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Ecological and essential oils characteristics of *Deverra tortuosa* (Desf.) DC. in Egyptian deserts

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ABSTRACT

The present study aims to assess the relationship between soil chemical characteristics and associated species and the essential oils of *Deverra tortuosa* **(**Desf.) DC. in two Egyptian deserts.

Plant samples were collected for chemical analysis from two desert habitats differing in climatic and edaphic conditions: coastal (West of Alexandria) and inland (Wadi Hagul) in the eastern desert.

D. tortuosa is recoded as a common associate in most of plant communities. Higher associated plant species were recorded in the coastal desert (32 species) compared with 15 species in inland desert. Soil chemical properties were generally higher in the coastal desert except pH and sulphates showed higher values in inland desert.

Forty essential oils from *D. tortuosa* were recorded in both inland and coastal desert habitats, of which 21were restricted to inland desert, 10 were found in coastal desert and nine are represented in both habitats. The obtained results will optimized the application of *Deverra tortuosa*as a source of essential oils.

Keywords: Apiaceae, *Deverra tortuosa*, Egyptian deserts, essential oils, soil variables.

INTRODUCTION

Desert vegetation is particularly sensitive to the natural and human interventions. Many species are of economic importance in the arid regions playing a significant role in soil protection and sand dune stabilization against movement by wind or water. In addition, they provide a source of forage for animals, fuel and food for local inhabitants and have medicinal and potential industrial value (Laudadio *et al.*, 2009a,b; Barakat *et al*,. 2010; Bansi *et al.*, 2014).

Deverra tortuosa is used by the Egyptians for the preparation of a carminative drink and is occasionally eaten by grazing animals (Ahmed *et al*., 1969). It is also used for relief of stomach pains, as an anti-asthmatic, against scorpion stings (Boukef *et al*., 1982), against intestinal parasites, when blood is excreted in the urine or when coughing blood, and for the regulation of menstruation (Pathak *et al*.,1974). *Deverra* species are used in traditional medicine for the treatment of fevers, hepatitis, asthma, diabetes digestive difficulties and rheumatism (Vérité *et al.*, 2004). The species is known in traditional local medicine for the treatment of hypertension, against constipation, and in the case of bites (El-Mokasabi, 2014).

Essential oils, i.e. volatile secondary substances of plant origin, can have wide ranging applications in traditional folk medicine and food, flavoring, cosmetic and fragrance industries. Recently, many

essential oils and their constituents have been investigated for their multifunctional properties (Hajji *et al*., 2010).

Plants, naturally, produce essential oils to protect them-selves from pathogen micro-organisms. These essential oils have been used in the folk medicine since thousands of years as antimicrobial (Fisher and Phillips, 2008). Essential oils were frequently referred to as the natural and environmentally friendly cleaning solutions. They are used as a substitute to chemicals to disinfect and spread a pleasant scent in the air (Segvic Klaric *et al.*, 2007). They are also used to control human diseases of microbial origin and to cure such diseases as atherosclerosis and cancer (Warnke *et al.*, 2006).

Due to the high economic potentialities of *Deverra tortuosa* in particular the medicinal value, the present study was undertaken to compare the essential oil composition of *Deverra tortuosa* in relation to soil chemical variables and climatic conditions in two Egyptian deserts.

MATERIALS AND METHODS

1. Study species:

Deverra tortuosa (Desf.) DC. Synonym: *Pituranthos tortuosus (*Desf.) known in Arabic as "Guezzah", Strongly aromatic glabrous shrub, 30-80 cm; stems dichotomously branched, striate; leaves caducous; basal leaves 3-8 cm, 2-pinnatisect into linear-subulate, acute lobes; petiole sheathing, with broad scarious margin; lower cauline leaves with sheaths to 1.5 cm; blade 1-2.5 cm, ternatisect, the lobes linear-subulate; upper leaves reduced to sheaths with filiform apices; umbels mostly terminal; peduncle 1.5-4 cm, stout; umbel-rays 6-10, 1-2 cm, subequal; bracts 2-3 x 1-1.5 mm, triangular, the margin scarious, the apex mucronate; bracteoles minute; bracts and bracteoles persistent; pedicel 0-1.5 mm; flowers hardly opening; petals almost glabrous; styles longer than the depressed stylopodium; fruit 1-1.5 mm, globose, hirsute (Täckholm, 1974; Boluos, 1999 and 2002). It grows in almost all the phytogeographical regions of Egypt especially desert wadis, sandy and stony plains (Boluos 2000).

2. Study area

2-1 West Alexandria along Northwestern Mediterranean Coast

The Mediterranean coastal land of Egypt, in general, belongs to the semi arid climatic zone of Koppen's (1931) classification system (as quoted by Trewartha, 1954), and the Mediterranean bioclimatic zone of Emberger (1955). The bioclimatic map of UNESCO/FAO (1963) indicates that it is of a sub-desert warm climate. The maximum amount falls during either January or December and varies appreciably between the different stations. Rainfall of torrential nature may be expected –"values (in one day) up to 120.8 mm (Shaltout, 1983) (Table 1).

Table 1.Climatic data of meteorological stations (West of Alexandria and Wadi Hagul), Anonymous,(1980).

Meteorological variable	Mean	
	West of Alexandria	Wadi Hagul
Maximum air temperature (ºC)	24.9	27.6
Minimum air temperature (ºC)	14.9	17.6
Relative Humidity (%)	72	51.0
Evaporation (mm/day)	5.2	11.5
Rainfall (mm/month)	192.1	–

2-2 Wadi Hagul

Wadi Hagul occupies an area of approximately 345 km^2, in the Eastern Desert and lies at the Northwestern part of Suez Gulf. Wadi Hagul lies within arid desert climate with very low rainfall, high temperature and high evaporation rate. The metrological data of neighboring Suez station (climatic average of 28 years from 1985 to 2013) showed that the climate is obviously hot and dry. The mean annually air temperature is 23.5 ^{0}C; January is the coldest month with an average temperature of 14.7 ^{0}C; while August is the hottest one with temperature of 34.5^{0}C. Rainfall is scarce, patchy and usually cascades during the winter. The average annual rainfall is 2.7 mm (Table 1).

2-3 Field study

The present study was carried out at locations illustrated in Figure (1). Six individuals of *Deverra tortuosa* were sampled and composite soil samples were collected from the rhizosphere of the target species. In each habitat the associated species were recorded and voucher specimens were identified and deposited in the Herbarium of the Botany and Microbiology Department, Faculty of Science, Damietta University, Egypt. Identification and nomenclature of the plants were following Täckholm (1974); Boluos (1999, 2000, 2002).

Fig.(1): Location map of Egypt showing the different habitats of *Deverra tortuosa* in A: West of Alexandria (Coastal desert) and B: Wadi Hagul (Inland desert).

3. Laboratory analyses

Soil samples were air dried, passed through 2 mm sieve and analyzed for pH, conductivity (EC), chlorides and sulphates following the procedures of United States Salinity Laboratory (Jackson 1962; Piper1974), Total Nitrogen according to Microkhjeldahl method of Hawk *et al.*, (1947),Total Phosphorus according to The adopted method of the American Public Health Association (1992).Concentrations of the cations: Na^+, K^+, Ca^{+2} and Mg^{+2} were determined using a Corning 410 Flame

Photometer Model Jenway PFP7 (Rowell, 1994).

4. Essential oil isolation

Two samples of freshly aerial parts of *Deverra tortuosa* from Wadi Hagul representing Inland desert (400 g) and West Alexandria representing Coastal desert (300 g) were subjected to hydro-distillation for 8 hr using a Clevenger-type apparatus giving their essential oils, which yielded after drying over anhydrous sodium sulphate. The essential oils were stored in dark glass tubes under refrigeration (4°C) until use. The steam distilled oils were subjected to GC/MS analysis.

5. GC/MS analysis of the essential oils

GC/MS analysis for the essential oils was carried out using a Varian GC interfaced to Finnegan SSQ 7000 mass selective Detector (SMD) with ICIS V2.0 data system for MS identification of the GC components. The column used was DB-5 (J&W Scientific, Folosm, CA) cross-linked fused silica capillary column (30 m long, 0.25 mm internal diameter) coated with ploy dimethyl siloxane (0.5µm film thickness). The oven temperature was programmed from 50oC for 3 min. isothermally, then heating by 7^{o}C/ min. to 250^{o}C and isothermally for 10 min., at 250^{o}C. Injector temperature was 200^{o}C and the volume injected was 0.5 µl. Transitionline and ion source temperature were 250^{o}C and 150^{o}C, respectively. The mass spectrometer had a delay of 3 min. to avoid the solvent peak and then scanned from m/z 50 to m/z 300. Ionization energy was set at 70 eV. (Agriculture Research Center, National Research Center, Dokki, Cairo, Egypt).

2.8. Essential oils components identification

The different components were identified by their retention times and, as well as comparing the obtained EI-MS spectra with a series of previously reported EI-MS spectra deposited in NIST library.

RESULTS

In Egypt, *D. tortuosa* is one of the most widespread plant species in different phytogeographical regions. The abundance and vigor of the plant vary depending on the environmental conditions that prevail in each region.Thirty seven species are recorded with *D. tortuosa* in both habitats of which 32 were recorded in the coastal desert and fifteen species in inland desert (Table 2).

In the western Mediterranean coastal desert, where climate is semi-arid with relatively high rainfall (mean annual = 150-300mm), associated with relatively low temperature (mean annual = 20^{o}C), *D. tortuosa* grows as associated species with several psammophytes and halophytes dominating by e.g. *Ammophila arenaria, Atriple xhalimus, Suaeda pruinosa, Thymalaea hirsuta* and *Zygphyllum album*.

D. tortuosa grows as associated species in the eastern desert wadis e.g. Wadi Hagul which is extremely arid (mean annual = 15-30 mm), associated with high temperature (mean annual = 25^{o}C), *D. tortuosa* with true xerophytic plant species e.g. *Artemisia herbaalba, Echinops spinosissmus, Retama raetam, Zygophyllum decumbens* and *Zilla spinsa.*

Table 2. Plant species associated with *Deverra tortuosa* in Egyptian deserts.

Species	Coastal desert	Inland desert	Species	Coastal desert	Inland desert
Ammophila arenaria	+	-	*Lycium shawii*	+	+
Artemisia herba alba	+	+	*Lygeum spartum*	+	-
Asphodelus microcarpus	+	-	*Moltoniopsis ciliate*	+	-
Atractylis carduus	+	+	*Noaea mucronata*	+	+
Atriplex halimus	+	-	*Panicum turgidum*	-	+
Crucianella maritima	+	-	*Pennisetum divisum*	-	+
Deverra tortuosa	+	+	*Reaumaria hirtella*	+	+
Echinops spinosissmus	+	+	*Reseda alba*	+	+
Echiochilon fruticosum	+	-	*Retama raetam*	+	+
Echium sericium	+	-	*Salsola kali*	+	-
Elymus farctus	+	-	*Salvia lanigera*	+	-
Euphorbia paralias	+	-	*Suaeda pruinosa*	+	-
Globularia arabica	+	-	*Teucrum pollium*	+	-
Gymno carpos decandrum	+	-	*Thymalae ahirsuta*	+	-
Helianthemum lippii	+	-	*Zygophyllum album*	+	-
Launaea nudicaulis	+	+	*Zygophyllum decumbens*	-	+
Launaea spinosa	-	+	*Zilla spinosa*	-	+
Limoniastrum monopetalum	+	-			
Limonium pruinosum	+	-			
Lotus polyphyllos	+	-			
Number of strands in Coastal desert	**3**				
Inland desert	**3**				
Total number of species Coastal desert	**32**				
Inland desert	**15**				

Table (3) shows the chemical properties of the soil supporting the growth of *D. tortuosa* in coastal and inland desert of Egypt. Soil chemical properties were generally higher in the coastal desert except pH and sulphates showed higher values in inland desert.

Table 3.Chemical characteristics of soil that support *Deverra tortuosa* in Egyptian deserts.

Parameter	Coastal desert			Inland desert		
	Sites I	II	III	I	II	III
pH	7.56	7.55	7.46	7.81	7.97	7.96
EC (mS/cm)	0.59	0.49	0.36	0.21	0.49	0.38
Total N (%)	0.28	0.27	0.29	0.13	0.14	0.21
Total P (%)	0.41	0.56	0.31	0.26	0.12	0.14
Cl^- (%)	0.35	0.92	0.55	0.22	0.63	0.32
SO_4^{-2}(%)	0.03	0.04	0.02	0.12	0.23	0.19
Na^+ mg/100g soil	0.22	0.36	0.26	0.19	0.08	0.04
K^+ mg/100g soil	0.12	0.09	0.06	0.14	0.07	0.03
Ca^{+2} mg/100g soil	3.21	2.91	2.88	2.11	1.88	1.73
Mg^{+2} mg/100g soil	2.41	5.17	6.03	4.11	3.09	3.29

GC/MS analysis for the essential oils of aerial parts of *D. tortuosa* in two different localities in Egypt indicated the presence of 40 compounds; twenty one compounds were found in essential oil from inland desert only, ten compounds were found in essential oil from coastal desert and the rest nine compounds were found in the two localities e.g. (γ-terpinene, terpinen-4-ol and α-selinene) (Table 4).

Table 4: Comparison of essential oil components of *Deverra tortuosa* in Egyptian deserts.

No	Essential Oil component name	R.T	Coastal desert	Inland desert	M.F	M.W
1	3,5-heptadienal, 2-ethylidene-6-methyl	6.35	-	+	$C_{10}H_{14}O$	150
2	bicyclo[2.2.1]heptane-2,5-diol, 1,7,7-trimethyl	6.77	-	+	$C_{10}H_{18}O_2$	170
3	6-camphenol	6.87	-	+	$C_{10}H_{16}O$	152
4	exo-2,7,7-trimethylbicyclo[2.2.1]heptan-2-ol	8.03	-	+	$C_{10}H_{18}O$	154
5	(-)-myrtenol	8.12	-	+	$C_{10}H_{16}O$	152
6	2-pinen-4-one	8.41	-	+	$C_{10}H_{14}O$	150
7	cis-carveol	8.52	-	+	$C_{10}H_{16}O$	
8	(Z)-p-mentha-1(7),8-dien-2-ol	9.15	-	+	$C_{10}H_{16}O$	152
9	α-ylangene	10.82	-	+	$C_{15}H_{24}$	204
10	α-copaene	11.36	-	+	$C_{15}H_{24}$	204
11	β-copaene	11.54	-	+	$C_{15}H_{24}$	204
12	α-calacorene	14.29	-	+	$C_{15}H_{20}$	200
13	7-isopropyl-1,4-dimethyl-Azulene	16.49	-	+	$C_{15}H_{18}$	198
14	6-epi-shyobunol	12.52	-	+	$C_{15}H_{26}O$	222
15	4-epi-cubedol	13.47	-	+	$C_{15}H_{26}O$	222
16	caryophyllene oxide	15.04	-	+	$C_{15}H_{24}O$	220
17	isoaromadendrene epoxide	15.31	-	+	$C_{15}H_{24}O$	220
18	1.6-[1-(Hydroxymethyl)vinyl]-4,8a-dimethyl naphtha.	15.57	-	+	$C_{15}H_{24}O_2$	236
19	aromadendrene oxide-(2)	15.88	-	+	$C_{15}H_{24}O$	220
20	8-isopropenyl-1,3,3,7-tetramethyl-bicyclo[5.1.0]oct-5	16.63	-	+	$C_{15}H_{22}O$	218
21	2,5-octadecadiynoic acid, methyl ester	16.89	-	+	$C_{19}H_{30}O_2$	290
22	4-methoxy-6-(2-propenyl)-1,3-benzodioxole	13.86	+	-	$C_{11}H_{12}O_3$	192
23	butylidenephthalide	16.59	+	-	$C_{12}H_{12}O_2$	188
24	1.(4-Isopropyl-1,3-cyclohexadien-1-yl)methanol	9.62	+	-	$C_{10}H_{16}O$	152
25	citral	9.34	+	-	$C_{10}H_{16}O$	152
26	.β-eudesmol	16.17	+	-	$C_{15}H_{26}O$	222
27	cis-sabinene hydrate	8.01	+	-	$C_{10}H_{18}O$	154
28	p-mentha-1,4-dien-7-ol	10.49	+	-	$C_{10}H_{16}O$	152
29	cis-p-menth-1-en-3-ol	8.26	+	-	$C_{10}H_{18}O$	154
30	trans-ligustilide	17.67	+	-	$C_{12}H_{14}O_2$	190
31	cis-p-menth-2-en-1-ol	6.74	+	-	$C_{10}H_{18}O$	154
32	cis-verbenol	7.27	+	+	$C_{10}H_{16}O$	152
33	cis-Z-α-bisabolene epoxide	16.28	+	+	$C_{15}H_{24}O$	220
34	perhydrofarnesyl acetone	19.06	+	+	$C_{18}H_{36}O$	268
35	γ-terpinene	5.65	+	+	$C_{10}H_{16}$	136
36	p-cymen-7-ol	9.80	+	+	$C_{10}H_{14}O$	150
37	(E)-p-menth-2,8-dien-1-ol	8.76	+	+	$C_{10}H_{16}O$	152
38	Ledene oxide-(II)	14.94	+	+	$C_{15}H_{24}O$	220
39	terpinen-4-ol	7.77	+	+	$C_{10}H_{18}O$	154
40	α-selinene	13.37	+	+	$C_{15}H_{24}$	204

DISSCUSION

In ecological studies of certain habitats of the Mediterranean coastal region of Egypt; variations in the distribution of vegetation type have been recognized in association with edaphic and topographic variations. These studies were either extensive general survey, or intensive with the objective of correlating vegetation and environmental variables, all were dealing

with specific types of habitat or confined to limited locations. The local distribution of communities in different habitats is linked primarily to physiographic variations. Ayyad (1973) reported that according to these variations two main sets of habitats might be distinguished in the western Mediterranean region of Egypt, one on ridges and plateaus, and the other in depressions. Ridge and plateau habitats may be further differentiated into two main types: (1) the coastal ridge, composed mainly of snow-white oolitic calcareous grains overlained by dunes in most of its parts, and the inland less calcareous ridges, and (2) the southern tableland.

Kamal and El-Darier (1995) recorded 91 species (52 perennials and 39 annuals) in the part of the western Mediterranean desert at about 65 km west of Alexandria. The most common perennials were *Thymelaea hirsuta*, *Noaea mucronata*, *Deverra tortuosa*, *Echinops spinosus*, *Anabasis articulate* and *Anabasis oropediorum*. The most common annual species were *Lobularia arabica*, *Adonis dentatus*, *Filago desertorum*, *Picris radicata* and *Cutandia dichotoma*. Hammouda (1982) reported that the most common perennials in the vegetation of the western Mediterranean coastal land were *Thyemela eahirsuta*, *Deverra tortuosa*, *Anabasis articulata*, *Gymnocarposdecander* and *Salvia lanigera*, and the most rare were *Stipagrostis ciliata*, *Diplotaxis simplex*, *Heliotropium bacciferum*, *Polycarpaea repens*, *Sonchus oleraceaus*, *Atriplex semibaccata*, *Anchusamilleri* and *Polycarpon succulentum.*

Wadi Hagul is one of the most notable and dry diverse wadis in the Eastern Desert. It includes most of the prospective projects areas in Egypt for relieving the overpopulation problem in the narrow strip of the Nile Delta. Two previous studies have been performed to evaluate the flora and soil-vegetation relationship in Wadi Hagul. Kassas and Zahran (1962) have been conducted a vegetation survey on the Red Sea coastal region, including Wadi Hagul. Later study by Abdelaal (2017) assessed the real status of floristic inventory in Wadi Hagul and defined the prevailing plant clusters and relate to soil and anthropogenic factors.

The results indicated that the chemical composition of essential oils from two deserts (coastal and inland) was different, this agrees to Al-Gaby and Allam (2009) who indicated that the volatile oils of *Deverra tortuosa* from Southern Sinai have a different composition from other regions in Egypt with camphene (31.0%) as the major constituent. The chemical composition of essential oils of the same plants may vary widely depending on geographical location, season, environmental conditions and nutritional status of the plants (Perry *et al*., 1999).

According to Al-Gaby and Allam (2000),the essential oil of *D. tortuosa* from Egypt is a mixture of a number of volatile components, mainly terpenoids, with camphene (31%) as the major constituent of the oil. According to krifa *et al.* (2015), the essential oil contained sabinene, α-pinene, limonene and terpinen-4-ol as major constituents. Sabinene and 4-terpineol (Abdelgaleil *et al*., 2012).

Previous reports on the chemical composition of *D. tortuosa* included the investigation of its phenolic, hydrodistilled essential oil and sesquiterpene lactone contents (Mahran *et al*., 1989; Abdel-Mogib *et al.*,1992; Abdel-Ghani and Hafez, 1995; Singab *et al*.,1998).The chemical composition of essential oils from aerial parts of *D. tortuosa* grown in some areas of Egypt has shown a wide range of variations even in their major constituents (Abdallah and Ezzat, 2011; Abdel-Ghani and Hafez, 1995; Al-Gaby and Allam, 2000).

The present study has attempted to indicate the effect of soil chemical variables and climatic conditionson the composition of essential oils of *D. tortuosa*in the coastal and inland desert in Egypt. The results contribute to improving the application of the plant as a source of essential oils.

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الخصائص البيئية وخصائص الزيوت الطيارة لنبات القزاح في الصحارى المصرية

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المستخلص

تهدف هذه الدراسة إلى تقييم العلاقة بين الخصائص الكيميائية للتربة والأنواع المرتبطة بها على الزيوت الطيارة المستخلصة من نبات القزاح في نوعين من الصحاري المصرية. تم جمع عينات نباتية من موائل صحراوية مختلفة في الظروف المناخية والتنافسية: الساحلية (غرب الإسكندرية) والداخلية (وادي حجول).

أشارت الدراسة الحقلية إلى أن نبات القزاح موزع على نطاق واسع وكان عدد الأنواع النباتية المرافقة له أعلى في الصحراء الساحلية (32 نوعًا) مقارنة بـ 15 نوعًا في الصحراء الداخلية. وقد كانت الخواص الكيميائية للتربة أعلى عمومًا في الصحراء الساحلية باستثناء الأس الهيدروجيني والكبريتات التي أظهرت قيمًا أعلى في الصحراء الداخلية. تم استخلاص 40 مركب من الزيوت الطيارة في كل من الموائل الصحراوية الداخلية والساحلية ، منها 21 مركب مقتصر على الصحراء الداخلية، 10 مركبات موجودة في الصحراء الساحلية و9 مركبات ممثلة في كلا الموائل. النتائج التي تم الحصول عليها سوف تحسن تطبيق استخدام نبات القزاح كمصدر للزيوت الطيارة.

Ecological and essential oils characteristics of *Deverra tortuosa* (Desf.) DC. in Egyptian deserts