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Ecology of four medicinal plants along the western Mediterranean coast of Egypt

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The study provides a description of the ecological features of four medicinal plant species: *Euphorbia paralias* L., *Glebionis coronaria* (L.) Tzvelev, *Lepidium draba* L. and *Phlomis floccosa* D. Don. in the Western Mediterranean Coast of Egypt. The results showed that, the total recorded species in the study area is 53 species belonging to 21 families. Based on their importance values, the classification of the plant species recorded in the 30 sampled stands, has resulted in three vegetation clusters (A, B and C), named after the first dominant species as follow, cluster A: *Fagonia cretica*; cluster B: *Ononis serrata*; and cluster C: *Euphorbia paralias*. The linkage between vegetation groups and soil variables was illustrated on the ordination diagram of Canonical Correspondence Analysis (CCA). It showed that, clay, pH, sodium, chloride, EC and potassium were the main edaphic factors that control the abundance and distribution of the characteristic species in the identified groups.

Keywords: Ordination, chorology, medicinal plants, Western Mediterranean coast.

1.Introduction

Nature has bestowed on people a very rich botanical wealth and a large number of plant species growing in different parts of the world. Medicinal plants have always been a basic resource for human health since the beginning of civilization, perhaps since the stone Age **[1]**. Medicinal plants have played an important role in the traditional and orthodox systems of medicine in curing different types of diseases **[2]**. The use of medicinal plants in most developing countries, as a normative basis for the maintenance of good health, has been widely observed. Nearly 80% of the world's population relies on traditional medicine, mostly plant extracts, for primary health care **[3]**.

The flora of Egypt comprises about 2165 plant species in addition to many species that have been successfully introduced and naturalized in Egypt **[4, 5].** These species are distributed in different localities that vary in type of soil and prevailing climatic conditions. The Western Mediterranean coast of Egypt extends between Abu Qir and Sallum with a total length of 550 km. It is one of the richest phytogeographical regions in Egypt because of its relatively high rainfall. It contains 1033 species which represent about 50% of the total flora of Egypt **[6].** According to **[7],** there are six main landforms in the Western Mediterranean section, namely: coastal sand dunes, rocky ridges, inland plateau, wadis, saline depressions, and non- saline depressions.

Euphorbia paralias (family Euphorbiaceae) is a long-lived herbaceous coastal plant native to Africa, temperate Asia, and many parts of Europe and invasive in Australia. The plant is fleshy and glaucous with stalks that turn reddish brown with age and grows up to 70 cm tall. *Euphorbia* species are widely used in traditional medicine to treat diseases of stomach, liver and uterine cancer, and asthma diseases **[8].**

Glebionis coronaria, formerly called Chrysanthemum coronarium, is a species of flowering plant in the Asteraceae family. It is native to the Mediterranean region. It is cultivated and naturalized in East Asia and North America. It is an annual and herbaceous plant. This plant is an ornamental, even it was found as a common weed. The plant is valued as a food in China and Japan and has numerous

biological properties chiefly antioxidant, antimicrobial and anticancer **[9]**.

Lepidium draba L., hoary cress, is an herbaceous mustard (Brassicaceae) that is an invasive weed of agricultural land, pastures, rangeland, roadsides, and waste areas, particularly in disturbed, riparian, or irrigated sites **[10]**. This plant is rich with phenols, flavonoids, glycosides, saponins as well as antibacterial and antioxidant activities **[11]**.

Phlomis flocossa D. Don (Family Lamiaceae) is a perennial herb, growing up to 40 cm and native to Egypt, Libya and Tunisia. In Egypt, this plant inhabits rocky habitats along the Western Mediterranean region **[12]**. *Phlomis* species are rich sources of several classes of glycosides, including phenylpropanoids, diterpenoids, iridoids, flavonoids and phenylethanoids **[13]**.

The present work was conducted to (i) investigate the floristic features associated with the selected medicinal plants, and (ii) detect the soil factors prevailing the abundance and distribution of the recognized plant groups in the study area.

2. Materials and methods

2.1. Study area

The study was carried out along the western sector of Mediterranean coastal land of Egypt that extends for about 550 km between Alexandria westward to Sallum at the Libyan border and with an average width of 20 km in a north–south direction **(Fig. 1)**.

Fig (1): Map of Egypt shows the study area.

2.2. Vegetation and data analysis

Thirty stands of 20 m^2 each were selected along the study area, during Spring 2022. In each stand, all vascular plants were listed. The importance-value was estimated by the sum of relative-density and relative cover **[14]**. The plant species were named after Täckholm **[15]** and Boulos **[5].** According to Raunkiaer **[16]**, the life-form spectrum was labeled. The chorotypes of the surveyed species were created after Zohary **[17]** and Feinbrun-Dothan **[18]**.

TWINSPAN was operated to categorize the floristic records of 53 species in 30 stands **[19-20],** while DCA was directed to distribute the sampled stands. CCA-biplot to connect the leading characteristic species with the measured soil factors **[21]**.

2.3. Soil- analysis

Three soil samples were collected at 50 cm depth and pooled together as a composite-sample. For soil-texture, the drying sieves method was used to determine the percentage of soil fractions. Soil-porosity and water-holding-capacity were measured in accordance with the AOAC **[22]**. Organic carbon was quantified by the Walkley & Black method. Sulphates were valued using a $BaCl_2$ solution. Calcium carbonate was dissolved in HCl and then determined using NaOH. Total nitrogen was assessed by Kjeldahl-assay. Electrical-conductivity and soil pH were measured. Chlorides and bicarbonates were appraised by titration-method. Total-phosphorus was valued by the stannous-chloride. Soil Na^+, K^+, Ca^{++} and Mg^{++} were approximated using a Flame-Photometer. All of these methods were approved according to AOAC **[22]**.

3. Results

3.1. Floristic features

The floristic associates with the four medicinal plants in the present study are displayed in **Table (1)**. In total, 53 plant-species, 21 families documented in 30 stands. These species are distinguished into 27 annuals, 24 perennials and two biennials. The largest, most species-rich families were Asteraceae (16 species), Poaceae (8 species), and Chenopodiaceae= Brassicaceae= Fabaceae (3 each). The remaining seventeen families had a

low representation (by either 2 or one species each).

As displayed in **Table (1)**, the life-forms of 53 species encompassed 53% therophytes, 24% hemicryptophytes, 9% cryptophytes, 8% chamaephytes, and 6% phanerophytes.

The floristic classes of recorded-species are presented in **Table (1)**. Mediterranean elements had the highest contribution by 46%, Irano-Turanian elements (21%), and Saharo-Sindian elements (19%).

Table (1): Floristic analysis of the plant species recorded in the study area**.**

Species	Family	Life span	Life form	Floristic category
Aegilops kotschyi Boiss.	Poaceae	Ann	Th	IR-TR+SA-SI
Allium roseum L.	Amaryllidaceae	Per	Cr	SA
Ammophila arenaria (L.) Link	Poaceae	Per	Cr	ME
Anabasis articulata (Forssk.) Moq.	Chenopodiaceae	Per	Ch	SA-SI+IR-TR
Anthemis cotula L.	Asteraceae	Ann	Th	ME
Anthemis microsperma Boiss. & Kotschy	Asteraceae	Ann	Th	SA
Atriplex halimus L.	Chenopodiaceae	Per	Ph	ME+SA-SI
Avena fatua L.	Poaceae	Ann	Th	PAL
Beta vulgaris L.	Chenopodiaceae	Bi	Th	ME+ER-SR+IR-TR
Brassica tournefortii Gouan	Brassicaceae	Ann	Th	ME+IR-TR+SA-SI
Bromus diandrus Roth	Poaceae	Ann	Th	ME
Bromus rubens L.	Poaceae	Ann	Th	ME+IR-TR
Cakile maritima Scop.	Brassicaceae	Ann	Th	ME+ER-SR
Carduus getulus Pomel	Asteraceae	Ann	Th	SA-SI
Carthamus tenuis (Boiss & Blanche) Bronm.	Asteraceae	Ann	Th	ME
Centaurea calcitrapa L.	Asteraceae	Ann	Th	ME
Convolvulus althaeoides L.	Convolvulaceae	Per	H	ME+IR-TR+SA-SI
Conyza bonariensis (L.) Cronquist	Asteraceae	Ann	Th	NEO
Crucianella maritima L.	Rubiaceae	Per	H	ME
Cynara cornigera Lindl.	Asteraceae	Per	H	ME
Echinops spinosus L.	Asteraceae	Per	H	ME+SA-SI
Echium angustifolium Mill.	Boraginaceae	Per	H	ME
Emex spinosa (L.) Campd.	Polygonaceae	Ann	Th	ME+SA-SI
Eryngium creticum Lam.	Apiaceae	Per	H	ME+IR-TR
Euphorbia paralias L.	Euphorbiaceae	Per	H	ME+ ES
Fagonia cretica L.	Zygophyllaceae	Per	Ch	ME
Fumaria bracteosa Pomel	Papaveraceae	Ann	Th	ME+IR-TR+ER-SR
Glebionis coronaria (L.) Tzvelev	Asteraceae	Ann	Th	ME+IR-TR
Hordeum marinum Huds.	Poaceae	Ann	Th	ME+IR-TR+ER-SR
Hyoseris radiata L.	Asteraceae	Ann	Cr	ME
Launaea mucronata Subsp. *mucronata* (Forssk.) Muschl.	Asteraceae	Per	H	ME+SA-SI
Lepidium draba L.	Brassicaceae	Per	H	ME+IR-TR+ER-SR
Lotus polyphyllos E. D. Clarke	Fabaceae	Per	H	ME
Lygeum spartum Loefl. ex. L.	Poaceae	Per	H	ME
Malva parviflora L.	Malvaceae	Ann	Th	ME+IR-TR
Mesembryanthemum crystallinum L.	Aizoaceae	Ann	Th	ME+ER-SR
Ononis serrata Forssk.	Fabaceae	Ann	Th	ME+SA-SI
Ononis vaginalis Vahl	Fabaceae	Per	Ch	IR-TR+SA-SI
Onopordum alexandrinum Boiss.	Asteraceae	Bi	Th	IR-TR+SA-SI
Pancratium arabicum Sickenb.	Amaryllidaceae	Per	Cr	ME
Peganum harmala L.	Nitrariaceae	Per	H	ME+ IR-TR+SA-SI
Phlomis floccosa D. Don	Lamiaceae	Per	Ph	ME
Plantago notata Lag.	Plantaginaceae	Ann	Th	IR-TR+SA-SI
Poa annua L.	Poaceae	Ann	Th	COSM
Polygonum equisetiforme Sm.	Polygonaceae	Per	Cr	ME+IR-TR
Pseudorlaya pumila (L.) Grande	Apiaceae	Ann	Th	ME
Senecio glaucus L.	Asteraceae	Ann.	Th	ME+IR-TR + SA-SI
Silene succulenta Forssk.	Caryophyllaceae	Per	H	ME
Sonchus oleraceus L.	Asteraceae	Ann	Th	COSM
Thymelaea hirsuta (L.) Endl.	Thymelaceae	Per	Ph	ME
Urospermum picroides (L.) F. W. Schmidt	Asteraceae	Ann	Th	ME+IR-TR
Volutaria lippii (L.) Cass.	Asteraceae	Ann	Th	SA-SI

Life span is indicated by Ann: annual, Bi: biennial, Per: perennial, life form by Th: therophyte; Ch: chamaephyte; H: hemicryptophytes; Ph: phanerophytes; Cr: cryptophytes; and floristic category by ME: Mediterranean; SA-SI: Saharo-Sindian; IR-TR: Irano-Turanian; S-Z: Sudano-Zambezian; ER-SR: Euro-Siberian; PAL: Palaeotropical, COSM: Cosmopolitan

3.2. Analysis of vegetation data

Based on the importance value of the recorded species, classification of the 30 stands using TWINSPAN yielded three groups or community types labelled A, B and C **(Fig. 2)**. Group (A): *Fagonia cretica*, group (B): *Ononis serrata* and group (C): *Euphorbia paralias*. The identification was based on the first species with the highest importance values.

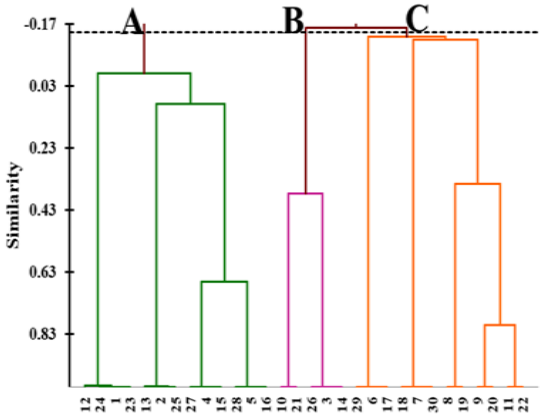

Fig. (2): TWINSPAN dendrogram shows the three vegetation groups. Dashed line shows the level of classification.

Vegetation group A included 28 species, distributed in 13 stands, with *Fagonia cretica* (IV=26.31) as the first dominant species **(Table 2)**. The most important associates in this group include *Onopordum alexandrinum*, *Emex spinosa*, *Glebionis coronaria*, *Echinops spinosus* and *Lepidium draba*. Group B comprised five stands and 19 species, dominated by *Ononis serrata* (IV=46.73). The other important species in this group were *Fagonia cretica* (IV= 15.75%), *Polygonum equisetiforme* (IV= 12.97 %), *Echinops spinosus* (IV=12.03 %), *Hyoseris radiate* (IV=12 %), *Pancratium arabicum* (IV= 11.34 %) and *Ammophila arenaria* (9.67%). Group-C included 12 stands and 27 species, and *Euphorbia paralias* as the first dominant species with the highest IV of 26.87%. *Pancratium arabicum*, *Thymelaea hirsute*, *Cynara cornigera*, and *Carduus getulus*, were the important species in this group with importance values of 18.43%, 13.79%, 12.13%, 11.61%, 9.79%, 9.39% and 8.79%, respectively **(Table 2)**.

Table (2): Characteristic features of three vegetation groups with their first and important species with their importance values (IV).

Group	No. of stands	No. of species	Dominant species	Important-species
A	13	28	Fagonia cretica (IV=26.31)	Onopordum alexandrinum (IV=20.93%), Emex spinosa (IV= 16.09%), Glebionis coronaria (IV= 15.65 %), Echinops spinosus (IV= 14.28%) and Lepidium draba (IV= 10.71%)
B	5	19	Ononis serrata (IV=46.73)	Fagonia cretica (IV= 15.75%), Polygonum equisetiforme (IV= 12.97 %), Echinops spinosus (IV=12.03 %), Hyoseris radiate (IV=12 %), Pancratium arabicum (IV= 11.34 %) and Ammophila arenaria (IV= 9.67%)
C	12	27	Euphorbia paralias (IV=26.87%)	Pancratium arabicum (IV= 18.43), Thymelaea hirsute (IV= 13.79), Cynara cornigera (IV= 12.13) and Carduus getulus (IV= 11.61)

Figure (3). Detrended Correspondence Analysis (DCA) ordination diagram of the 30 stands with vegetation groups.

The DCA of 30 sampled-stands is explained in **Fig. (3)**. It is obvious; the clusters group B was superimposed with group A at the right side of the diagram and also superimposed with group C but at the left side of the ordination diagram.

3.3. Vegetation- soil correlation

The distinction of soil within the obtained groups is in **Table (3)**. The group (A) preferred soils with high silt content (6.2%), clay (1.66%), water-holding capacity (38.12%), pH (7.96), bicarbonates (0.26 mg/100 g dry soil). Vegetation group B had the highest-values of sand (93.66%), sodium (65.74 mg 100 g^{-1} dry soil) and potassium (17.93 mg 100 g-1 dry soil). Finally, the soil of vegetation group (C) was characterized by the highest calcium carbonates (16.55%), organic carbon (0.70%), electric conductivity (0.83 umhos cm^{-1}), chlorides (1.09 mg 100 g^{-1} dry soil), and sulphates (2.76 mg 100 g^{-1} dry soil)

Table (3): Mean soil values± standard errors for three vegetation groups

Soil variable	Vegetation group		
	A	B	C
Sand (%)	92.13± 2.77	93.66±1.91	92.67±3.80
Silt (%)	6.± 2.53	4.78±1.81	5.89±3.55
Clay (%)	1.66± 0.66	1.56±0.11	1.45±0.53
WHC (%)	38.12± 3.19	36.67±3.53	36.55±3.03
pH	7.96± 0.39	7.79±0.30	7.68±0.31
$CaCO_3$ (%)	10.51±10.98	8.81±11.42	16.55±15.59
HCO3- (%)	0.26± 0.09	0.25±0.09	0.22±0.06
OC (%)	0.61±0.30	0.53±0.16	0.70±0.29
EC (mmhos cm^{-1})	0.54±0.34	0.55±0.18	0.83±0.63
Cl- (%)	0.61±0.68	0.59±0.33	1.09±1.04
$SO4^{--}$(%)	1.88± 2.49	1.44±2.64	2.76±3.16
Na+ (mg/ 100g)	35.13±15.81	65.74±35.76	51.35±30.65
K+ (mg/ 100g)	7.39±4.57	17.93±15.01	10.29±8.78

WHC: water-holding capacity, OC: organic carbon, EC: electrical conductivity.

Results of the CCA of characteristic species and soil factors, especially clay, pH, sodium, chloride, EC and potassium were the leading variables in the study area **(Fig. 4)**. *Lepidium draba* and *Emex spinosa* which were important species in group A showed a close relationship with pH. *Ononis serrata* which was an important species in group B showed close relationships with sodium and potassium. In the upper left side of CCA diagram, *Zygophyllum album* which was an indicator species in group C showed close relationships with electrical conductivity and chlorides.

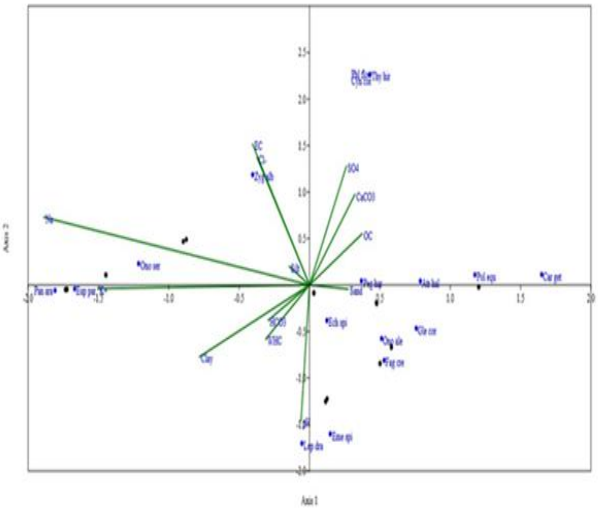

Fig. (4): CCA-ordination of the leading species (blue points) in each group (A, B and C) and soil variables (green arrows) in the present study. (Eigen value= 65%).

4. Discussion

In the 30 surveyed stands in the study area, the target four medicinal plants and their associated plant species included 53 species and were related to 21 families. About 62.26% of these species fit into only five families. These families were the leading families in the Egyptian flora **[5]**. These results agreed with previous researches **[23-26]**. The richness of a specific family reveals the capability of its members to persist under severe conditions, prevail in coastal-inland deserts (i.e. the study area) with high salinity and scanty rainfall.

The predominance of therophytes, Sahara-Sindian with Mediterranean-species was obvious in surveyed species. This indicates hot-dry conditions, and human factors in the study area **[27]**. The prevalence of Saharo-Sindian elements is a better indicator of harsh-conditions **[28]**.

The composition of life-forms provides information that may aid in judging the reaction of plant-cover to environmental features **[27]**. The life-form spectrums are physiognomic traits that are broadly defined in floristic studies. The supremacy of therophytes was correlated to the Mediterranean climate, short life-cycle, and ecological elasticity **[24– 25]**.

Therophytes are also less adapted to drought-salinity and their occurrence is sporadic; they grow only during the rainy-season **[27].** Approximately, 55.6 % of therophytes are represented in the Deltaic Mediterranean coast vegetation. The high number of annuals could be attributed to the study's timing (Spring, 2022) where enough-rainfall, which gave a good chance for annuals to appear. On the other hand, cryptophytes, hemicryptophytes, and chamaephytes have a part in the succession of vegetation in the coastal and inland deserts. The study area was clearly part of both Mediterranean territory and Saharo-Sindian-territory. This is clarified by the high contribution of Mediterranean and Saharo-Sindian chorotypes. This finding was confirmed by **[23, 28–30]** The current study contains a mixture of chorotype elements. This finding verifies the ability of a specific floristic category to invade the region from other neighbouring phytogeographic -regions **[30].**

A detailed description of vegetation is more important for providing a mental picture of a region and its vegetation, allowing for comparison and classification of vegetation units. Regarding classification, the vegetation that characterizes the study area was partitioned by the TWINSPAN classification into three vegetation groups or community types. The identified groups were more or less similar to those reported in previous studies **[24–26].**

Results of the CCA of characteristic species and soil factors, especially clay, pH, sodium, chloride, EC and potassium were the leading variables in the study area. The important environmental factors which regulate the growth and development of the Mediterranean region include rainfall distribution, soil and air temperatures.

5. Conclusions

The Mediterranean coastal region of Egypt are subjected to the latest human-induced threats influencing the vegetation and habitats, so a conservation strategy for them is urgently required. In the 30 surveyed stands, the investigated medicinal plants and their associated plant species included 53 plant species, and 21 families. Clay, pH, sodium, chloride, EC and potassium were the leading variables in the study area.

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