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Ecology of Centaurea calcitrapa L. and Centaurea glomerata Vahl in the Mediterranean coast of Nile Delta, Egypt

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Abstract: *Centaurea* is a genus from family Asteraceae that is featured by ethnobotanical properties and in used in folk medicine for treatment of various diseases. This work aims to identify abundance and distribution pattern of *Centaurea calcitrapa* and *C. glomerata* as well as, soil factors controlling their distribution in Mediterranean coast of Egypt. The results showed that floristic feature analysis to the study area revealed 65 species belongs to 24 families, the most recorded species were therophytes of Mediterranean origin. The analysis of Two Way Indicator Species Analysis (TWINSPAN) revealed six clusters (A-D); the indicator species were as follow, cluster A, *Juncus acutus*; cluster B, *Centaurea calcitrapa*; cluster C, *Centaurea glomerata* and cluster D, *Plantago squarrosa*. Canonical Correspondence Analysis (CCA) indicated that the major efficacious environmental agents (soil) that affect the distribution of *C. calcitrapa*, were water holding capacity (WHC), silt, clay, OC, K, P and N, while the controlling factors of *C. glomerata* were sand and $CaCO_3$.

keywords: Centaurea calcitrapa, Centaurea glomerata, CCA, Soil

1.Introduction

Asteraceae is considered one of the world's larger families of flowering plants, especially in the semi-arid regions of the tropics and subtropics, with approximately 1600 genera and 25000 species worldwide [1]. Boulos [2] mentioned in the flora in Egypt that Asteraceae comprises 228 species in 98 genera. The economic importance of this family can be broken down into various classification, food for man and animals, medicinal, wood, weeds, and garden plants than as a source of food. The most well-known food product of this family is sunflower oil, kernels lettuce and herbal tea like chamomile [3].

Centaurea, is a genus of family Asteraceae which comprise about 500 species of herbaceous plants native to the Mediterranean region. It is broadly used in Middle East folk medicine for treatment of several infections as anti-diarrheal, anti-inflammatory, ant-irheumatic, anti-pyretic and anti-bacterial [1,4]. Previous researches carried out on *Centaurea* species reported the occurrence of several natural constituents that display several biological actions [5, 6].

Centaurea calcitrapa is a biennial, herbaceous plant, commonly known as purple star-thistle. Traditionally, leaves and shoots of *C. calcitrapa* L. is utilized in diet, either fresh or in managed shape, for making tonics as well as it used in treatment of fever and jaundice [7,8,9].

Centaurea glomerata Vahl is an annual, monoecious plant. As reported by Shaltout *et al*., [10], this species is restricted to some habitats in the Mediterranean coastal region in Egypt. Previous phytochemical researches reported that this plant possess various compounds as sesquiterpene lactones and flavonoids as well as its antioxidant activity [11,12] which qualified it as folk medicine [13]. The aim of this work is to identify abundance and distribution pattern of *C. calcitrapa* L. and *C. glomerata* Vahl., and the soil factors controlling its distribution in Mediterranean coast of Egyp.

2. Materials and methods

1. Selection of Quadrates for Vegetation analysis

Twenty-five quadrates (area = 5 x 5 m each) were selected for sampling the vegetation associated with the selected species recognized in Qalabsho and Xian as well as Beheira governorate. Density and cover were estimated by Shukla and Chandel [14] and Canfield [15] assay, respectively. A calculation of relative density and relative cover were done and added together to give a rating of its importance value (IV) in each quadrate which is out of 200. All samples were set and preserved in the Herbarium of Botany Department, Faculty of Science, and Mansoura University. Life forms in the current study were described and classified by Raunkiaer [16,17]. The classification, identification, nomenclature and floristic categories were established by Zohary [18], Täckholm [19] and Boulos [20].

2. Soil Analysis

2.2. Physical characteristics

The soil textured were estimated by sieving method described by Piper [21]. Water holding capacity by Hilgard Pan Box [21].

2.3. Chemical characteristics

Calcium carbonate was measured by titration against 1N NaOH, the method was described by Jackson [22]. Oxidizable organic carbon was identified using Walkely and Black rapid titration method as mentioned by Piper [21]. Electrical-pH meter (Model lutron pH 206) was used to estimate the soil Electrical conductivity and pH [22]. The determination of chlorides was made by titration method using N/35.5 silver nitrate and potassium chromate solution as indicator [22]. Sulphates were determined gravimetrically using barium chloride solution [23]. The total nitrogen was estimated by the conventional semi-micromodification of Kjeldahl method [24].

Extractable cations were estimated According to Allen *et al*. [25], the extractable cations sodium and potassium were estimated by Flame Photometer (Model PHF 80 B Biologie Spectrophotometer), while calcium and magnesium were determined using atomic absorption spectrometer (A Perkin-Elmer, Model 2380.USA). Total phosphorus was estimated according American Public Health Association [26].

Data Analysis

Multivariate analysis: The classification of species data was carried out by using the Two-Way Indicator Species Analysis TWINSPAN [27]. Ordination was done by Canonical Correspondence Analysis (CCA) evaluate the relationship between plant species and environmental factors according to ter Braak [28].

Significance of variation: One-Way analysis of variance (ANOVA) was used to evaluate the significance of difference between a set of means of soil variables representing TWINSPAN groups using SPSS version 18.

3. Results and Discussion

1. floristic features

Plant Life-Span: The floristic composition of the plant species in the study area are presented, which demonstrated that, the overall number of plant species recorded in this study is 65 species. These species are classified as shown in Figure (1a) into three substantial groups based on their life span: 45 annual species (69%), two biennial species (3%) and 18 perennial species (28%).

Plant Life-Forms: In reference to the explanation of life-forms of the weeds represented in the current work are assorted into seven classes as follows: therophytes, chamaephytes, hemicryptophytes, cryptophytes and nanophanerophyes (Figure 1 b). The greater number of the recorded species are therophytes (68%), followed by hemicryptophytes (11%), geophytes (8%) then nanophanerophytes (6%). While the lowest class of life-forms was phanerophytes which exhibited value of 1%.

The floristic and chorotypes analysis: The current work showed that the total number of plant species surveyed and reported is 65 species belonging to 24 families (Figure 2a). The family Asteraceae represents 22% of the overall registered plant species, followed by family Poaceae 20%, Fabaceae 9%, Chenopodiaceae 6%, Polygonaceae and Boraginaceae each was 5%whereas the rest of families was 1%.

The most popular floristic elements recorded in the study area (Figure 2b) were Mediterranean with 47 species (39%), Saharo-Sindian with 18 species (22) Irano-Turaninan with 21species (17%), Euro-Siberia with 14 species (11%), Cosmopolitan with 8 species

(7%), Sudano-Zambezian with 6 species (5%), Palaeotropical with 3 species (2%) and Pantropical with one species (1%).

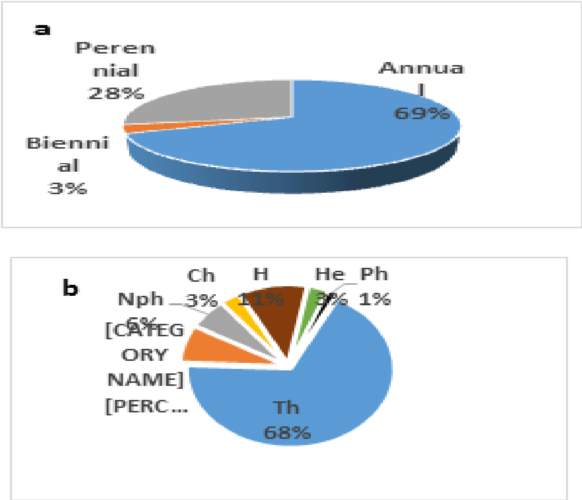

Figure (1): a) Plant life Span and b) plant life form in the study area. Th: Therophytes; G: Geophytes; NPh: Nanophanerophytes; Ch: Chamaephytes; H: Hemicryptophytes; He: Helophytes; Ph: Phanerophytes.

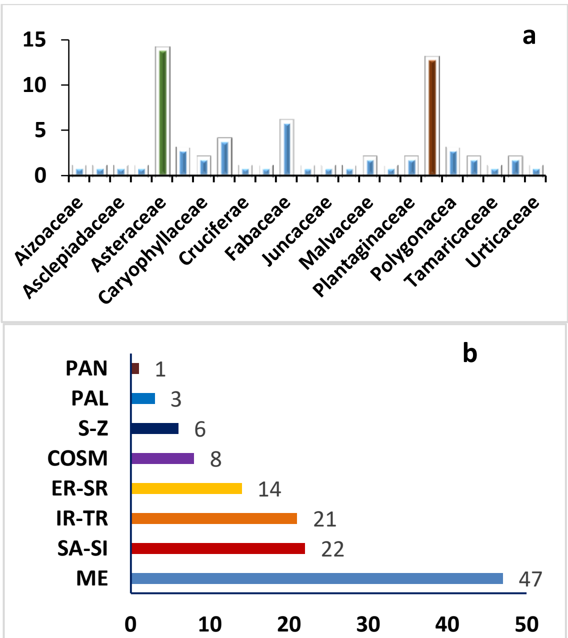

Figure (2a): The recorded families and b) the principal floristic categories of the recorded species in study area. ME: Mediterranean; SA-SI: Saharo-Sindian; IR-TR: Irano-Turanina; ER-SR: Euro-Siberian; COSM: Cosmopolitan; S-Z: Sudano-Zambezian; PAL: Palaeotropical; PAN: Pantropical.

2. Vegetation analysis:

An objective multivariate analysis was applied for a data set of 25 quadrates. The dendrogram diagram (Figure 3) produced by the two-way indicator type analysis (TWINSPAN) based on the relative density and relative cover values recorded four groups of plants that reflect the natural communities' composition in the field. Each group consists of a group of quadrates with more plant uniformity than the other groups. Group A consists of two quadrates. This group is co-indicated by *Juncus acutus* (important value = 42.75%). Group B contains eleven quadrates. *C. calcitrapa* is the indicator species with IV equals 41.59%. Group C consists of nine quadrates. *C. glomerata* indicates this group with IV = 29.38%. Group D involves three quadrates. This group is dominated by the *Plantago squarrosa* (IV = 30.03%).

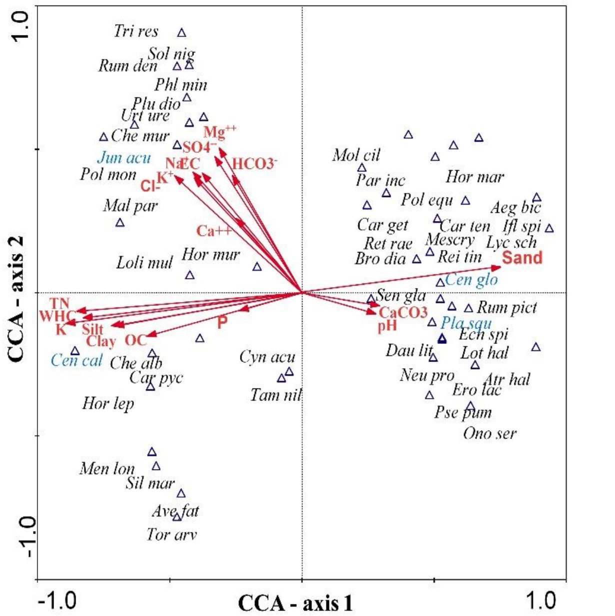

Figure (4): Canonical Correspondence Analysis (CCA) ordination biplot of the leading characteristic species and soil variables in the study areas.

Table (1): Importance values ± SD **of the indicator plant species.**

Species	Groups			
	A	B	C	D
Centaureacalcitrapa	15.65±22.13	41.86±23.74	0.00	0.00
Centaureaglomerata	0.00	0.00	29.38±14.84	29.40±21.64
Juncus acutus	42.75±10.96	0.00	0.00	0.00
Plantago squarrosa	42.75±10.96	0.00	2.57±5.46	30.03±3.52

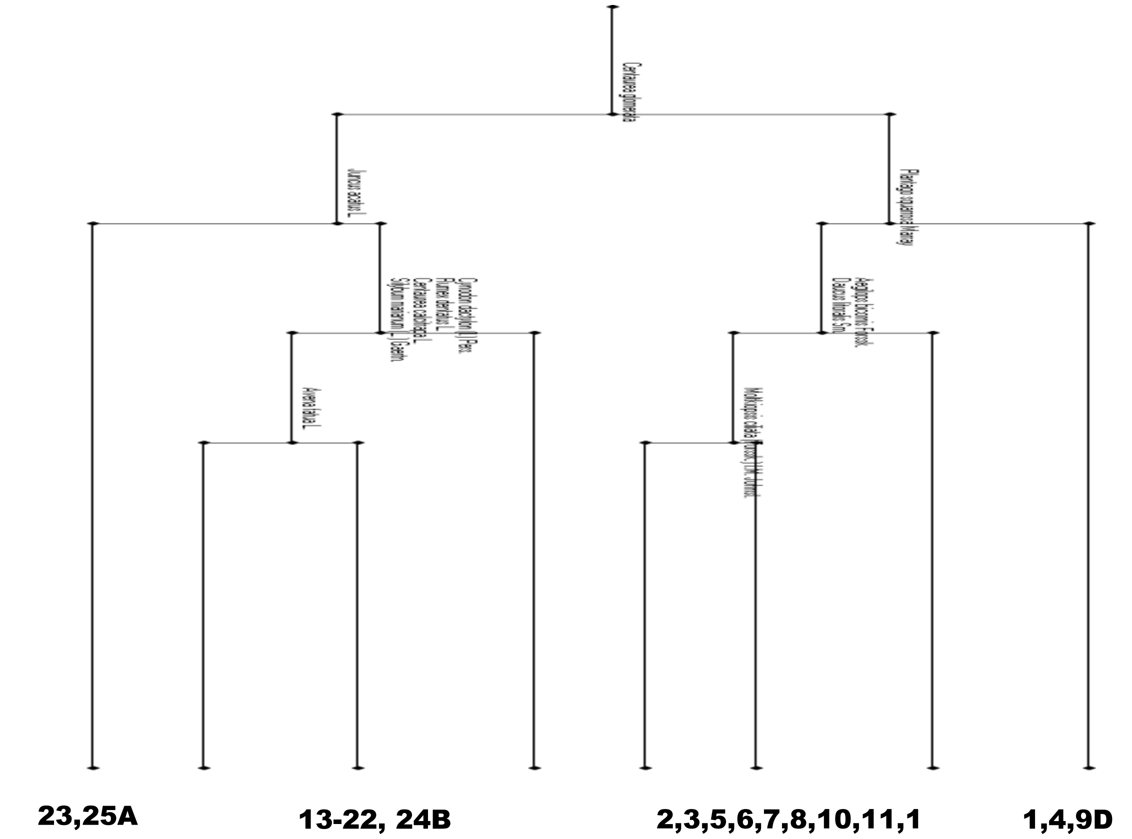

Figure (3): TWINSPAN dendrogram of the 25 quadrates based on importance values of 65 species at the study area. Indicator species are abbreviate to the first three letters of the genus and the first three letters of species name, respectively**.**

Vegetation-environment relationship:

The coordination diagram resulting from Canonical Correspondence (CCA) regarding the relationship between plant species and the soil is shown in Figure (4). The dots symbolize species, and the arrows symbolize soil factors. The length of the arrow expressed its relative importance. Dropping perpendicular to the arrows from each of the "species points" indicates the species' relative position along the ecological gradient represented by the arrow. The relationship among vegetation cover and soil features is displayed on the ordination diagram resulting from the CCA of the species biplot and environment. *C. glomerata* (indicator species in group C) exhibited a close relationship with sand at the upper right side of CCA diagram. On the other hand, *Plantago squarrosa* (indicator species of group D) showed a clear relationship with $CaCO_3$ and pH values at the lower right side of the diagram. In the more down left side of the CCA diagram, *C. calcitrapa* (group B) showed very close relationships with many soil variables such as, WHC, silt, clay, OC, K, P and N. While *Juncus acutus* (indicator species of group A), *Rumex dentatus*, *Pluchea discoriodes*, etc. showed a clear relationship with Ca^{++}, Cl^{-}, K^{+}, Na^{+}, SO_4^{--}, Mg^{++}, HCO_3^{-} and EC values at the upper left side

Soil analysis:

Table (2) showed the mean values of soil properties of groups produced by TWINSPAN and ANOVA analysis between these groups. Group A has the highest mean values of WHC, OC, EC, Ca^{2+} , Mg^{2+} ,Na^{+} , K^{+}, HCO_3^{-} , Cl^{-} and SO_4^{-2} (56.55%, 0.72%, 1.72, 1.97mg/100g, 1.19mg/100g, 4.75mg/100g, 0.87mg/100g, 2.23mg/100g, 4.84mg/100g and 1.70 mg/100g respectively). Group B showed relatively high mean values of sand, silt, clay and available N, P and K (45.24%, 36.48%, 16.68%, 69.47 ppm, 13.01 ppm and 295.25 ppm). Group C recorded the maximum mean value of $CaCO_3$ (5.30). Group D exhibited the highest mean values of pH (8.10) and the lowest mean values of WHC, OC, EC, Ca^{2+} , Mg^{2+} ,Na^{+} , K^{+} , HCO_3^{-} , Cl^{-} , SO_4^{-2} and available N, P and K.

ANOVA analysis revealed a very high significant variation of hydrosoil WHC, TN, and available among vegetation groups (p <

0.001). Sand, silt and clay, showed significant variation ($p < 0.01$), while Cl^- is slightly varied among groups ($p < 0.05$). Some variables are non-significantly different such as $CaCO_3$, OC, EC, pH, HCO_3^-, SO_4^{--}, Ca^{2+}, Mg^{2+}, Na^+, and K^+

Table (2) Mean values ± SD of the soil variables representing the four vegetation groups obtained by TWINSPAN and their ANOVA analysis. * = Significant at P ≤ 0.05; ** = Significant at P ≤ 0.01 and *** = Significant at P ≤ 0.001.

Soil parameters	Groups				P-value
	A	B	C	D	
Sand %	56.85±1.06	45.24±21.51	76.78±2.21	75.93±3.50	0.001***
Silt %	29.00±1.13	36.48±16.04	15.6±1.80	15.77±2.55	0.002**
Clay %	14.15±0.07	16.68±7.27	7.47±0.66	8.20±1.06	0.003**
WHC%	56.55±0.07	54.19±6.24	38.64±3.60	38.10±5.06	0.000***
$CaCO_3$ %	4.58±0.52	4.87±0.94	5.30±0.80	5.11±0.91	0.621ns
OC %	0.72±0.03	0.67±0.27	0.44±0.13	0.43±0.14	0.070ns
EC	1.72±1.48	0.88±0.63	0.55±0.17	0.46±0.02	0.058ns
pH	7.82±0.18	7.99±0.18	8.08±0.16	8.10±0.09	0.214ns
Ca^{++} mg/100g	1.97±1.36	1.09±0.60	0.85±0.16	0.79±0.06	0.062ns
Mg^{++} mg/100g	1.19±1.12	0.62±0.49	0.41±0.18	0.33±0.04	0.126ns
Na^+ mg/100g	4.75±4.19	2.47±1.88	1.31±0.39	1.22±0.06	0.051ns
K^+ mg/100g	0.87±0.98	0.42±0.38	0.19±0.12	0.12±0.02	0.072ns
HCO_3^- mg/100g	2.23±1.96	1.11±0.77	0.85±0.18	0.82±0.02	0.104ns
Cl^- mg/100g	4.84±3.88	2.57±1.75	1.33±0.51	1.17±0.07	0.027*
SO_4^{-2} mg/100g	1.70±1.82	0.91±0.78	0.56±0.19	0.44±0.03	0.160ns
TN (ppm)	68.67±1.64	69.47±6.42	55.65±4.75	52.62±3.17	0.000***
TP (ppm)	6.27±0.18	13.01±21.17	5.79±0.33	5.40±0.03	0.683ns
K (ppm)	291.42±4.57	295.25±14.14	264.21±14.00	249.67±8.34	0.000***

Discussion:

The natural plant wealth in the present work is consist of 65 species belonging to 24 families. Out of these families, Asteraceae comprises 14 species, followed by family Poaceae 13 species, Fabaceae 6 species and Chenopodiaceae 4 species were the major families. This indicated that, these families are principal taxa and comprise the chief part of the flora of the study area. This agrees more or less with the finding of Mashaly [29] on the ecology of the Deltaic Mediterranean coast, Galal and Fawzy [30] on the sand dune vegetation in the coast of the Nile Delta, Mashaly *et al.* [31] on the habitats and plant communities in the Nile Delta of Egypt, Maswada [32] on the ecology of some geophytes in the Mediterranean coastal region of Kafr El-Sheikh Province. The weed flora in the present work showed that the annual species shared with 69%, 3% of biennial species and 28% of perennial species. The prevalence of annuals could be attributed to their greater reproductive ability, ecological, morphological and genetic plasticity Galal and Fawzy [30], Maswada [32].

The composition of life forms provides information that can assist in acquiring a clear picture of how vegetation respond to any alteration in certain environmental aspects [33]. The life form spectra are significant physiognomic traits which have broadly used by ecologists and chorologists in the vegetation and floristic works. Also, it provides an insight into basic function of vegetation and may be considered as the most susceptible “registration apparatus” of the habitat [34].

Raunkiaer [16,17] counted the Mediterranean climate sort as therophyte due to the high percentage (more than 50% of the total species) of this life-form in the Mediterranean flora. This is confirmed later by Hassib [35] in Egypt, Zohary [36] in Palestine.

The dominance of therophytes is probably due to their short life cycles that provide it a capability to develop a resistance for the instability of the environmental condition. They have also a capability to set seeds without the need of pollinator [34]. The cryptophytes, hemicryptophytes and chamaephytes do an essential part in the process of sand accumulation and succession of vegetation in the study area. These life forms could act as obstacles in the way of wind and/or water borne materials which are thus deposited around them. These enable such plants to develop adventitious roots and aerial shoots from their buried organs and to replace these when they die [29].

The significant environmental aspects which control the growth and development of Mediterranean region comprise rainfall dispersal, soil and air temperatures. These aspects may fluctuate from year to year, which may give the plants adequate conditions for prolonging the period of vegetative growth up to late spring with flowering and fruiting periods arising in early summer [37]. This may explain why in the present study the vegetative and flowering stages have their peaks during spring in some habitats and during summer in others.

Phytogeographically, Egypt is the converging place of floristic elements belonging to at least four phytogeographical regions: the African Sudano-Zambezian, the Asiatic Irano-Turanian, the Afro-Asiatic Saharo-Sindian and the Euro-Afro-Asiatic Mediterranean [38]. The floristic analysis of the current study pointed out that, the Mediterranean taxa is represented by relatively high percentage of plant species (39%). This was confirmed by, Galal & Fawzy [30] , Mashaly *et al.* [31], Maswada [32].

Vegetation analysis by two-way indicator analysis (TWINSPAN) revealed that the studied plants (*C. calcitrapa* and *C. glomerata*) were the indicator species of groups B and C which represented the majority of the studied sites. On the other hand, the coordination diagram resulting from Canonical Correspondence (CCA) regarding the relationship between plant species and the soil factors showed that the most controlling factors affecting the distribution of *C. calcitrapa* were, WHC, silt, clay, OC, K, P and N as well as it is grow in sandy loamy soil. This agree with data reported about the ecology of *C. calcitrapa*, where it is present in a diverse range of soils, but in moist, heavy soils, they can expand very well. Also, it has been found in abundance on fertile soils (OC) in the United States and it is defined as adaptable over a variety of climates. It is observed on poorer pastures, on roadsides, around stock-yards and stock-yards Areas neglected [38], while the factors affecting *C. glomerata* distribution were mainly sand percentage followed by $CaCO_3$. Soil analysis revealed that the soil supporting *C. calcitrapa* was sand loamy where the soil supporting *C. glomerata* was sandy soil this in harmony with Huxley [39].

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