

## Size Distribution of Some Endangered Plant Species, Al-Jabal Al-Akhdar, Libya.

H.A.M., Mosallam<sup>1\*</sup>, A.M<sup>1</sup>., Hashim Sergiwa S.S<sup>2</sup> and M.A<sup>3</sup>

### Abdalrhim

<sup>1</sup>Department of Botany, Faculty of Science, Ain Shams University, Cairo, Egypt. <sup>2</sup>Department of Agriculture, Faculty of Science, Omer Al-Mukhtar University, El-Beida, and <sup>3</sup>Department of Botany, Faculty of Science, Benghazi University, Benghazi, Libya.

**A**L-JABAL Al-Akhdar Mountain is the richest vegetation and highest species diversity in Libya. The aim of the present study was to evaluate the population structure of twelve endangered species in Al-Jabal Al-Akhdar. These species are: *Arbutus pavarii* Pamp., *Cupressus sempervirens* L., *Ceratonia siliqua* L., *Juniperus phoenicea* L., *Laurus nobilis* L., *Olea europaea* L., *Pinus halepensis* Miller., *Pistacia lentiscus* L., *Quercus coccifera* L., *Seriphidium herba-alba* (Asso) Soják., *Thymus capitatus* (L.) Hoffmanns. & Link and *Ziziphous lotus* (L.) Lam. These species collected from downstream, midstream and upstream of Al-Marj-Al-Baida motorway, El-Beida, Jardas Jerrari, Shahat, Sidi Ahmad Al-Hemery, Susah and Wadi El-Kouf in Al-Jabal Al-Akhdar. The size index of each individual was calculated and then used to classify population into seven size classes. The height, mean diameter, height to diameter ratio, size index and volume per individual in each size class were determined. Generally, the height to diameter ratio was more than unity for *Arbutus pavarii*, *Cupressus sempervirens*, *Ceratonia siliqua*, *Juniperus phoenicea*, *Laurus nobilis*, *Olea europaea*, *Pinus halepensis* and *Quercus coccifera*, this means that the diameter of these species tend to expand vertically rather than horizontally, while the height to diameter ratio was less than unity for *Pistacia lentiscus*, *Seriphidium herba-alba*, *Thymus capitatus* and *Ziziphous lotus*. Five forms of size distributions along the different elevations were recognized: more or less inverse J-shaped distribution, positive skewed distribution, bell shaped distribution, more or less J-shaped distribution and more or less stationary size distribution biased to large size.

**Keywords:** Size structure, Endangered, Elevation gradient, Al-Jabal Al-Akhdar, Libya.

The human activities have dramatically affected the biodiversity of Al-Jabal Al-Akhdar, Libya. In recent decades, this effect has been intensified due to the increase in the population and the import of modern mechanization which has caused an increase of the destructive effects of human activities. Although this

region is one of the important areas for wildlife in Libya, it suffers from extreme biodiversity destruction and degradation. The breakdown of authority and spread of weapons associated with the conflict may prove a more significant and is an immediate threat which was underlined by a recent (May 2011) quote from a Libyan scientist. So, the situation has become very dangerous regarding the forest as many people have taken the advantage of the chaos and removed hundreds of hectares to change the land use to agricultural lands in the area under study. Furthermore, the climatic changes with decreasing the amounts of precipitations during last four decades, led to complete damage of some plants in the study area, and changing the vegetation composition.

It is very important now to begin extensive environmental studies and conservation programs, including not only soil and biodiversity conservation but also beauty conservation and attention to local inhabitants because they play an important role in the ecosystem throughout the whole area (EL-Barasi and Manam, 2013).

At Al-Jabal Al-Akhdar, the decline of species such as *A. pavarii*, a vulnerable endemic shrub (Kabieli *et al.*, 2016a) and common keystone species *J. phoenicea*, an evergreen tree that is, in many areas, showing low juvenile recruitment and dieback of vegetative branches (Kabieli *et al.*, 2016b). *Arbutus pavarii*, an endemic species, classified as one of the red list of IUCN in the study area due to excessive human disturbance (IUCN, 2013).

The size structure of plant populations has been frequently used to assess regeneration status and to predict future population changes by assuming that populations with many small stems in relation to larger ones are self-replacing or increasing, whereas populations with relatively few small stems are believed to be declining in abundance (Buyavejchewin *et al.*, 2003 and Baker *et al.*, 2005).

The distribution of plant species along elevation gradients is governed by a series of interacting biological, environmental and historical factors (Colwell and Lees, 2000). Elevation represents a complex gradient along which many environmental variables change simultaneously (Austin *et al.*, 1996). Thus, the effect of each variable could be difficult to separate and these interacting factors would be difficult to disentangle. Furthermore, the observable associations between species distribution and elevation bands may help to understand the possible effects of environmental changes, *i.e.*, by providing baseline information from which to measure or gauge the effect of climate change and anthropogenic changes on vegetation.

The target species in this study were twelve endangered species declared according to Al-Idrissi *et al.* (1996); Eldoumi *et al.*, (2002) and EL-Barasi and Manam. (2013). These species are: *Arbutus pavarii* Pamp., *Cupressus sempervirens* L., *Ceratonia siliqua* L., *Juniperus phoenicea* L., *Laurus nobilis* L., *Olea europaea* L., *Pinus halepensis* Miller., *Pistacia lentiscus* L., *Quercus*

*coccifera* L., *Seriphidium herba-alba* (Asso) Soják., *Thymus capitatus* (L.) Hoffmanns. & Link and *Ziziphous lotus* (L.) Lam. They were distributed along the different elevation levels (downstream = level I, midstream = level II and upstream = level III) at selected seven study wadis in Al-Jabal Al-Akhdar.

The present study aims to investigate the population structure of the twelve endangered plant species, in terms of size distribution, height, diameter and density in their favorable habitats, and to assess the effect of different habitats, which reflect the elevation gradient, on the size distribution and density of occurrences of the study species.

### Materials and Methods

*Study area:* The Al-Jabal Al-Akhdar mountainous region is in NE Libya, reaching 878m above sea level (a.s.l.) and characterized by a Mediterranean climate with cool rainy winter and hot dry summer (El-Tantawi, 2005). The location of the seven study wadis are shown in Fig. 1 and described in Table 1.

Study wadis	Altitude m (a.s.l)	Latitude	Longitude	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° '31 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

**TABLE 1.** (a.s.l) The study wadis in Al-Jabal Al-Akhdar landscape. Altitude = meter above sea level

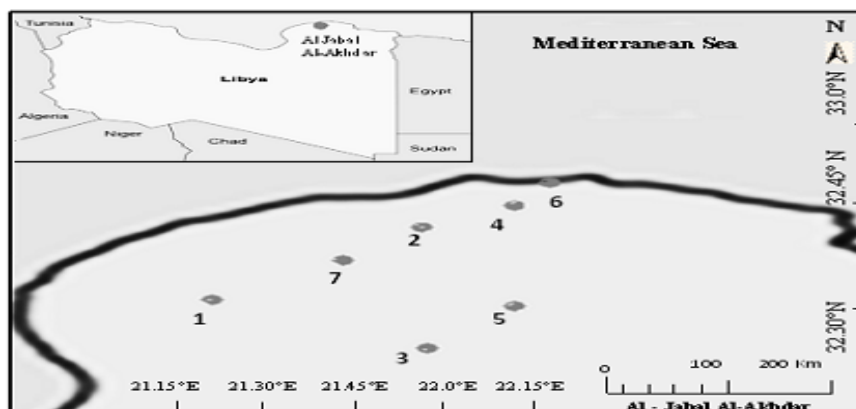


Fig. 1. Location map indicating the study area.

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 areaduring (2015-2016).

Site	Temperature °C			Total rainfall mm yr <sup>-1</sup>	Relative humidity %	Wind velocity km/hr
	Max.	Min.	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
Shahat	8.1	28.1	18.1	527	53	55
Sidi Ahmad Al-Hemery	8	20	14	578	50	73
Susah	10.7	23.5	17.1	341.4	73	42
Wadi El-Kouf	10.2	25.1	17.65	413.8	55	70

#### 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 study site. The total rainfall varied values between 285.3 mm yr<sup>-1</sup> and 578 mm yr<sup>-1</sup> in Jardas Jerrari and Sidi Ahmad Al-Hemery, respectively.

*Data collection:*

Sixty three (10m×10m) were selected at the seven wadis in Al-Jabal Al-Akhdar at the three different levels (21 in downstream, midstream and upstream). In each quadrates, the species list, the number of individuals and visual cover (%) of each species were recorded. Voucher specimens of the recorded species were deposited in the herbaria of Faculty of Science, Ain Shams University, (Egypt) and Faculty of Science, Omar Al-Mokhtar University, (Libya). Identification and nomenclature were according to Ali and Jafri (1976); Jafri and El-Gadi (1977–1993) and Boulos (1977, 1995, 1999, 2005 and 2009). Life forms of the recorded species were identified following the system of Raunkier (1934). In each site, the number of the target twelve individual was counted, and the height (H) and mean crown diameter (D based on 2-4 diameter measurements / ind.). The size index of each individual was calculated as the mean of its height and diameter [(H+D)/2]. The size estimates were then used to classify population into seven size classes. The size classes (m ind<sup>-1</sup>) are (1=0<1, 2=1.1-2, 3=2.1-3, 4=3.1-4, 5=4.1-5, 6=5.1-6 and 7= 6.1-7 m ind<sup>-1</sup>), except for *S.herba-alba* and *T.capitatus* were by centimeter (cm ind<sup>-1</sup>).

*Soil analysis:*

Soil samples were collected from the surface of each location, or up to the rocks or hard pans in case of shallow. In each location, one composite sample was collected from soil profiles (0 – 25cm), air dried then physical and chemical parameters of such soil samples were analyzed. Soil texture was determined according to Gupta (2000). Soil reaction (pH) was determined in the soil paste using a Beckman bench type pH-meter (Watson and Brown, 1998). Electrical conductivity (E.C) of the saturated soil extracts was determined as described by Allen *et al*, (1976) and expressed as dSm<sup>-1</sup>. The anions (Cl<sup>-</sup>, SO<sub>4</sub><sup>2-</sup>, CO<sub>3</sub><sup>-</sup>, HCO<sub>3</sub><sup>-</sup>) and cations (Na<sup>+</sup>, K<sup>+</sup>, Ca<sup>2+</sup> and Mg<sup>2+</sup>) of the soil extracts were analyzed following the method described by Blancher *et al*, (1965) and their values expressed as (m.eq. L<sup>-1</sup>).

**Results**

Twelve endangered perennial species belonging to eleven families were distributed along different elevation levels in seven studies wadis at north and south of Al-Jabal Al-Akhdar. *Cupressaceae* was represented by two species: *C.sempervirens* and *J.phoenicea* and the other families were represented only by one species (Table 3). Ten species were phanerophytes and two species were chamaephytes (*S.herba-alba* and *T. capitatus*). The phytogeographical elements of the studied species indicated that ten of the studies of species are Mediterranean elements represented by *C.siliqua*, *J.phoenicea*, *L.nobilis*, *O.europaea*, *P.halepensis*, *P.lentiscus*, *Q.coccifera*, *S.herba-alba*, *T.capitatus* and *Z.lotus*, while *A.pavarii* and *C.sempervirens* are endemic to Al-Jabal Al-Akhdar.

The mean height to diameter ratio, simple linear correlation coefficient (r) and size index of the twelve studies plant species in Al-Jabal Al-Akhdar region are shown in Table (4). Generally, the height to diameter ratio was more than

unity for *A.pavarii*, *C.sempervirens*, *C.siliqua*, *J.phoenicea*, *L.nobilis*, *O.europaea*, *P.halepensis* and *Q.coccifera*, this means that the diameter of these species tend to expand vertically rather than horizontally, while the height to diameter ratio was less than unity for *P.lentiscus*, *S.herba-alba*, *T.capitatus* and *Z.lotus*, this means that the diameter of these species tend to expand horizontally rather than vertically.

The relationships between the individuals heights to diameters of the twelve target species were simple linear with (r) value (Pearson correlation coefficient), and ranged between 0.291 for *P.lentiscus* (lowest r value) and 0.837 for *L.nobilis* (highest r value), which recorded at north wadis (Shahat) as shown in Fig. 2.

**TABLE 3. List of the twelve endangered perennialspecies with their families, local name and uses. Abbreviation: A= Active constituent, E=Edible, F= Fuel, G= Grazing and M=medicinal.**

Family Name	Scientific Name	Local Name	Uses				
			M	G	E	F	A
Anacardiaceae	<i>Pistacia lentiscus</i> L.	Battoum بطوم	+	+	+	+	+
Asteraceae	<i>Seriphidium herba-alba</i> (Asso) Soják	Shih شبيح	+	+	+	+	+
Cupressaceae	<i>Cupressus sempervirens</i> L. var. <i>horizontalis</i> (Mill.) Gord.	Srow سرو	+	+	-	+	+
	<i>Juniperus phoenicea</i> L.	Arar عرعار	+	+	+	+	+
Ericaceae	<i>Arbutus pavarii</i> Pamp.	Shmary شماري	+	+	+	+	+
Fabaceae	<i>Ceratonia siliqua</i> L.	Kharroub خروب	+	+	+	+	+
Fagaceae	<i>Quercus coccifera</i> L.	Ballout بلوط	+	+	+	+	+
Lamiaceae	<i>Thymus capitatus</i> (L.) Hoffmanns. & Link	Zaatar زعر	+	+	+	+	+
Lauraceae	<i>Laurus nobilis</i> L.	Rand رند	+	+	+	+	+
Oleaceae	<i>Olea europaea</i> L.	Zaitoun زيتون	+	+	+	+	+
Pinaceae	<i>Pinus halepensis</i> Miller.	Senouber صنوبر	+	+	-	+	+
Rhamnaceae	<i>Ziziphus lotus</i> (L.) Lam.	Sidr سدر	+	+	+	+	+

TABLE 4. Mean ( $\pm$ ) standard deviation of some demographic variables: (H: Height, D: Diameter, R<sup>2</sup>: simple linear correlation coefficient between height and diameter and size index. Note: (\*) measures of *S. herba-alba* and *T. capitatus* were by centimeter (cm).

Species	H (m)	D (m)	H/D	R <sup>2</sup>	Size index (m)
<i>Arbutus pavarii</i> Pamp.	2.23 $\pm$ 0.843	1.4 $\pm$ 0.527	1.65 $\pm$ 0.456	0.523	1.83 $\pm$ 0.634
<i>Ceratonia siliqua</i> L.	4.1 $\pm$ 0.629	3.1 $\pm$ 0.651	1.3 $\pm$ 0.286	0.398	3.6 $\pm$ 0.584
<i>Cupressus sempervirens</i> L. var. <i>horizontalis</i> (Mill.) Gord.	4.4 $\pm$ 1.130	3.1 $\pm$ 0.662	1.4 $\pm$ 0.245	0.665	3.75 $\pm$ 0.866
<i>Juniperus phoenicea</i> L.	2.26 $\pm$ 1.21	1.9 $\pm$ 0.749	1.2 $\pm$ 0.354	0.521	2.13 $\pm$ 0.917
<i>Laurus nobilis</i> L.	3.6 $\pm$ 0.504	2.7 $\pm$ 0.491	1.3 $\pm$ 0.110	0.837	3.14 $\pm$ 0.488
<i>Olea europaea</i> L.	2.75 $\pm$ 0.712	2.26 $\pm$ 0.736	1.2 $\pm$ 0.341	0.470	2.6 $\pm$ 0.694
<i>Pinus halepensis</i> Miller.	4.6 $\pm$ 1.027	3.18 $\pm$ 0.609	1.4 $\pm$ 0.474	0.635	3.9 $\pm$ 0.781
<i>Pistacia lentiscus</i> L.	1.6 $\pm$ 0.711	2.1 $\pm$ 0.844	0.8 $\pm$ 0.481	0.291	1.9 $\pm$ 0.693
<i>Quercus coccifera</i> L.	4.4 $\pm$ 0.619	3.24 $\pm$ 0.482	1.4 $\pm$ 0.153	0.511	3.8 $\pm$ 0.574
* <i>Seriphidium herba-alba</i> (Asso) Soják	28 $\pm$ 7.846	36 $\pm$ 5.465	0.7 $\pm$ 0.186	0.354	32 $\pm$ 9.49
* <i>Thymus capitatus</i> (L.) Hoffmanns. & Link	29.7 $\pm$ 8.22	35.3 $\pm$ 5.79	0.84 $\pm$ 0.201	0.364	32.5 $\pm$ 6.52
<i>Ziziphus lotus</i> (L.) Lam.	2.3 $\pm$ 0.626	2.5 $\pm$ 0.897	1 $\pm$ 0.292	0.445	2.4 $\pm$ 0.703

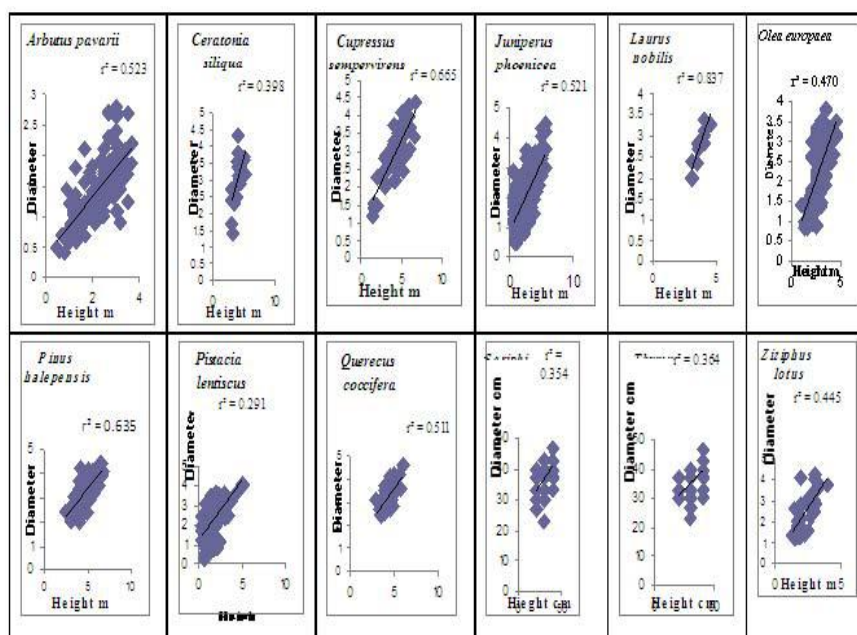


Fig. 2. Height diameter relationships for the studied endangered species in Al-Jabal Al-Akhdar region, R<sup>2</sup> = pearson correlation coefficient.

The diagrams illustrating the size distribution (Fig.3) of the studied species approximate one of the following size distributions: more or less inverse J-shaped distribution, positively skewed distribution towards the small size, more or less J-shaped distribution, stationary size distribution and more or less symmetrical distribution (i.e bell shaped).

In the present study, it was found that *A. pavarii* exhibited more or less J-shaped distribution along elevation levels I (down-stream) but symmetrical distribution (bell shaped) along elevation levels II and III of wadis Al-Marj-Al-Baida motorway, El-Beida, Shahat, Sidi Ahmad Al-Hemery and Wadi El-Kouf. *Ceratoniasiliqua* exhibited more or less symmetrical distribution (bell shaped) along elevation levels I and II of wadis Al-Marj-Al-Baida motorway, El-Beida, Shahat, Susah and Wadi El-Kouf. *Juniperus phoenicea* exhibited more or less positively skewed distribution towards the young individuals in the three studied levels at wadis Al-Marj-Al-Baida motorway, El-Beida, Jardas Jerrari, Shahat, Sidi Ahmad Al-Hemery, Susah and Wadi El-Kouf.

On the other hand, both *P. lentiscus* and *C. sempervirens* exhibited more or less positively skewed distribution towards the young individuals in the three levels at wadis Al-Marj-Al-Baida motorway, El-Beida, Shahat, Sidi Ahmad Al-Hemery, Susah and Wadi El-Kouf. *Olea europaea* exhibited more or less J-shaped distribution along elevation levels I (down-stream) but symmetrical distribution (bell shaped) along elevation levels II and III of wadis Al-Marj-Al-Baida motorway, El-Beida, Shahat, Susah and Wadi El-Kouf.

*Pinushalepensis* exhibited more or less symmetrical distribution (bell shaped) along elevation levels I, II and III of wadis Al-Marj-Al-Baida motorway, Shahat, Sidi Ahmad Al-Hemery, Susah and Wadi El-Kouf. *Quercus coccifera* showed more or less inverse J-shape distribution at down-stream and mid-stream but symmetrical (bell shaped) along elevation level III of wadis Al-Marj-Al-Baida motorway, El-Beida, Shahat, Susah and Wadi El-Kouf. *Ziziphous lotus* exhibited more or less J-shaped distribution along elevation levels I (mid-stream) but symmetrical distribution (bell shaped) along elevation level III of wadis Jardas Jerrari and Susah.

*Laurus nobilis* exhibited more or less stationary size distribution (biased to large size) in the two levels of Shahat wadis, while *S. herba-alba* and *T. capitatus* exhibited more or less positively skewed distribution towards the young individuals in the three studies levels at wadis Jardas Jerrari.

The negative skewed distribution of *C. siliqua*, *L. nobilis*, *Q. coccifera* and *P. halepensis* indicated the dominance of mature individuals over the juvenile ones. This distribution characterizes a declining population; because the population has a large proportion of larger individuals than smaller ones (*i.e.*



limited regeneration capacity). This may indicate that the recruitment of these species is restricted which may be related to hyper-aridity and low fertility

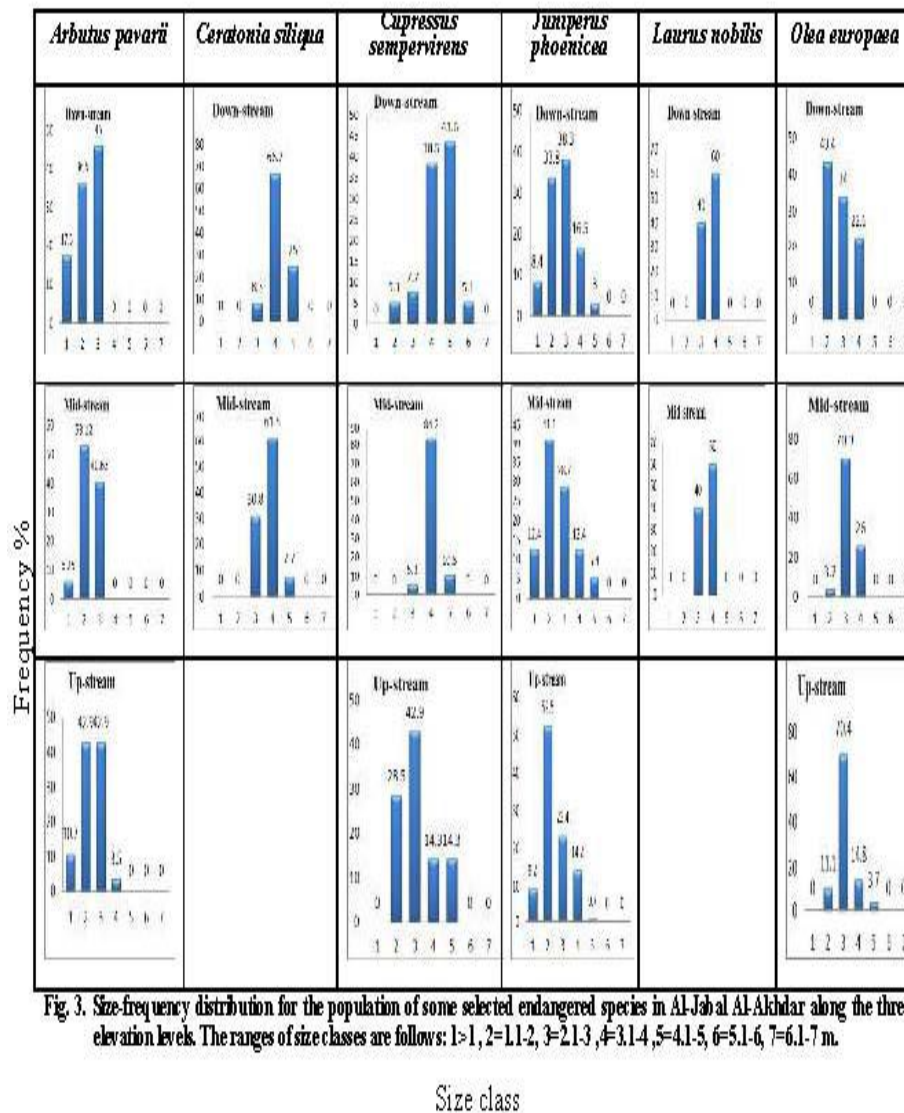
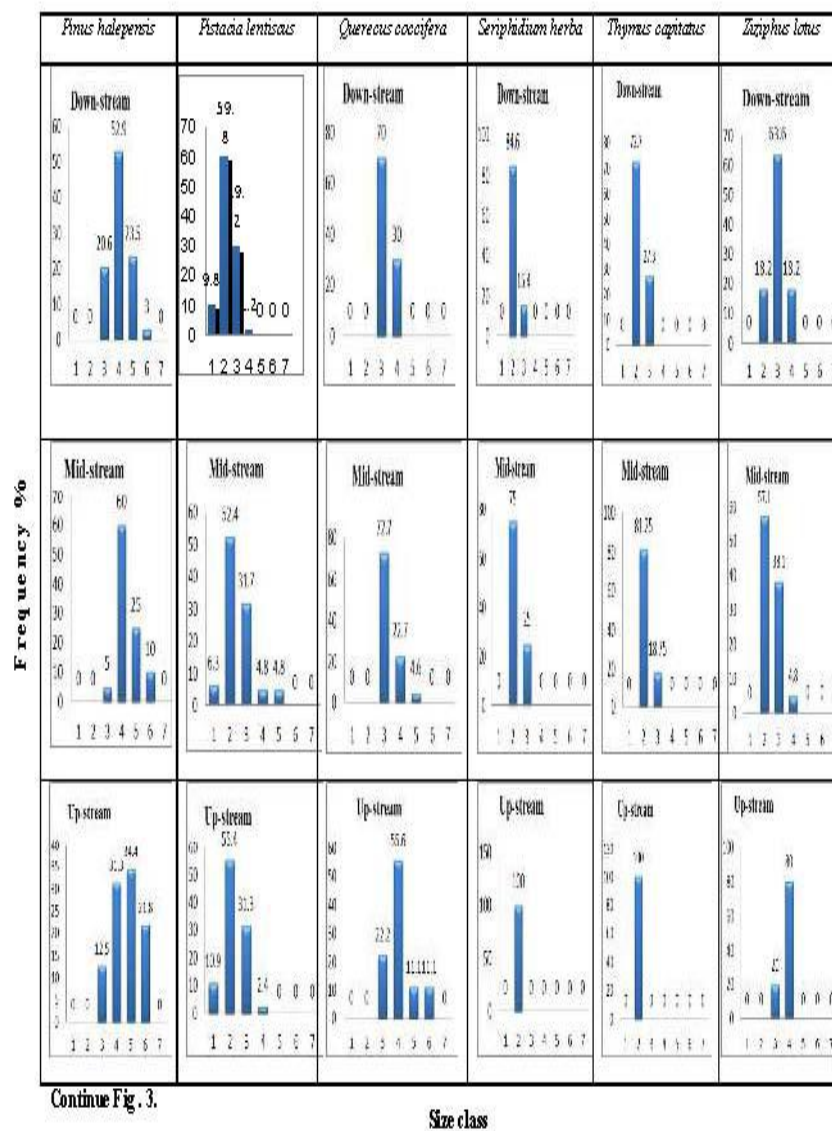


Fig. 3. Size-frequency distribution for the population of some selected endangered species in Al-Joh al Akhdar along the three elevation levels. The ranges of size classes are follows: 1>1, 2=1.1-2, 3=2.1-3, 4=3.1-4, 5=4.1-5, 6=5.1-6, 7=6.1-7 m.



Continue Fig. 3.

Size class

بطلح ٩%

Soil chemical and physical analyses in different elevation levels indicated that, at Al-Jabal Al-Akhdar wadis soils at elevation downstream were characterized by the highest values of E.C (0.304 ds/m) as well as sulphates, bicarbonates, magnesium, potassium and sodium (3.23, 0.73, 1, 3.6 and 0.73 m.eq.L<sup>-1</sup>, respectively) (table 5). Soils at midstream were characterized by the lowest values of E.C (0.214 ds/m) as well as sulphates and sodium (1.72 and 2.58 m.eq.L<sup>-1</sup>, respectively), but the highest value was calcium (5.9 m.eq.L<sup>-1</sup>). The highest chloride was recorded in soils of upstream level. Silt and E.C content in soil showed significant variations between three levels.

**TABLE 5. Means ± SD of the soil characteristics along downstream, midstream and upstream of the studied wadis in Al-Jabal Al-Akhdar.**

Soil variables	Elevation levels			F – value
	Downstream	Midstream	Upstream	
pH	7.8±0.37	7.7±0.41	7.7±0.32	0.216
E.C dsm <sup>-1</sup>	0.304±0.146	0.214±0.86	0.272±0.135	2.75*
Sand (%)	22.8±5.58	23.75±7.02	22.24±8.01	0.252
Silt (%)	41.1±9.18	34.81±7.8	34.1±10.1	3.84*
Clay (%)	36.1±11.82	41.49±12.25	43.7±15.11	1.87
CO <sub>3</sub> (m.eq. L <sup>-1</sup> )	0.0±0.0	0.0±0.0	0.0±0.0	0.0
HCO <sub>3</sub> <sup>-</sup> (m.eq. L <sup>-1</sup> )	0.73±0.52	0.67±0.54	0.61±0.74	0.146
SO <sub>4</sub> <sup>-</sup> (m.eq. L <sup>-1</sup> )	3.23±5.9	1.72±1.77	3.01±4.0	0.552
Cl <sup>-</sup> (m.eq. L <sup>-1</sup> )	1.6±4.22	0.81±1.6	2.94±5.1	1.337
Ca <sup>+2</sup> (m.eq. L <sup>-1</sup> )	4.71±11.15	5.9±14.04	5.6±13.6	0.053
Mg <sup>+2</sup> (m.eq. L <sup>-1</sup> )	1±2.5	0.85±1.88	0.33±0.69	0.762
Na <sup>+</sup> (m.eq. L <sup>-1</sup> )	3.6±6.89	2.58±4.56	3.42±6.52	0.161
K <sup>+</sup> (m.eq. L <sup>-1</sup> )	0.73±1.19	0.54±0.68	0.69±0.89	0.237

significant at P= 0.05

### Discussion

Many shrubs and trees of the arid regions are of structural and economic importance (Crisp and Lange, 1976). They play an important role in soil protection and stabilization against erosion by wind or water, provide a source of forage for animals and fuel for local inhabitants (Thalen, 1979). All the phanerophytes found in the Al-Jabal Al-Akhdar site were shrubs or facultative shrubs, more precisely, nanophanerophytes which are ¼m to 6 m tall. These species have the capability to survive the extremely dry soils with a wide range of salinity gradients (Zahran and Willis, 1992; Shaltout *et al*, 2003; El-Bana and Al-Mathnani, 2009). Al-Jabal Al-Akhdar wadis were markedly Mediterranean in floristic composition and characterized by phanerophytes forming fragmented patches of *C. sempervirens*, *J. phoenicea*, *O. europaea*, *Q. coccifera*, *C. siliqua* and *P. halepensis*. This includes *J. phoenicea* which is considered as one of the threatened trees in the Mediterranean Basin (El-Bana *et al.*, 2010).

The geographical elements of Libyan flora are dominated by the chorotypes of Mediterranean Sea and the Sahara Desert. The floristic elements and distribution characteristics also indicated that the climate and environmental conditions, ecological amplitude and adaptive capacity of the plants are influenced by the floristic origin and spatial patterns of plant diversity. Plant community patterns can be a functional tool for ecological restoration. Therefore, native species should be used for cultivation and regional vegetation should be used during the process of ecological recovery and rehabilitation.

The height and stem diameter of the studied individual species of different taxa are particularly important because they revealed the maximum size attained by functionally different species groups, which are crucial to a variety of ecological and evolutionary hypotheses (Niklas *et al.*, 2006).

The relationship between tree height and trunk diameter has been of interest ever since McMahon's (1973) off-cited study of the proportions of trees in relation to the limits imposed by mechanical support requirements. The extent to which trees approach these limits affects the cost in biomass of reaching a given position in the forest canopy and hence is of broad significance (Givnish, 1995; Aiba and Nakashizuka, 2007).

The height-to-diameter ratio gives an idea about the growth habit of the plant, variation in this ratio is lengthily a result of spacing (Wonn and O'Hara, 2001), under hyper-arid condition. This ratio is less than unity for many species (*i.e.*, the plant tends to expand horizontally rather than vertically. In this study, *P. lentiscus*, *S. herba-alba*, *T. capitatus* and *Z. lotus* exhibited the above behavior in this growth. This behavior may be a strategy of the desert trees and shrubs in order to provide safe sites for their self-regeneration, as the horizontal expansion usually provides shade which leads to decrease the severe heating effect and increase the soil moisture (Shaltout and Mady, 1993).

On the other hand, the height to diameter ratio in some species was exceed unity such as *A. pavarii*, *C. sempervirens*, *C. siliqua*, *J. phoenicea*, *L. nobilis*, *O. europaea*, *P. halepensis* and *Q. coccifera*, which means that their individuals tends to expand vertically rather than horizontally and this may be attributed to the high density or consequently high intra-specific competition of these plants (Galal, 2011 and Mosallam *et al.*, 2013).

The distribution of plant species along elevation gradients is governed by a series of interacting biological, environmental and historical factors (Colwell and Lees, 2000). In this context, *C. siliqua* and *L. nobilis* were exclusively recorded along the downstream and midstream of the studied wadis, which characterized by high values of E.C, calcium, sulphates, bicarbonates, magnesium, potassium and sodium. Also, *A. pavarii*, *P. halepensis*, *Q. coccifera*, *J. phoenicea*, *O. europaea*, *P. lentiscus*, *Z. lotus*, *T. capitatus*, *C. sempervirens* and *S. herba-alba* were exclusively represented along the three levels. (Stated that species with

limited elevation range always replace each other with some overlap along the mountainside). Moreover, the higher number of species in the lower elevation may be attributed to that low elevation may receive larger amount of runoff water than higher ones. Other climatic and abiotic factors vary along mountain gradients but have a more complex relationship to elevation. The best example, and probably most important of such a factor is precipitation (Gritti *et al.*, 2006; Hegazy *et al.*, 2008 and 2016).

The obtained results showed that density histograms of size distributions are good indicators of future trends in population number for the studied species especially for *J. phoenicea* and *A. pavarii*. Most of the studied species showed a "reverse-J" size structure, which is usually taken as an indicator of self-replacing populations. The size structures are ultimately formed by realized growth and mortality rates (Wright *et al.*, 2003; Kabil *et al.*, 2016 a,b), and species with similar initial size structure can follow very distinct trajectories over time due to differences in vital rates. The negative skewed distribution of *C. siliqua*, *L. nobilis*, *Q. coccifera* and *P. halepensis* indicated the dominance of mature individuals over the juvenile ones. This distribution characterizes a declining population; because the population has a large proportion of larger individuals than smaller ones (i.e. limited regeneration capacity). This may indicate that the recruitment of these species is rare which may be related to hyper-aridity and low fertility (Shaltout *et al.*, 2014 and 2015). The size and age of some plant life forms (notably trees) may be correlated in a general way, but unless there is evidence on this point, the interpretation of size as age may lead to simplistic or even inaccurate conclusions (White and Harper, 1970; Caswell, 1986).

Smaller trees were significantly more likely to die than larger trees within the young stands. Tree-diameter distributions within young stands were left skewed but those of older populations were normally distributed. These observations are consistent with asymmetric competition winnowing out small, suppressed trees from young stands, but having less effect in older stands, coincided with the results of Mosallam *et al.* (2013).

### Conclusion

The present study makes an assessment for twelve endangered with two endemic species in seven wadis at Al-Jabal Al-Akhdar northeast Libya, the results showed that histograms of size distributions are not good indicators of future trends in population number for some studied species such as *A. pavarii*, *C. sempervirens*, *C. siliqua*, *L. nobilis*, *Q. coccifera* and *P. halepensis* so it is hoped that this study helping us in planning for conservation of these plants, increase protection for the limited capacity regeneration species.

### References

- Aiba, M. and Nakas hizuka, T. (2007) Differences in the dry-mass cost of sapling vertical growth among 56 woody species co-occurring in a Bornean tropical rain forest. *Functional Ecology*, **21**, 41-49.

- Ali, S. and Jafri, S.M.H. (1976)** Flora of Libya.1-24. Department of Botany, El-Faateh University, Tripoli.
- Allen, S.; Grimshay, H.M.; Parkinson, J.A. and Quarmby, C. (1976)** "*Analysis of Ecology Materials*". Oxford, London: Blackwell Scientific Publications. pp: 565.
- Al-Idrissi, M.; Sbeita, A.; Jebriel, S.; Zintani, A.; Shreidi, A.; Ghawawi, H. and Tazi, M. (1996)** Libya: *Country Report to the FAO International Technical Conference on Plant Genetic Resources*. Leipzig, Germany. FAO.
- Austin, M.P.; Pausas, J.G. and Nicholls, A.O. (1996)** Patterns of tree species richness in relation to environment in south-eastern New South Wales, *Australia. Australian Journal Ecology*, **21**, 154-164.
- Baker, P.J.; Buyavejchewin, S.; Oliver, C.D. and Ashton, P.S. (2005)** Disturbance history and historical stand dynamics of a seasonal tropical forest in western Thailand. *Ecological Monographs*, **75**, 327-343.
- Blancher, R.; Rehm, G. and Caldwell, A. (1965)** Sulfur in plant materials by digestion with nitric and perchloric acid. *Soil Science Society of America Journal*, **29**,71-72.
- Boulos, L. (1977)** A check-list of the Libyan flora. 1<sup>st</sup>. Introduction and Adiantaceae – Orchidaceae. Publications from the Cairo University Herbarium, **7/8**, 115-141.
- Boulos, L. (1995)** *Flora of Egypt: Checklist*. Al Hadara Publishing, Cairo, Egypt, 283pp.
- Boulos, L. (1999)** *Flora of Egypt*, Volume. I (Azollaceae – Oxalidaceae). Al Hadara Publishing, Cairo, Egypt, 419 pp.
- Boulos, L. (2005)** *Flora of Egypt*. Volume. IV. Monocotyledons (Alismataceae-Orchidaceae). Al Hadara Publishing, Cairo, Egypt, 617 pp.
- Boulos, L. (2009)** *Flora of Egypt: Checklist. Revised Annotated Edition*. Al Hadara Publishing, Cairo, Egypt, 410 pp.
- Buyavejchewin, S.; LaFrankie, J.; Baker, P.; Kanzaki, M.; Ashton, P. and Yamakura, T. (2003)** Spatial distribution patterns of the dominant canopy dipeterocarp species in a seasonal dry evergreen forest in western Thailand. *Forest Ecology and Management*, **175**, 87-101.
- Caswell, H. (1986)** Life cycle models for plants. *Lectures on Mathematics in the Life Science*. **18**, 171-233.
- Colwell, R.K. and Lees, D.C. (2000)** The mid-domain effect: Geometric constraints on the geography of species richness. *Trends in Ecology and Evolution*, **15**, 70-76.
- Crisp, M.D. and Lange, R.T. (1976)** Age structure, distribution and survival under grazing of the arid-zone shrub *Acacia burkitii*. *Oikos*, **27**, 86-92.
- Eldoumi, F.; Elsaedi, O. and Zunni, S. (2002)** Study of Al-jabal Al-akhdar's plant cover. Final report in Arabic. University of Omar Al mokhtar. El-Bieda; Libya.

- El-Bana, M. and El-Mathnani, A. (2009)** Vegetation-soil relationships in the Wadi Al-Hayat area of the Libyan Sahara. *Australian Journal of Basic and Applied Sciences*, **3**, 740-747.
- El-Bana, M.; Shaltout, K.; Khalafallah, A. and Mosallam, H. (2010)** Ecological status of the Mediterranean *Juniperus phoenicea* L. relicts in the desert mountains of North Sinai, *Egypt. Flora*. **205**, 171-178.
- EL-Barasi, Y.M. and Manam, W.S. (2013)** Threats to plant diversity in the north eastern part of Libya (El-Jabal El-Akahdar and Marmarica Plateau), *Journal of Environmental Science and Engineering*, (**2**), 41-58.
- El-Tantawi, A.M. (2005)** Climate change in Libya and desertification of Jifara Plain. PhD Thesis. University of Johannes Gutenberg. Mainz, Germany.
- Galal, T.M. (2011)** Size structure and dynamics of some woody perennials along elevation gradient in Wadi Gimal, Red Sea coast of Egypt. *Flora*, **206**, 638-645.
- Givnish, T.J. (1995)** Plant stems: biomechanical adaptation for energy capture and influence on species distributions. "Plant Stems: Physiology and Functional Morphology" (Ed. B.L. Gartner), 3-49. Academic Press, San Diego.
- Gritti, E.; Smith, B. and Sykes, M. (2006)** Vulnerability of Mediterranean Basin ecosystems to climate change and invasion by exotic plant species. *Journal of Biogeography*, **33**, 145-157.
- Gupta, P.K. (2000)** "Soil, Plant, Water and Fertilizer Analysis". Agrobios (India), Jodhpur, New Delhi, India. p. 438.
- Hegazy, A.; Medany, M.; Kabiell, H. and Maez, M. (2008)** Spatial and temporal projected distribution of four crop plants in Egypt. *Natural Resources Forum* (United Nations), **32**, 3160-324.
- Hegazy, A.; Kabiell, H.; AlRowaily, S.; Lovett-Doust, L. and AlBorki, A. (2016)** Plant communities and reproductive phenology in mountainous regions of northern Libya. *Journal of Forestry Research*. (In press).
- IUCN, (2013)** "IUCN Red List of Threatened Species", Version.1, 2013, [www.iucnredlist.org](http://www.iucnredlist.org).
- Jafri, S. and El-Gadi, A. (1977)** *Flora of Libya*. Botany Department, Faculty of Science, Al Fatteh University, Tripoli.
- Jafri, S. and El-Gadi, A. (1993)** *Flora of Libya*. Botany Department, Faculty of Science, Al Fatteh University, Tripoli.
- Kabiell, H.; Hegazy, A.; Lovett Doust, L.; Al Rowaily, S. and Borki, A. (2016a)** Demography of the threatened endemic shrub, *Arbutus pavarii*, in the Al-Akhdar Mountainous Landscape of Libya. *Journal of Forestry Research*, (In press).
- Kabiell, H.; Hegazy, A.; Lovett Doust, L.; Al-Rowaily, S. and Al Borki, A. (2016b)** Ecological assessment of populations of *Juniperus phoenicea* L. in the Al-Akhdar mountainous landscape of Libya. *Arid Land Research and management*, **30**, 269-289.  
*Egypt. J. Bot.*, **57**, No.1 (2017)

- McMahon, T.A. (1973)** The mechanical design of trees. *Science*, **233**, 92-102.
- Mosallam, H.A.; Youssef, A.M.; Morsy, A.A. and Hashim, A.M. (2013)** Size structure and Dynamics of Eight Endangered plant Species of Some Wadis in Sinai Peninsula, Egypt. *Assiut University Journal of Botany*, (In press).
- Niklas, K.J.; Cobbi, E.D. and Marler, T. (2006)** A comparison between the Record Height-to-stem Diameter Allometries of Pachycaulis and Leptocaulis Species. *Annals of Botany*, **97**, 79-83.
- Raunkiaer, C. (1934)** "Plant Life Forms and Statistical Plant Geography". Clarendon Press, Oxford, pp: 632.
- Shaltout, K.; Al-Sodany, Y. and Shehata, M. (1993)** Vegetation along an elevation gradient in Al-Jabal Al-Akhdar, Libya, *Ecology amediterranea*, **29** (2), 125-138.
- Shaltout, K.H. and Mady, M.A. (2008): Current situation of the raudhas woody plant populations in the Central Saudi Arabia. *Feddes Repertorium*, **104**, 503-509.
- Shaltout, K.; Ahmed, D. and Shabana, H. (2015): Population structure and dynamics of the endemic species *Phlomis aurea* Decne in different habitats in southern Sinai Peninsula, Egypt. *Global Ecology and Conservation*, **4**, 505-515.
- Shaltout, K.; Fawzy, M.; Galal, T.; Awad, M.; El-Barasi, Y. and Saeed, B. (2014)** Impact of waste water discharge on the plant communities and size structure of Wadi El-Shees, Al-Jabal Al-Akhdar, Libya. *Feddes Repertorium*, **125**, 1-13.
- Thalen, D.C. (1979)** *Ecology and Utilization of Desert Shrub Rangelands in Iraq*. University of Groningen, Groningen: s.n. 428 p.
- Watson, M.E. and Brown, J.R. (1998)** Recommended Chemical Soil Test Procedures for the North Central Region. North Central Regional Research Publication. Missouri Agricultural Experiment Station SB 1001.
- White, J. and Harper, J. (1970)** Correlated changes in plant size and number in plant populations. *Journal of Ecology*, **58**, 467-485.
- Wonn, H.T.; O'Hara, K.L. (2001)** Height: diameter ratios and stability relationships for four northern rocky mountain tree species. *Western Journal of Applied Forestry*, **16** (2): 87-94.
- Wright, J.; Muller-Landau, H.; Condit, R. and Hubbell, S. (2003)** Gap dependent recruitment, realized vital rates, and size distributions of tropical trees. *Ecology*, **84**, 3174-3185.
- Zahran, M. and Willis, A. (1992)** "The Vegetation of Egypt". London: Chapman and Hall. pp: 424.

(Received //2016;  
accepted //2016)



## التوزيع الحجمي و ديناميكية بعض الأنواع النباتية المهددة بالإنقراض، الجبيل الأخضر- ليبيا.

حسنى عبد العزيز مسلم<sup>١</sup>، احمد هاشم محمد<sup>١</sup>، صلاح سالم سرفيوه<sup>٢</sup>، و مبروكة  
عبدالله جبريل عبدالرحيم<sup>٣</sup>

قسم النبات، كلية العلوم، جامعة عين شمس- مصر قسم الزراعة، كلية العلوم، جامعة  
عمر المختار- ليبيا قسم نبات، كلية العلوم، جامعة بنغازي- ليبيا

تمتلك منطقة الجبل الأخضر العديد من المناظر الطبيعية وأعلى تنوع نباتي في البلاد. تهدف الدراسة الحالية الى متابعة التوزيع الحجمي و العددي لبعض الأنواع النباتية المهددة بالإنقراض على ثلاثة ارتفاعات مختلفة بسبعة وديان فى الجبل الأخضر. تم تجميع نبات الشماري (*Arbutus pavarii*)، السرو (*Cupressus sempervirens*)، الخروب (*Ceratonia siliqua*)، العرعار (*Juniperus phoenicea*)، الرند (*Laurus nobilis*)، الزيتون (*Olea europaea*)، الصنوبر (*Pinus halepensis*)، بطوم (*Pistacia lentiscus*)، البلوط (*Quercus coccifera*)، الشبج (*Seriphidium herba-alba*)، زعتر (*Thymus capitatus*) والسدر (*Ziziphous lotus*). تمتقييم التركيبية السكانية للأنواع المهددة بالإنقراض فيتنو زيعجمي علطولمستوياتارتفاعاتمختلفة (أسفلمجرى، منتصف الطريق و أعلى الجبل) فيسبعة أودية فيمنطقة الجبل لأخضر. وتم قياس الأرتفاع (H) والفطر (D) لعدد من الأفراد لكل الأنواع وكانالأرتفاعالنسبةالفطرأكثر في (الشماري *Arbutus pavarii*، سرو *Cupressus sempervirens*، خروب *Ceratonia siliqua*، عر رفينيقي *Juniperus phoenicea*، الرند *Laurus nobilis*، الزيتون *Olea europaea*، صنوبرحلي *Pinus halepensis* و البلوط *Quercus coccifera*) وهذايعنيأنقطر هذاالأنواعاعتميلإللباتوسعموديايدلأمنأقيا، فيحينكانالأرتفاعالنسبةقطر هأقل في البطوم *Pistacia lentiscus*، الشبج *Seriphidium herba-alba*، الزعتر *Thymus capitatus* و السدر *Ziziphous lotus*، وهذا يعني أنقطر هذاالأنواعاعتميلإللباتوسيعاً فقيابد لأمعموديا.

وقد استنتجت الدراسة الحالية أن هناك خمسة انماط نمو للتوزيع الحجمي لهذه النباتات التي تنمو باودية الجبل الأخضر. واعطت النتائج مؤشرات سلبية عن التوزيع الحجمي و العددي لبعض هذه النباتات مثل الخروب (*Ceratonia siliqua*)، الرند (*Laurus nobilis*)، البلوط (*Quercus coccifera*) و الصنوبر (*Pinus halepensis*) حيث تزيد اعداد افرادها الناضجة ذات الحجم الكبير عن افرادها ذات الحجم الصغير.