi El-Kouf	369.7	32°40’ 57.00 “N	21°33’ 55.00”E	Wadi

*a.s.l.= Above sea level. m= Meters.

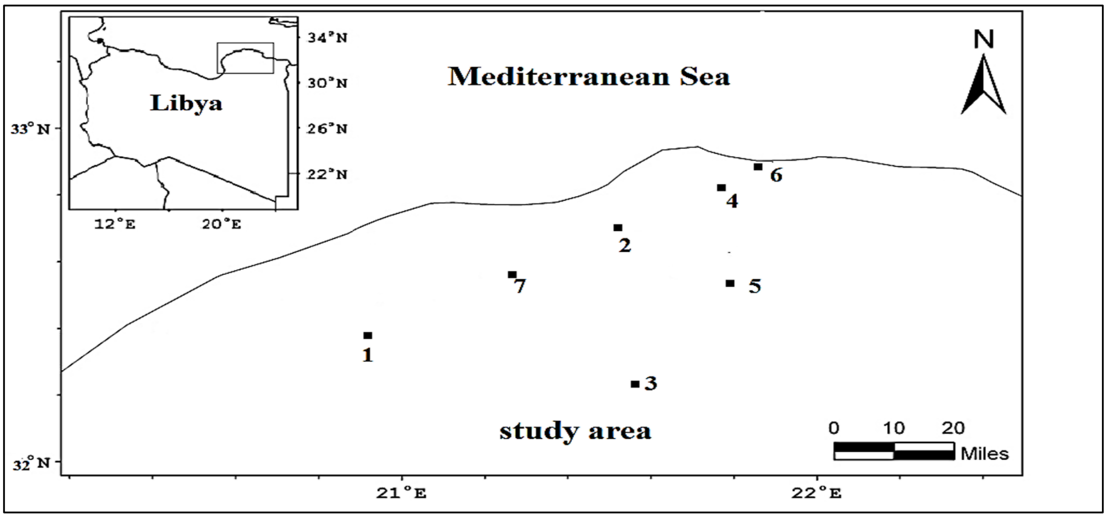

Fig. 1. The study area and site location of the seven studied wadis in Al-Jabal Al-Akhdar region [The site numbers are indicated on the map].

TABLE 2. Annual averages of maximum, minimum, mean temperature, total rainfall, relative humidity and wind velocity of Shahat, Al-Marj and Libyan Meteorological Department, Tripoli within Al-Jabal Al-Akhdar area during (2015-2016).

Site	Temperature °C			Total rainfall (mm/yr)	Relative humidity %	Wind velocity (km/hr)
	Min.	Max.	Mean.			
1- Al-Marj-Al-Baida motorway	10.7	34.1	22.4	379	65	68
2- El-Beida (Belghra)	12	28.8	20.4	567	68	72
3- Jardas Jerrari	7	19	13	285.3	52	70
4- Shahat	8.1	28.1	18.1	527	53	55
5- Sidi Ahmad Al-Hemery	8	20	14	578	50	73
6- Susah	10.7	23.5	17.1	341.4	73	42
7- Wadi El-Kouf	10.2	25.1	17.65	413.8	55	70

Soil was analyzed according to Richards (1954) and Ryan et al. (1996). Vegetation was sampled using a transect/ quadrant method. The stand size was 10× 10m (approximate the minimal area of the plant communities). In each stand, the following data were recorded: 1- A list of species, 2- First and second dominant species and 3- A visual estimate of the percentage total cover and the cover of each species according to Braun-Blanquet dominance abundance scale. Voucher specimens of all plant species were collected, identified and deposited in each of Ain Shams University, Faculty of Science, Botany Department, Ecological Research Unit and Omar Al-Mokhtar University, Faculty of Science, Libya. Species identification followed Ali & Jafri (1976), Tackholm (1974), Jafri & El-Gadi (1977, 1993), and the Latin name were following Boulos (1972, 1977, 1979a, b, 1995, 1997, 2005 and 2009). Life forms of the species were identified following Raunkiaer scheme (1934). The global geographical distribution (chorological affinity) of the recorded species in the study area was determined from Zohary (1966, 1972 and 1973), Feinbrun-Dothann (1978, 1986) and Boulos (1999, 2009). This will helps in assessing the rarity forms of these species. The global distribution was coded as follows: Saharo-Arabian (SA), Sudanian (SU), Mediterranean (ME), Irano-Turanian (IT) and Euro-Siberian (ES).

Detrended Correspondence Analysis (DCA) was used to separate vegetation groups and Canonical Correspondence Analysis (CCA) was used to reveal the influence of the study environmental variables (17 sites x 12 variable matrix) on vegetation distribution (CANOCO version 4.5 software; Ter Braak & Smilauer (2002). Regression between the altitude and the number of species was analyzed using the best fit curve. Polynomial equation was used for north facing and south facing slopes (SPSS software version 12).

Results

Floristic analysis

Floristic list

The studied seven wadis of Al-Jabal Al-Akhdar are habitats for 91 species, belonging to 85 genera and 44 families (Suppl. Table 1). Regarding the number of species within each family, the abundant families were Asteraceae which has the highest contribution to the total number of the recorded species (comprising sixteen species with ratio 18 %), followed by Lamiaceae (comprising twelve species with ratio 14 %). The data showed that 20 endemic species belonging to 14 families and 20 genera were recorded in the study area: Cupressaceae (*Cupressus sempervirens* L. var. *horizontalis* (Mill.) Gord); Iridaceae (*Crocus boulosii* Greuter. and *Romulea cyrenaica* Beguinot.); Araceae (*Arum cyreanicum* Hruby.); Capparaceae (*Capparis spinosa* L. var. *krugeriana* (Pamp.) Jafri.); Geraniaceae (*Erodium keithii* Guitt. & Le.); Euphorbiaceae (*Euphorbia pseudo-apios* Maire & Weiller.); Ephederaceae (*Ephedra altissima* Desf.var.*altissima* Pamp.); Ericaceae (*Arbutus pavarii* Pamp.); Primulaceae (*Cyclamen rohlfsianum* Aschers.); Convolvulaceae (*Convolvulus maireanus* Pamp.); Lamiaceae (*Ballota andreuzziana* Pamp. and *Teucrium zanonii* Pamp.); Plantaginaceae (*Plantago ceranaica* Durand & Barratte.); Valerianaceae (*Valerianella petrovichii* Aschers.) and Asteraceae (*Anthemis cyrenaica* Coss.var. cyrenaica. *Bellis sylvestris* Cyr. var. cyrenaica Beg., *Centaurea cyrenaica* Beg. & Vacc., *Cynara cyrenaica* Maire & Weill and *Onopordum cyrenaicum* Maire & Weill.). The life form spectra of the recorded species showed the predominance of Phanerophytes (28 species= 31 % of the total species), followed by Chamaephytes (24 species= 26%), then Therophytes (19 species= 21%), Hemicryptophyte (12 species= 13%) and finally, Geophytes (8 species= 9%) as shown in Fig. 2, the chorological analysis of species in the study area (Fig. 3) revealed that Saharo-Arabian elements representing 4% of the total species. The Mediterranean species were dominating as mono-regional elements with a species number of 44 representing 48% of the total species. Bi-regional elements were represented by 11 species; the Mediterranean and Irano-Turanian elements together are represented by 8 species (9% of the total species). Meanwhile, pluri-regional elements are presented by 7 species. The floristic composition of the study area also includes 5 cosmopolitan species and endemic species represented by 20 species (about 22% of the total species).

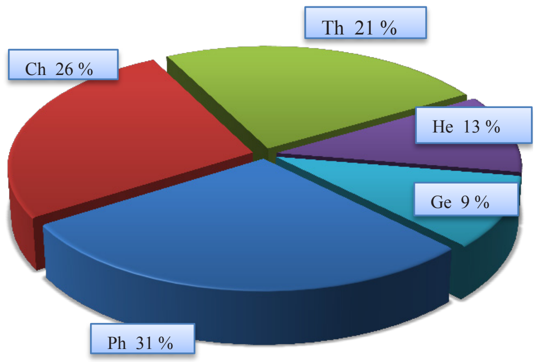

Fig. 2. Proportional percentage of life forms of the studied species in Al-Jabal Al- Akhdar region [Abbreviation: Ph= Phanerophytes, Ch= Chamaephytes, Th= Therophytes, He= Hemicryptophytes, and Ge= Genophytes].

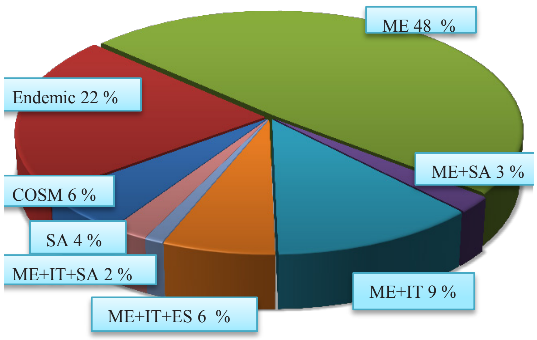

Fig. 3. Proportional percentage of chorotypes of recorded species in seven wadis at Al-Jabal Al-Akhdar region [Abbreviation: Cosmopolitan (COSM) Irano-Turanian (IT), Mediterranean (ME), Saharo - Arabian (SA), Euro-Sibarian (ES) and Sudanian (SU)].

Ecological characteristics

Multivariate analysis

TWINSPAN classification: The data of 63 stands of vegetation growing naturally in Al-

Jabal Al- Akhdar were analyzed using Two Way Indicator Species Analysis (TWINSPAN) Hill (1979a) to classify the stands at the 3rd level into seven vegetation groups labeled A – G as in Fig. 4. These seven groups were separated along the DCA ordination plane of axis 1 and 2 as in Fig. 5; Group A: Comprises three stands dominated by *Seriphidium herba-alba* with the highest mean importance value, Group B: Comprises four stands dominated also by *Seriphidium herba-alba,* Group C: Comprises two stands co-dominated by *Seriphidium herba-alba* and *Thymus capitatus*, Group D: Comprises 11 stands dominated by *Juniperus phoenicea,* Group E: Comprises nine stands dominated by *Arbutus pavarii,* Group F: Comprises 28 stands dominated by *Juniperus phoenicea* and Group G: comprises six stands dominated by *Juniperus phoenicea* (Suppl. Table 2). Soil characteristics of each of the seven sample groups identified by TWINSPAN program were summarized in Suppl. Table 3. Mean value of K^+ showed significant variation among groups at P= 0.05, while Na^+, Cl^- and SO_4^- content in soil showed significant variations between groups A-G.

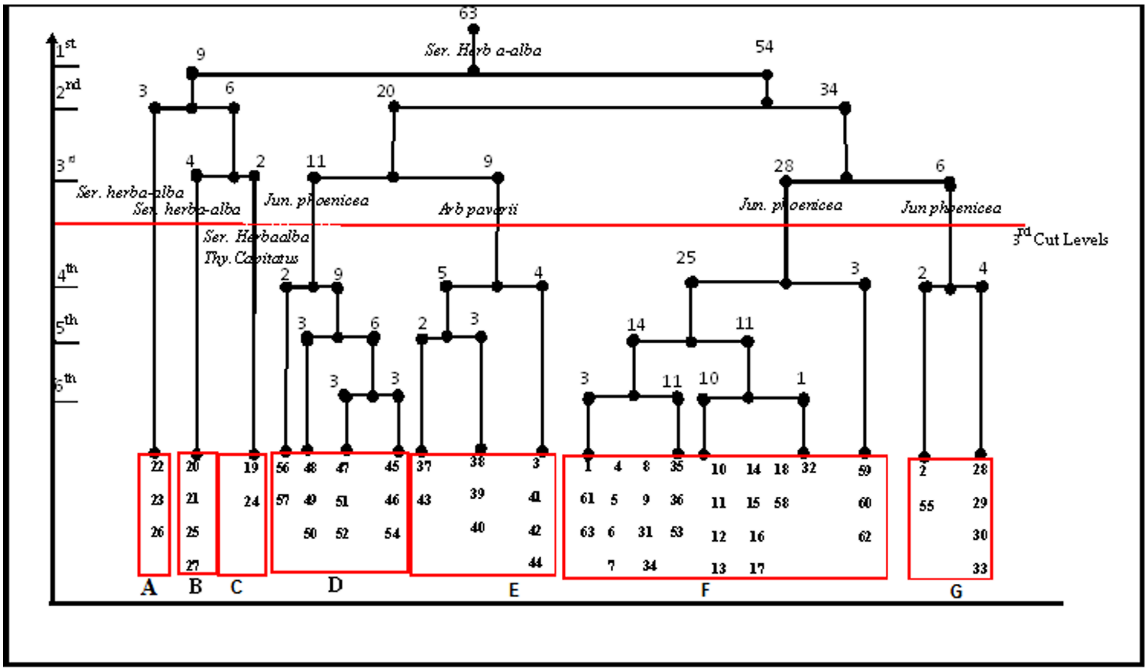

Fig. 4. Two way indicator species analysis (TWINSPAN) dendrogram of the 63 sampled stands based on the importance values of the 91 species [The indicator species are abbreviated by the first three letters of genus and species respectively as follow: *Ser= Seriphidium, Thy= Thymus, Jun= Juniperus and Arb = Arbutus*].

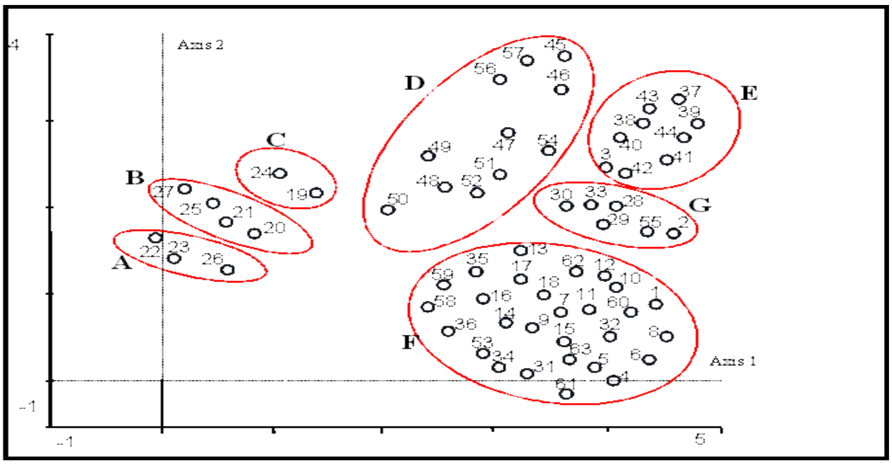

Fig. 5. Detrended Correspondence Analysis (DCA) ordination diagram of the 63 studies stands with their vegetation group.

Canonical correspondence analysis (CCA) ordination: The most important correlation of edaphic variables correlated with species distribution at Al-Jabal Al-Akhdar wadis were chloride content, pH value, clay and major cations (Ca^{++}, Na^{+} and K^{+}). By dropping a perpendicular to the arrow from each "species-point" an indication is provided of the relative position of species along the edaphic variables which represented by the arrows. The arrows representing 13 edaphic variables were in conjunction with twelve selected endangered species that were among indicator and preferential species of TWINSPAN-groups (Fig. 6). *Thymus capitatus, Ziziphus lotus* and *Ballota andreuzziana* in group **A** and endemic species *Arum cyrenaicum, Bellis sylvestris* and *Centaurea cyrenaica* were separated at the upper right side of CCA-biplot diagram and showed limited correlations with CI^{-}, Na^{+}, K^{+} and SO_4^{-2}. *Pinus halepensis, Cupressus sempervirens, Thapsia garganica* and *Nerium oleander* in group D, *Arbutus pavarii*, *Cistus parviflorus* in group E, *Quercus coccifera*, *Ceratonia siliqua*, and *Lonicera etrusa* in group F and endemic species *Cyclamen rohlfsianum, Cynara cyrenaica, Ephedera altissima, Plantago ceranaica* and *Romulea cyrenaica* were separated at the upper left side of CCA-biplot digram and showed limited correlations with clay and HCO_3^{-}. On the other hand, *Laurus nobilis* in group G, *Capparis spinosa* in group F and the endemic species *Anthemis cyrenaica, Erodium keithii, Convolvulus maireanus, Crocus boulosii, Teucrium zononii* and *Valerianella petrovichii* were separated at the lower right side of CCA-biplot digram and showed limited correlations with silt, sand, E.C and pH value. *Juniperus phoenicea*, *Pistacia lentiscus*, *Olea europaea, Phlomis floccosa*, *Drimia maritima* and *Asphodelus microcarpus* in group F and the endemic species *Euphorbia pseudo-apios* and *Onopordum cyrenaicum* were separated at the lower left side of CCA-biplot digram and showed limited correlations with Ca^{+2} and Mg^{+2}.

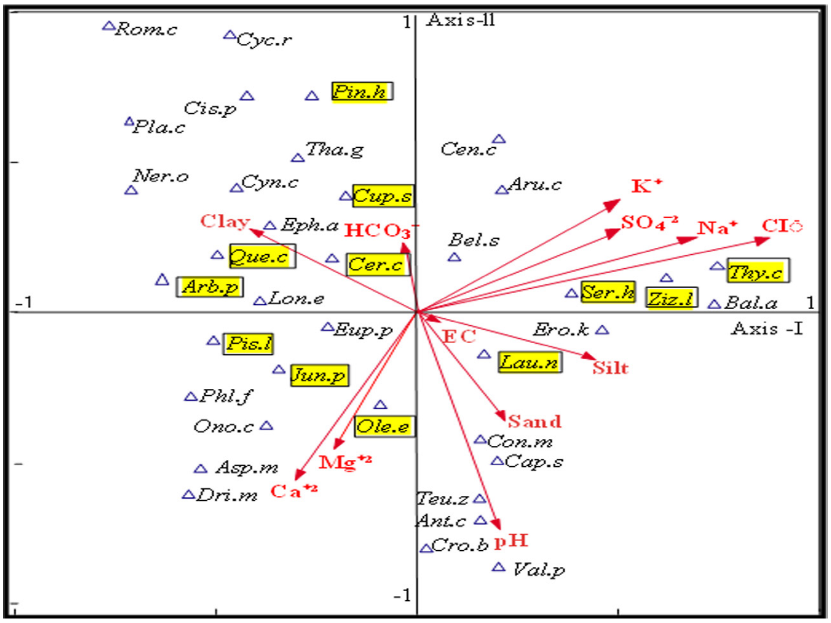

Fig. 6. Canonical Correspondence Analysis (CCA) ordination diagram of the studied plant species with the twelve soil variables represented by arrows in the study area [Abbreviation: (□) = Target species (endangered); (Δ) = Species and (↑) = Environmental variables; Species names are abbreviated to the first three letters of genus name and first letter of species: ***Ant.c= Anthemis cyrenaica, Arb.p= Arbutus pavarii, Asp.m= Asphodelus microcarpus, Ball.a= Ballota andreuzziana, Bel.s= Bellis sylvestris, Cap.s= Capparis spinosa, Cen.c= Centaurea Cyrenaica, Cer.s= Ceratonia siliqua, Cis.p= Cistus parviflorus, Con.m= Convolvulus maireanus, Cro.b= Crocus boulosii, Cup.s= Cupressus sempervirens, Cyc.r= Cyclamen rohlfsianum, Cyn.c= Cynara cyrenaica, Dri.m= Drimia maritime, Eph.a= Ephedera altissima, Ero.k= Erodium keithii, Eup.p= Euphorbia pseudo-apios, Jun.p= Juniperus phoenicea, Lar.n= Laurus nobilis, Lon.e= Lonicera etrusa, Ner.o= Nerium oleander, Ole.e= Olea europaea, Ono.c= Onopordum cyrenaicum, Phl.f= Phlomis floccosa, Pin.h= Pinus halepensis, Pis.l= Pistachia lentiscus, Pla.c= Plantago ceranaica, Que.c= Quercus coccifera, Rom.c= Romulea cyrenaica, Ser.h= Seriphidium herba-alba, Teu.z= Teucrium zononii, Thy.c= Thymus capitatus, Val.p= Valerianella petrovichii and Ziz.l= Ziziphus lotus*****].**

Discussion

More than 90 % of Libya is an arid desert ecosystem. One of the two elevated regions, approximately 1200 km apart in inland of the Mediterranean coastal plain is Al-Jabal Al-Akdr mountain in the east (Al-Idrissi et al., 1996).

The relation between the vegetation and the environmental factors including: climate, topography, edaphic factors, human activities and other biotic factors has been studied by many geographers and ecologists with especial emphasis on Al-Jabal Al-Akhdar. According to Nwer (2005), the climate of Libya is influenced by the Mediterranean Sea to the north and the Sahara desert to the south. The characteristics of the soil surface, altitudinal gradients and landform types provide microhabitats dominated by characteristic vegetation. The field observations were consistent with the results of the investigation of soil properties. High sand, silt contents, relatively low content of clay and low organic matter contributed to the deterioration of soil structure stability; hence exposed soil aggregates could not resist disruptive forces of rain drop impact leading to aggregate breakdown and particle detachment. The study area sometimes receives several events of heavy rains during winter. Accordingly, it exposed and unstable soils develop crusts.

According to Qaiser & El-Gadi (1984) and Al-Idrissi et al. (1996), the total number of species recorded in Libya was 1750 vascular plant species distributed in 744 genera and 118 plant families and 50% of this total is confined to Al-Jabal AlAkhdar region. Only 91 species were recorded in the current study. Asteraceae followed by Lamiaceae had the highest contribution to the flora of the present study. The fact that elevations above the sea level, aspect and soil parameters do not explain the majority of variance in the data leaves the diverse local conditions and habitat types as the main determinant of vegetation variations. Another explanation in this study may be the disturbance of vegetation due to overgrazing or over collecting of firewood and other human activities that always influence the pattern and distribution of vegetation negatively or even destroy old vegetation types and creating new ones. In this context, Fekete et al. (2000) and Hegazy et al. (2004) obtained the same results. Accordingly, more varied vegetation cover was found in wadis and in probably remote sites. Al-Idrissi et al. (1996) recorded extreme degradation of tree species through mismanagement and overexploitation for making fire wood and clearing natural vegetation for reclamation of cropping lands.

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). Out of the recorded 59 endemic species in this region (Qaiser & El-Gadi, 1984; Boulos, 1997), El-Darier & El-Mogaspi (2009) recorded only 44 endemic plant species. The difference between the two studies (15 species) sheds light on the possibilities of some ecological problems related to different land uses and human activities in the region. *Euphorbia pseudo-apios* was exclusively recorded in the present study as an endemic species at Al-Jabal Al-Akhdar.

In this study, 28 plant species were phanerophytes, formed (31%) of the total number of species identified. All the phanerophytes found in Al-Jabal Al- Akhdar site were shrubs or semi facultative shrubs, more precisely, nanophanerophytes which are 25cm to 6m tall. These species have the capability to survive in extremely dry soils with a wide range of salinity gradients (Zahran & Willis, 1992; Shaltout et al., 2003; El-Bana & Al-Mathnani, 2009). On the other hand, the vegetation of the wetter Wadi at Al-Jabal Al-Akhdar was markedly Mediterranean in composition and characterized by phanerophytes forming fragmented patches of *Cupressus sempervirens*, *Juniperus phoenicea*, *Olea europaea*, *Quercus coccifera*, *Ceratonia siliqua* and *Pinus halepensis*. El-Bana et al. (2010) also stated that and the variation in elevation along the valley leads to the dominance of species of chamaephyte and phanerophyte which characterize the Mediterranean region. This proves that life-forms have close relationships with environmental factors (Muller-Dombois & Ellenberg, 1974).

The floristic categories of the recorded species showed that mono-regional taxa had the highest contribution, followed by endemic, bi-regional, pluri-regional and cosmopolitan. In addition, 44 species were Mediterranean and 4 species were Saharo-Arabian taxa. According to Zohary (1973), the Mediterranean territory of the Middle East occupies a comparatively narrow belt along the Mediterranean Sea and there is a gap in this belt between southern Palestine and Libya; in which the Saharo-Arabian belt closely approaches the Mediterranean coast. The presence of the phytogeographical elements other than the Mediterranean in the study area may reflect the intense climatic changes and/or the degradation of the Mediterranean ecosystem, which facilitated the invasion of some elements from the adjacent regions (Madi et al., 2002).

These results showed that Al-Jabal Al-Akhdar region has diverse ecosystems and very interesting aspects for the vegetation studies. The application of TWINSPAN classification technique to the vegetation data produced seven groups and the application of DECORANA to the same data showed resemblances among some of these groups. Groups D, F and G were dominated by *Juniperus phoenicea*; this coincided with the study of Shaltout et al. (2014).

Three TWINSPAN groups (A, B and C) were separated in wadis down, mid- and up-stream (three different elevation levels). Both are nearly similar in terms of vegetation, however, the separation into three groups may be due to variation in soil characteristics. The indicator species of these three groups was *Seriphidium herba-alba*. Group A was characterized by soils of high sand and E.C; preferential species associated with this group were *Thymus capitatus*, *Ziziphus lotus* and *Ballota andreuzziana*. In contrast, group B was characterized by high silt, SO_4^{-2}, Cl^-, Na^+ and K^+ content in soil that support the growth of preferential species associated with this group (e.g. *Thymus capitatus*, *Ziziphus lotus* and *Juniperus phoenicea*). Group C was characterized by the lowest values of chemical and physical characteristics of soil; preferential species associated with this group were *Thymus capitatus*, *Ziziphus lotus*, *Phlomis floccosa*, *Juniperus phoenicea* and *Ballota andreuzziana.*

The altitudinal patterns of plant species richness are mainly affected by the patterns of water and temperature conditions, altered along an altitude gradient which creates a variety of habitats (Zhao et al., 2005; Hegazy et al., 2011; Abdel-Rahman, 2019). The temperature decreases by an average of about 0.64°C for each 100m increase in elevation (El-Tantawi, 2005). Moreover, the aerological influence of the mountain on sea water vapor loaded winds, which pass over, increases the possibility and amount of precipitation at higher altitudes (El-Tantawi, 2005; Grytnes et al., 2006). However, in the present study, the species richness did not differ substantially on the slope than on the mountain top, i. e. elevation did not affect the species richness of the northern slope vegetation. (group F) comprised a higher percentage of trees and shrubs but low ratio of herbs at the highest elevation (group A and B). Grytnes et al. (2006) stated that the vegetation composition responds more strongly to altitude than to species richness.

In tropical and cold temperate mountains, the species richness decreases with elevation, as the decrease in temperature with altitude limits the distribution of plant species (Zhao et al., 2005). In contrast, in Al-Jabal Al-Akhdar (855.5m a.s.l) the highest species diversity lies at middle altitudes in group F. This may be explained by the positive effect of increased precipitation with elevation in subtropical regions. Meanwhile, the adverse effects of decreasing temperature were not obvious on the species richness at this middle elevation gradient (Grytnes et al., 2006).

The soil in most areas of Al-Jabal Al-Akhdar consists mostly of clay (38.02%), silt (37.9%) and sand (24.4%); with pH ranged from 7- 8. The most common texture is silty loam, which is found mainly on wadi bottoms and slopes. Soils with a high clay content silty clay loam and clay loam are mainly found on slopes. The north western part of the study area, with more precipitation has darker soils than the dry southern and eastern parts. As a rule, the chemical reaction of the soils is strongly alkaline. The pH-value is usually higher in the wadis than in other places. Serious salinity problems are rare.

Significant differences in soil variables were detected among the studied seven wadis in several soil attributes such as pH, E.C, sand, silt, clay, CO_3^{-2}, HCO_3^-, SO_4^{-2}, Cl^-, Ca^{+2}, Mg^{+2}, Na^+ and K^+. Significant differences in soil variables were detected among the seven wadis in many soil attributes, e.g: pH, clay, Mg^{+2}, K^+, sand and gravel, respectively, which agree with the studies of Hegazy et al. (2011), Mosallam (2007) and Mosallam et al. (2017).

Conclusion

Al-Jabal Al-Akhdar area has a variety of landform types: terraces, gorges, slopes, ridges, wadis and plains. Landform type and other elements such as elevation, soil physical characteristics, slope, aspect and topography all play an important role in determining the distribution of plant communities.

The findings of the present study revealed that edaphic factors (chloride content, pH value, clay and major cations (Ca^{++}, Na^{+} and K^{+}) have particular importance in distribution of different vegetation patterns and the affinity of certain species towards a particular soil variable(s).

The present study provided an assessment of the vegetation composition at Al-Jabal Al-Akhdar that could help in management and conservation of these natural resources. The recorded 91 plant species can play a vital role in the economic and medicinal purposes of the region.

The value of vegetation monitoring would be greater if additional data were collected to measure persistence of endemic or endangered species. The present study concluded that long-term studies on the vegetation of Al-Jabal Al-Akhdar and continuation of vegetation monitoring are important, and it will provide a baseline data for mapping all endemic and endangered species. Moreover, strict legislation must be applied to conserve the unique features of Al-Jabal Al-Akhdar ecosystem.

Conflict of interest: The authors reported no potential conflict of interest.

Authors contribution: All authors are equally contributed in conceptualization, methodology, formal analysis, investigation, data curation, writing—original draft preparation, and writing—review and editing.

Ethical approval: Not applicable.

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تأثير العوامل التربية على تكوين الغطاء النباتي في الجبل الأخضر، ليبيا

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منطقة الجبل الأخضر هي نظام بيئي جبلي نموذجي،كما ان منطقة شمال شرق ليبيا تتميز ببيئة فريدة من نوعها علي مستوي الشرق الأوسط. هدفت هذه الدراسة إلى فحص النمط المكاني لتكوين الغطاء النباتي وعلاقته بالمتغيرات البيئية في الجبل الأخضر. تم فحص وتجميع العينات النباتية لدراسة الكساء الخضري فى 36 موقع موزعة على سبعة أودية مدروسة في الجبل الأخضر.وقد أظهرت النتائج أن منطقة الدراسة هي موطن لـ 19 نوعًا نباتيا ينتمون إلى 58 جنسًا و 44 فصيلة. ووجد ان اثنا عشر من الأنواع المسجلة هى نباتات مستوطنة ومهددة بالانقراض.

أدى استخدام برنامج تطبيق طرائق التحليل العددى متعددة الطرق الحديثة TWINSPAN إلى تحديد سبع مجموعات نباتية من A إلى G عند مستوى القطع الثالث. أظهر استخدام تقنية الرسم البياني التسيقي (CCA) لفحص العلاقة بين الغطاء النباتي والمتغيرات البيئية المدروسة خاصة العوامل التربية أن أهم ارتباط للمتغيرات البيئية مع توزيع الأنواع في الجبل الأخضر هو محتوى الكلوريد وقيمة الأس الهيدروجيني ومحتوى الطمي والكاتيونات الرئيسية مثل الصوديوم، الكالسيوم، الماغنسيوم والبوتاسيوم (Na^+ , Ca^{+2}, Mg^{+2} and K^+).