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Phenotypic Variations in *Calligonum comosum*L`Her (Polygonaceae) Grown in Al-Nefud Desert in Saudi Arabia

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Abstract

Vegetative community structures and phenotypic variations within *Calligonum comosum* L`Her individuals grown in two different locations in Al-Nefud desert in Saudi Arabia; Nefud Al-Shakika and Al-Dahnaa, have been studied. Eleven species have been recorded in both areas; five of them were present in both locations. *Ephedra elata* and *Convolvulus lanatus* were recorded in Nefud Al-Shakika only. While *Heliotropium bacciferum, Cleome arabica, Dodonaea viscosa* and *Erodium gleurocophyllum* were found in Al-Dahnaa only. The importance values of the species recorded have been calculated and cluster analyses of the studied quadrates have been made using TWINSPAN method. Vegetative morphological characters showed great variations within *C. comosum* collected from the two locations. Floral morphological characters are more stable, except the fruit colour and hair which was different in the *C. comosum* plants grown in the two locations. Epidermal stem secretions as well as mineral contents varied in response to change in locations. ANOVA test have been carried out to evaluate the differences between the two areas. The variations in these characters are discussed according to the difference in climates, soil characters and water availability.

Keywords: Phenotypic variation; Vegetative morphology; Fruit morphology; Pollen grains; Mineral contents; Al-Nefud- Al-Dahnaa.

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1. Introduction

Calligonum comosum L`Her is a large perennial bush, found in desert scrub and waste in any climatic zone. It inhabits much of the North African desert, the desert sands of the Middle East, Pakistan as well as the sand dunes in both central and eastern Arabia [1]. This species belongs to family Polygonaceae and characterizes by being tall , evergreen shrub reaching up to 3 metres in length , but is usually found in bush from 1 to 2 metres high but it reaches up to 2.5 metre in Nefud Al-Shakika desert [2]. The stem is woody, hard and white to grayish-white with swollen nodes and long internodes. The plant is considered apophillous as it looks leafless. *C. comosum* lacks a main trunk but has rigid

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lignified basal white branches, but upper young branches are green and thin with very small caducous leaves [3]. The stiff, green branches produce an abundance of flowers in the early spring months (March and April). Flower pedicels are as long as or longer than the perianth. The silvery-white sweet smelling little blooms are followed by the hairy fruits which are yellowish green, yellow or even shades of red [3]. The fruits covered by long hairs which arising from four vertical wing-like narrow ridges. The plant has a long tap root which enables the plant to collect sand and is used as sand dune stabilizer [4]. Al-Khalifa *et al*. [5] found that *C. comosum* has thicker vessel walls with long and narrow vessel elements and fibers, and relay to these characters help its adaptation to hot deserts.

This plant has a lot of uses by Bedouins; they use the woody stem as firewood in winter. It plays an important role in the productivity and stability of the desert environment [6]. The long and far reaching roots make it a good sand stabilizer and the sand is often heaped around it in large hummocks [1]. It is also used in hedges, ground cover, windbreaks and landscaping. Its fresh flowers can be eaten as it is high in sugar and nitrogenous components [7]. The plant has been used to treat stomach ailments by local healers, and the stems and leaves are chewed for curing toothache [8]. Its root decoction is used for gum sores [4].

For all of these ethno-medicinal uses, the plant has been faced with unorganized rural activities that led to its extinction in many places. For this, and because of the Moreover, there is little available information about the species, especially the range of its morphological variations under the arid conditions which it faces. Therefore, the present study work was done as a step forward to know the ways its internal and external features adapted to the environmental stress.

The aim of this paper was to elucidate the vegetation community structures and phenotypic variations found in *C. comosum* L`Her grown in two distant areas from Al-Nefud desert in Saudi Arabia; Nefoud Al-Shakika and Al-Dahnaa; as they were different in soil characters and climatic conditions. Also, efforts were made to know the variations in *C. comosum* association as well as the alterations in the phenotypic characters between members of *C. comosum* grown in the two desert locations in response to climatic conditions, especially the water deficit in these arid habitats.

2. Locations and General Description

Al-Nefud is a desert in the northern part of the Arabian peninsula at 28° 30' 00" N 041° 00' 00" E, occupying a great oval depression. It is about 290 km long and 225 km wide. The Nefud is an erg, noted for its sudden violent winds, which resulted large crescent-shaped dunes. This desert rarely has rain, once or twice a year. The Nefud is connected to the Rub al Khali by Al-Dahnaa arc, which extend through the east of Najd plateau to west Al-Damam city. The Dahnaa arc is characterized by being a corridor of gravel plains and sand dunes and has plenty of iron oxide which makes the soil color red. While the Nefud Al-Shakika desert (see map below) is the part of the Nefud located near Buraida and Onayza cities and characterized by having calciferous, white soil [9].

Map: Location of deserts in Saudi Arabia

The two studied sites have been chosen , one in Nefud Al-Shakika south Onyza city on Najd plateau and the second west Al-Dahnaa in the way between Al-Riyadh city and Al-Damam (Map 1). Each of these locations were dominated by *Calligonum comosum* L`Her beside other species such as *Artemisia monosperma, Ephedra elata* and *Haloxylon ammodendron*.

3. Materials and Methods

Ten quadrates (10×10 m.) have been made and visited monthly from Oct. 2005 to May 2007, except in the three summer months (June, July & August). Soil samples have been collected from three different depths (surface, 10-35 cm, 35-60 cm) from the two locations and analyzed using x-ray analyses technique. Representatives of vegetative parts of *C. comosum* have been preserved in 95% ethyl alcohol until further examinations. The preserved specimens were regularly examined for its morphological and anatomical characters.

Plants were collected from the two regions in February 2007. Parts of the stem have been taken from at least 10 plants from each location; Nefud Al-Shakika and Al-Dahnaa; for investigations. Flowers and fruits have been collected in March and April of the same year. These specimens have been subjected to the following investigations:-

1- Parts of the stems have been examined by stereo - microscopes to examine the external surface.
2- Fresh parts of the stems have been sectioned transversely, manually, to examine the difference in internal structures.
3- Pollen grains and fruits have been microscopically examined and measured.
4- Small pieces of the stems have been subjected to x-ray analyses, in order to know the variations in element contents between the two locations.

5- The Importance values (I.V.) of the most dominant species have been calculated [10].
6- The TWINSPAN technique [11] was applied for agglomerations of the studied quadrates in each area using the I.V. of the recorded species.
7- Relative equitability or relative evenness of plant was expressed according to the following diversity indices; Margalef and Shannon species richness [12], Pielou`s evenness [13].
8- ANOVA test has been carried between the two studied areas, as well as between the different quadrates in each area [14] to evaluate the difference between them.

All the measurements are in centimeter except those for pollen grains, which are in micron. At least 10 plants are measured, the measured nodes and internodes are those of fifth from the terminal bud. Measurements of the fruits include the hairs covering it. Terminologies for anatomical characters are those of Barthlott [15] and for pollen grains are from Faegri [16]. Climatic data, degrees of temperature and amount of rain fall, have been obtained from climatic stations in both Al-Riyad city, for those of Al-Dahnaa desert, and Onayza city, for those of Nefud Al-Shakika desert.

4. Results

The climate in both deserts is very arid but in Nefud Al-Shakika there is a moist period in January, March and April only (Fig. 1). In Al-Dahnaa desert, there is moist period during December only (Fig. 2).The soil analyses of the collected samples showed that the soil in both areas is slightly alkaline, sandy and poor in salts and minerals as shown in Tables 1 and 2. The soil in Nefud Al-Shakika has higher moisture percentage and yellow while in Al-Dahnaa it has low moisture percentage and red.

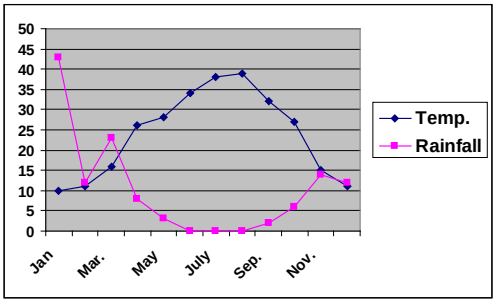

Fig. 1. Climatic sketch for Nefud Al-Shakika desert during the period from 1997- 2000.

The clustering tree obtained after the application of TWINSPAN on the quadrates studied showed that in Nefud Al-Shakika the quadrates have been grouped in two groups at similarity index of 40 and one of these groups divides into two at similarity index of 55 (Fig. 3). In Al-Dahna the studied quadrates grouped in two categories at similarity index of 40 (Fig. 4).

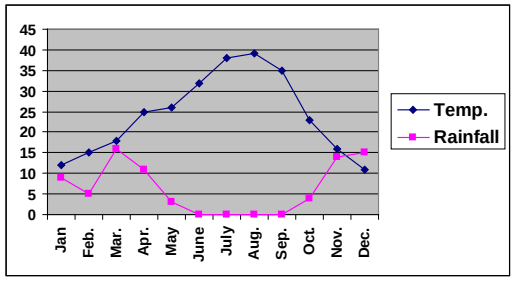

Fig. 2. Climatic sketch for Al-Dahnaa desert during the period from 1997- 2007.

Table 1. Physical characters of the soil in the two studied areas.

Char→ Loc↓	RH	Col	Tex	%sand	%Mud	%Clay
Nefud 1	4.66	Yel	Sandy	93.33	2.33	4.33
Nefud 2	4.12	Yel	Sandy	93.66	2.66	3.66
Nefud 3	3.55	Yel	Sandy	2.00	2.00	2.33
Dahnaa 1	2.42	Red	Sandy	2.33	2.33	3.66
Dahnaa 2	2.11	Red	Sandy	2.33	2.33	3.33
Dahnaa 3	2.02	Red	Sandy	2.00	2.00	3.00

RH=Relative Humidity, Col= Color, Tex= Texture, 1= Soil from the surface, 2= Soil from 10-35 cm depth, 3= Soil from 35-60cm depth

Table 2. Chemical characters of the soil in the two studied areas.

Char→ Loc↓	PH	EC	Sol. salt (mlmos)	$CaCO_3$	K	Na	Fe	Mg	Cl	SO_4	P
Nefud 1	7.6	0.08	48.5	1.2	68	14.8	0.11	29	93	108	6.8
Nefud 2	7.8	0.12	81.3	1.2	60	14.6	0.21	20	92	132	6.7
Nefud 3	7.7	0.8	54.8	1.0	73	15	0.18	17	85	127	6.8
Dahnaa 1	7.6	0.05	31.3	2.7	45	10.7	0.5	7.4	68	78	6.6
Dahnaa 2	7.6	0.06	40.2	2.5	52	18.5	0.42	6.4	68	96	6.6
Dahnaa 3	7.6	0.07	43.5	1.8	40	11	0.26	5.8	66	82	6.2

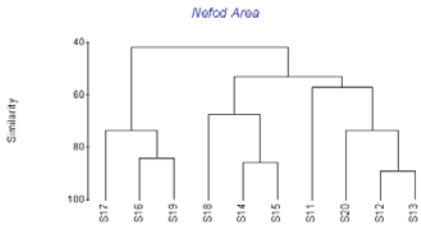

Fig. 3. Agglomerative clustering of the studied quadrates in Nefud Al-Shakika after the application of TWINSPAN.

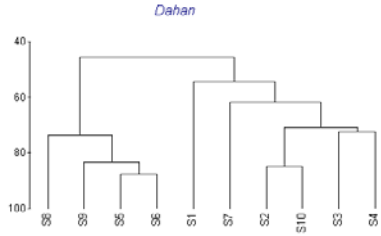

Fig. 4. Agglomerative clustering of the studied quadrates in Al-Dahnaa after the application of TWINSPAN.

The results obtained from different samples showed no variations throughout the studied period and accordingly the means of the measurements and the general appearance of the plant as noticed throughout our visits are summarized in Tables 3, 4, 5 and 6 and illustrated in Figs. 5 and 6, and Photographs 1- 3. In Table 3, the recorded number of species is eleven; of them seven were present in Nefud Al-Shakika and nine of them were present in Al-Dahnaa. Five species; *Calligonum comosum, Capparis deciduas, Panicum turgidum, Elusine compressa* and *Dipterygium glaucum* were found in both deserts**.** On the other hand, *Ephedra alata* and *Convolvulus lanatus* were found in Nefud Al-Shakika only, while *Heliotropium bacciferum, Cleome arabica, Dodonaea viscosa* and *Erodium gleurocophyllum* were found in Al-Dahnaa desert only (Fig. 5). Species frequencies, densities, covers and Importance values (IV) are also presented in Table 3.

From Table 4 and Fig. 6, we can notice that the size of the plant, both length and width, differs between the habitats. In Nefud Al-Shakika, the plant is taller in general, but it has different width (Photo 1 A), while in Al-Dahnaa the maximum length of the plant is greatly shorter than that in the former location during the same time while the mean of the width are slightly bigger (Photo 1 B). The stem color is grayish or grayish white with inter-node length reaches 6.6 cm in Nefud Al-Shakika but never exceed 4.5 cm in Al-Dahnaa. The nodes are generally swollen and 1.3 cm thick in the first region and become slightly larger in the second region. The variations in the measured morphological characters are illustrated in Fig. 6.

Table 3. Species recorded in the two locations and their Importance values (I.V.), covers, relative densities and relative frequencies.

No.	Sp.↓ Loc.→	Nefud Al-Shakika				Al-Dahnaa			
		I.V.	Cover	Dens. %	Freq. %	I.V.	Cover	Dens. %	Freq. %
1	*Calligonum comosum*	62.25	5	10.65	100	55.43	5	9.46	100
2	*Capparis deciduas*	23.67	1	8.79	40	57.53	2	29.65	100
3	*Heliotropium bacciferum*	--	--	--	--	34.24	1	14.82	90
4	*Panicum turgidum*	26.97	2	4.17	50	37.84	2	12.94	80
5	*Eleusine compressa*	68.16	1	40.28	100	31.83	1	12.4	90
6	*Cleome arabica*	--	--	--	--	28.74	1	10.78	80
7	*Dodonaea viscosa*	--	--	--	--	18.56	1	5.12	50
8	*Erodium gleurocophyllum*	--	--	--	--	25.96	2	4.04	60
9	*Dipterygium glaucum*	11.27	1	1.39	20	9.09	1	0.81	20
10	*Ephedra alata*	79.64	5	28.24	100	--	--	--	--
11	*Convolvulus lanatus*	27.28		6.48	40	--	--	--	--

Table 4. Morphological characters studied in *Calligonum comosum* L`Her.

Character / Region	Nefud Al-Shakika	Al-Dahnaa
Plant length (cm)	93-236 (151.9)	85-142 (116.3)
Plant width (cm)	135-365 (230.9)	166-345 (276)
Stem color	Grayish white	Gray
Epidermal secretion	Fine granules	Scales
Inter-node length	2.6-6.6 (3.8)	2.0-4.5 (3.0)
Node width	0.2-1.3 (0.62)	0.3-1.6 (o.675)
Flowering time	Mid of February	Beginning of March
Fruiting time	End of February	Mid of March
Fruit color	Yellow, few yellowish pink	Red, few yellowish pink
Fruit length	0.9-1.6 (1.2)	0.8-1.9 (1.5)
Fruit-hairs length	0.2-0.35 (0.28)	0.5-0.65 (0.52)
Cutin ornamentation on fruit cells	Longitudinal striations	Unobvious
Wax secretions on fruit cells	Few	Dense
Wax shape on fruit cells	Granules	Needle-shape
Pollen grain shape	Perprolate	Perprolate
Pollen grain length	33.1-37.2 (35.3 Um)	31.6-36.2 (34.4 Um)
Pollen grain width	18.3-22.2 (20.1 Um)	18.2-21.1 (19.0 Um)
Aperture type	Tricolpate	Tricolpate
Aperture length	31.9-35.6 (34.2 Um)	29.7-34.1 (32.6 Um)

Table 5. Anatomical characters studied in *Calligonum comosum* L`Her.

Character / Region	Nefud Al-Shakika	Al-Dahnaa
Cuticle thickness	Thin	Thick
Wax shape	Needle-shaped	Platelets
Stem texture	Mealy	Scaly
Epidermal cell shape	Barrel-shape	Barrel-shape
Sub-epidermal cell	Present	Present
Number of cortex layers	3-5	3-6
Presence of air chambers	Absent	Present
Number of vascular bundles	5-8	5-7
Size of secondary phloem	More than ten layers	Less than seven layers
Type of secondary xylem	Porous	Nonporous
Shape of radial cells	Discontinuous, rectangular	Continuous, rectangular

Table 6. Mineral contents in *Calligonum comosum* L`Her.

Mineral/Region	Nefud Al-Shakika	Al-Dahnaa	Used materials
Mg	2.95	7.03	MgO
Si	4.19	4.99	Quartz
P	2.78	2.06	GaP
S	6.04	2.60	FeS2
Cl	5.42	14.41	KCl
K	46.44	37.1	MAD
Ca	3.55	6.59	Wollas
Cu	15.35	13.4	Cu
Zn	13.27	11.83	Zn
Sum	100	100	

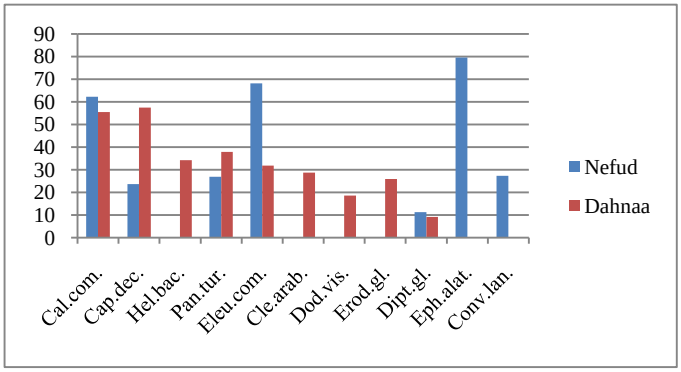

Fig. 5. Importance values (I.V.) of the recorded species in the two studied areas.

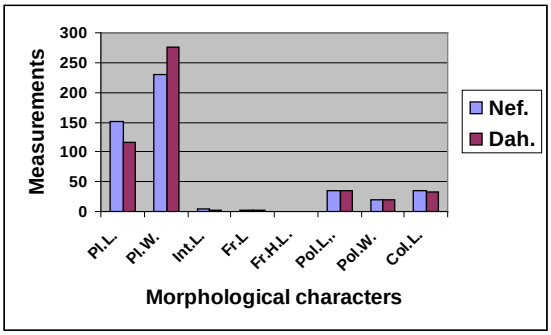

Fig. 6. Variations in the measured morphological characters in the two deserts (Pl.L.= plant length, Pl.W.= plant width, Int.L.= internode legth, Fr.L.=fruit length, Fr.H.L.=fruit hair length, Pol.L.= pollen grain length, Pol.W.= pollen grain width, Col.L.= colpi lenth).

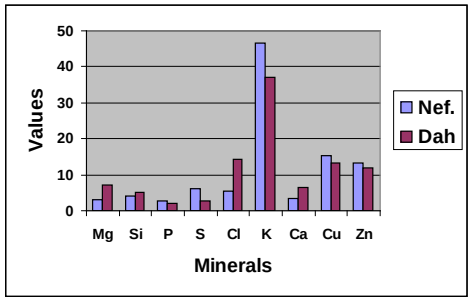

Fig. 7. Mineral contents in the stem of *Calligonum comosum* in both sites.

Table 7. Diversity indices in Nefud Al-Shakika.

No. of Quadrate	No. of species	No. of individuals	Species richness Margalef index	Species evenness Pielou index	Diversity species Shanon index
11	5	29	1.188	0.8668	1.395
12	6	33	1.430	0.8813	1.579
13	6	17	1.765	0.7709	1.381
14	4	13	1.170	0.9422	1.306
15	5	21	1.314	0.8823	1.420
16	4	19	1.019	0.9119	1.264
17	4	13	1.170	0.7733	1.072
18	3	20	0.6676	0.7298	0.8018
19	4	24	0.944	0.8461	1.173
20	4	27	0.9102	0.9079	1.259

Table 8. Diversity indices in Al-Dahnaa.

No. of Quadrate	No.of Species	No. of Individuals	Species Richness Margalef index	Species Evenness	Species Diversity Shanon index
1	8	46	1.828	0.8661	1,801
2	7	59	1.471	0.9372	1.824
3	6	34	1.418	0.9242	1.656
4	7	50	1.534	0.7475	1.455
5	6	19	1.698	0.9203	1.649
6	6	26	1.535	0.8189	1.467
7	7	17	2.118	0.9476	1.844
8	8	48	1.808	0.7169	1.491
9	4	33	0.858	0.8145	1.129
10	8	61	1.703	0.9232	1.920

Table 9. Variations between the two studied locations after the application of ANOVA test.

Source of variation	Sum of quadrates	Degree of freedom	Mean quadrates	F value	P value
Between group	0.059678	1	0.059678	0.798893	.373529
In grou	7.619503	102	0.074701	-	-
Smatiom	7.679181	103	-	-	-

(A) **(B)**

Photo 1.

(A) **(B)**

Photo 2

Photo 2. Fruits of Calligonum comosum (A) in Nefud Al-Shakika,(B) Al-Dahnaa

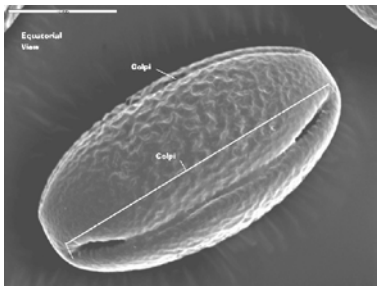

Photo 3. Pollen grain morphology of *Calligonum comosum* as shown by SEM in equatorial view

The flowering time differs in the two sites, as it starts in the mid of February in Nefud Al-Shakika and delayed about two weeks in Al-Dahnaa. This is followed by the fruiting time; which is after two weeks of flowering. The fruits are rectangular in shape with four longitudinal rows of hairs. The length of the fruits is about one cm in both regions, but their colors differ in both regions. In Nefud Al-Shakika, the fruit color is mostly yellow with few ones yellowish-pink (Photo 2 A), while in Al-Dahnaa region the fruits are mostly red with few ones yellowish-pink (Photo 2 B). The hairs covering the fruits are about 3 mm in length in Nefud Al-Shakika and 5 mm in length in Al-Dahnaa, and in both deserts they have straight ends. The surface view of the fruit cells were hardly recognized by the stereomicroscope because of the dense hairs, but they seem to be elongated with straight walls and longitudinal cutin striations on upper walls of Nefud Al-Shakika's fruits and undifferentiated in Al-Dahnaa ones, which are completely covered by needle-shaped wax secretions on the spaces between the hairs.

The anthers are connected to the filaments in versatile position; the epidermal cells of the anthers are diametric with striated epicuticular secretions. The pollen grains are symmetric, iso-polar and perprolate in shape, they have three colpi which extent longitudinally to reach near the poles (Photo 3). Pollen length and width as well as the colpi length do not differ greatly between the two regions (Table 4). The pollen grains have rugate exine ornamentation.

The stem is white in color or grayish, its texture is either mealy in Nefud Al-Shakika, or scaly in Al-Dahnaa. The examination of the transverse sections in the uppermost parts of the stem by light microscope reveals that the epidermal cells covered with a layer of cutin which obviously differs in thickness in the two regions. The epidermal cells are barrel-shaped with a layer of sub epidermal cells composed of compact rectangular parenchyma cells without intercellular spaces. The cortex is composed of three to six layers of chlorenchyma cells. The primary vascular bundles are from five to eight with wide vessels and compressed phloem. The stem quickly starts the secondary growth, which becomes obvious in the vessels and phloem which sooner become circular layers of both secondary phloem and xylem. In this state air-chambers appeared between the cortex and the secondary phloem in the stems of Al-Dahnaa region only. The size of the secondary phloem differs as well between the two regions; which is larger and more organized in Nefud Al-Shakika than that in Al-Dahnaa. The type of secondary xylem differs also, as it appears to be porous, with parenchyma cells in between the vessels in Nefud Al-Shakika in contrast to the non porous xylem in Al-Dahnaa. The ray cells are rectangular in shape, continuous in Al-Dahnaa and discontinuous in Nefud Al-Shakika (Table 5).

The examination of the stem under the stereomicroscopes reveals that there is a wax layer over the stem surface, which is sparse and needle-shaped in Nefud Al-Shakika while it is condensed and platelet - shape in Al-Dahnaa. In both regions, there are areas in the epidermis with elevated papillae.

The mineral contents in the tissues of the plant differ between the two regions in their examination by x-ray. From Table 6, we can notice that Sulfur and Potassium contents

are noticeably higher in those grown in Nefud Al-Shakika , while Phosphorous, Cupper and Zinc are bit higher in the same area than those grown in Al-Dahnaa. In contrast to Magnesium, Chlorine and Calcium contents which are greatly higher in Al-Dahnaa and Silicon is a bit higher as well (Fig. 7).

The diversity indices obtained in the studied quadrates show great similarities between the quadrates in each area (Tables 7 and 8). From Table 9 we find that there is significant differences between the two areas as the values of F and P are considerably high. Nevetheless individuals of *Calligonum comosum* have fixed characters in each location, in spite of the considerable variations between the quadrates studied as shown from the results of ANOVA test (Table 9).

Biodiversity features in the studied deserts

These two sites are parts of Al-Nefud desert, which is characterized by specific fine sandy soils with huge sand dunes and special climatic changes, and has its own specific creatures. Thus the ecoregion contains endemic plant and animal species, making these two cites distinctive from the other parts of Al-Nefud. In our study, we recorded 11 xerophytic species which are adapted to these harsh ecological features, four of them are restricted to Al-Dahnaa site; *Heliotropium bacciferum, Cleome arabica, Dodonaea viscosa* and *Erodium gleurocophyllum*. Whereas there are only two species found in Nefud Al-Shakika only; *Ephedra alata* and *Convolvulus lanatus.* This poor vegetation may be due to the low water deficit in the very fine granules of the soil beside the strong winds and scantiness of rainfall. Accordingly these two sites have weak speciation and biodiversity.

5. Discussion

The study of the effect of habitats on the phenotypic characters of wild plants has been a matter of interest since long time ago. This subject has been called as phenotypic plasticity that is the way plants respond to the change in environments. Shaltout *et al.* [17] found that morphological characters, especially leaf apices and margins, in *Thymelaea hirsute* (L.) Endl. grown along different environmental gradients in Western Mediterranean region of Egypt have been changed according to both aridity and CaCO3 contents in the soil. Taia and El-Olayan [18] found that moisture content, leaf characters as well as the length of the plants and their vital status can be affected under different habitats. Meanwhile Taia and El-Ghanem [19] found that mineral contents of the plants can be affected as well. In *Calligonum comosum* the leaves are deciduous as soon as the plant start growing, thus, we cannot notice any change in the leaves. According to our results the vegetative characters those affected most by different habitats are plant length, width and colors. The colors of flowers and fruits can be affected also. But the main parts of the flower as well as anther shape, ornamentation and attachment with filament beside characters of pollen grains are unchanged. This indicates that floral characters are more stable than vegetative ones. Tomlinson [20] suggested that the

utilization of vegetative morphological characters in the systematic of higher plants are of limited use than morphological features of the sexual reproductive system due to the belief in the innate conservatism of reproductive features. According to White [21] the plant body is made up of an indefinite number of repeating units, which he called them as modules. These modules have a greater diversity of possible functions and for that the vegetative characters have a great capacity for replication repair in contrast to flowers which have set of functions which are invariable. Taia and El-Ghanem [19] found that leaf characters can be used in systematic, while stem characters are more variable. This may be due the modular system proposed by White [21]. Barthlott [22] gave precise micro structural features of seed surfaces which provide valuable taxonomic information. Tavakkoli *et al.* [23] found that fruit characters in *Calligonum* can be used in distinguishing its species. In our work the fruit hairs can be considered as ecological variable characters. Also, micro structural characters are valuable than fruit color and size in studying ecological stresses. The presence of the multi-cellular appendages in four longitudinal rows is considered, as well good taxonomical character, which is invariable according to different habitats. Cellular arrangement of inter appendages areas are stable in both habitats; the only variable thing is the wax deposition which may be due to ecological factors.

The internal structures of desert plants give an idea about their adaptation with the external stress falling on them. Lyshede [24] studied the structure of the epidermal and sub-epidermal cells of both *Anabasis articulate* and *Calligonum comosum* found that the epidermal cell walls of the stem, in the two studied species, swelled rapidly during water absorption and released the water slowly when dehydrated. Slatyer [25] reported that criteria in pine wood and he nominated it as hysteresis. According to our observations, the stem in both habitats, covered with wax depositions, beside the cutinized epidermal cells which can protect the cells from water loss. The only places which permit water exchange are the stomata and the lenticels. Meanwhile, Jonsson [26] noticed the presence of large amount of mucilage in the epidermal cells in *Calligonum* sp. This may be another reason for preventing losing water as mucilage able to absorb and store water. Besides the long and narrow vessel elements with thicker walls as mentioned by Al-Khalifa *et al.* [5] enables the plant to raise the water and keep it for long periods. All these anatomical characters; wax deposition, cutinized epidermal cells and mucilage beside the morphological characters indicate to the highly adaptation of this species to the aridity present in the habitats. Adel Dhief [27] found a species-dependent response to summer drought, as *C. comosum* ended all phenophases in June or before severe desert drastic season.

The vegetative value of range plants has been studied by many authors.Oelberg [28] studied the different factors affecting the nutritive value of range forage. Heneidy [29] studied the nutrient content in range plants grown at Omayed region in Alexandria, while Sharaf El-Din [30] studied the nutritive value of the raudhas plants in central Saudi Arabia. They all found that, the nutritive value of any forage is dependent upon its content of energy- producing nutrients and nutrients essential to body growth. Sharaf El-

Din [30] found that the evaluated species have low contents of N, P, K and Na but high contents of Ca, Mg and Mn. Tthe habitats can affect the contents of some minerals in the same species as Fe, Mn, K and Zn [19] during the three seasons (autumn, winter and spring). In our results, the mineral content is generally low, except the potassium which is moderate in the studied regions. In spite of that, we can notice that Mg, P, S, Cl and Ca contents varied between the two regions. This means that the mineral content is affected by the habitats and accordingly the nutritive value of the plant can be affected.. Abdel-Salam [31] found that the ratio of Ca : P is the most important thing in the animal diet, as he said that it is preferred to be from 2 to three. In *C. comosum* this ratio is more than three in El-Dahnaa region (6.59/2.06), while it is less than two in Nefud Al-Shakika (3.55/2.78) which means that nutritive value of range plants can be affected in the different habitats.

From this work, we can say that *C. comosum* L`Her is completely adapted with the arid habitats, both morphologically and anatomically. The morphological characters can be altered according to environmental changes, but the floral characters are more or less fixed. Anatomical characters, especially those related to protection, altered according to the stress the plant faces. Mineral contents are affected by the habitats, as well; accordingly the nutritive value of the plant can be changed in the different habitats.

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