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# Vegetation Analysis and Distribution of Five Medicinal Plants along Altitudinal Gradient at SKP, South Sinai, Egypt

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**ABSTRACT: The aim of this study was to explore the change in vegetation structure and species distribution along altitudinal gradient at Saint Katherine Protectorate (SKP) mountains, with special attention to the distribution of five medicinal plants (*Cleome droserifolia, Achillea fragrantissima, Chiliadenus montanus, Origanum syriacum* and *Thymus decussatus*). 108 species (81perennial, 24 annual and 3 biannual) belong to 90 genera and 35 families were recorded with Asteraceae as the most abundant family. Elements of Saharo-Arabian chamaephytes were the major component of the floristic structure. The recorded species classified by cluster analysis into four vegetation groups. Most of soil variables unchanged significantly along the altitudinal gradient. The results of CCA ordination indicated that altitude, or the species' altitude range limits, was the most important factor affecting distribution of plants and determine the floristic composition. Seven endemic and three near-endemic species were recorded mainly above 1500 m. Some of them are very rare. The causes of rarity or low population size are not due to absence of suitable habitats but mainly due to the traits of species and their diaspores. The diaspores of some species possess anchor mechanisms which greatly reduce its dispersibility and hamper it to reach the relatively near suitable habitats. The ethno-pharmacological plants *A. fragrantissima, C. montanus* and *O. syriacum* appeared in groups B, C and D, while *C. droserifolia* appeared only in group A (at altitudes 210-680 m asl) and *T. decussatus* appeared only in group D (≈1932-2129 m). *C. droserifolia* and *O. syriacum* were less abundant than others.**

**Key words:** Altitudinal gradient; Ethno-pharmacological plants; Endemics; SKP, Sinai.

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## INTRODUCTION

The floristic studies in Sinai have been considered an attractive and interesting topic for many botanists and explorers, and received a special attention during the last four decades (Danin 1976, 1986, 1993, Batanouny, 1985, El-Hadidi, 1991, Fayed, 1991, Boulos and Gibali, 1993 and Boulos, 2008). The pre-Cambrian block of Southern Sinai is crossed by a great number of faults which caused by kratogenic disturbances dating back to the Cretaceous. The rocks of this old block are quite solid and weathering-resistance, so they remain as high peaks (such as Gabal Kathrina and Gabal Musa; Gabal= mountain). The degree of rock solidity additively affected the area's landforms. The wadis running in areas of very solid rocks are gorge-like, while those in areas of less solid rocks are wide (Abu Al-Izz, 1971). However, this roughness geomorphology of SKP has led to variations of enormous number of microhabitats and land forms which resulted in relatively high diversity in communities and flora.

The changing environmental factors attributed to altitudinal gradients, such as nutrients, temperature, photoperiod and light quality, have all been found to affect floristic composition of Saint Katherine mountains. Based on the World Health Organization (WHO, 2013), about 80% of the world populations still rely on medicinal herbs. Herbal medicinal products are used, for example, by nearly 19% of the adult populations in the United States (Kennedy, 2005, Patwardhan *et al.,* 2005, Zeeshan *et al.,* 2009). Flora of Sinai is rich with medicinal plants. *Thymus decussatus*, which is near-endemic in Saint Katherine, used as carminative, diuretics, urinary tract antiseptic and for kidney problems (Aboutable *et al.,* 1986). Several studies found that *Thymus* essential oils have antimicrobial activity against important pathogenic microorganisms such as *Staphylococcus aureus* (Bounatirou *et al.,* 2007, Rasooli and Mirmostafa, 2002), *Helicobacter pylori* and *Candida albicans* (Hazzit *et al.,* 2009; Zeeshan *et al.,* 2009; Faleiro *et al.,* 2003, Kshipra Nag and Zia-Ul Hasan, 2011; Anubha, 2013, Mohanraj and Karuppusamy 2017).

Mostafa *et al.,* (2016) showed that methanol extract contained some active constituents which have anti-microbial and significant cytotoxic activity against Ehrlich ascites carcinoma cell as well as two human cancer cell–lines (U251: brain- tumor and Hepg2: Liver carcinoma cell–lines). In addition, thyme oil is reported to have antispasmodic and expectorant, and as Khan and Abourashed, (2010) mentioned, these activities were found mainly due to thymol and carvacrol. They also reported that the thyme extracts, volatile oil, and main constituents have free radical scavenging and protective effects against hepatotoxicity, DNA damage and brain phospholipid oxidation.

*Origanum syriacum,* which endemic to Saint Katherine (Boulos, 2002), is used to treatment of upset stomach, headache, colics, nervous complaints, cough and other respiratory ailments (Batanouny *et al.,*1999, Der Marderosian and Beutler, 2002).

*Achillea fragrantissima* has been used in folk medicine in the Arabian region as hypoglycemic and also for the treatment of gastrointestinal disturbances (Segal *et al.,* 1987 and Yaniv *et al.,* 1987). In addition, this medicinal plant has analgesic, anti-ulcer, hepatoprotective and wound healing activities (Nemeth and Bernath, 2008). Bakr *et al.,* (2014) found that dichloromethane extract of *A. fragrantissima* contained some active compounds such as flavones (acerocine, cirsimaritin, cirsiliol, luteolin, apigenin) and phenolic acid (caffeic acid), from which acerocine have cytotoxic activity against liver cell carcinoma cell line, and has high free radicals scavenging activity.

*Chiliadenus montanus* is used for diarrhea, stomachaches, and chest diseases in traditional medicine (Täckholm, 1974). This plant is also used as a herbal tea for the treatment of renal troubles, and contain some chemical components which have been shown to exhibit anti-diabetic, anti-microbial, anti-obesity anti-atherogenic, and anti-oxidant activities (Al-Howiriny *et al.,* 2005, Hussein, 2011 and Hegazy *et al.,* 2014). Hydroalcoholic extract of *C. montanus* contained cinnamic acids, flavonols, quercetin glucuronide, syringentin galactoside or glucoside, kaempferol 3-O-acetyl-glucoside, and it used as antioxidant and has cytoprotective activities (Eissa *et al.*, 2013).

There are some considerable researches which confirmed the utility of *Cleome droserifolia* as a hypoglycemic herb (El-Khawaga *et al.,* 2010, Shtaiwi *et al.,* 2013). About 65 compounds have been detected in the hydro-distilled oil of *C. droserifolia* by which the oil exhibited antimicrobial activity and exerted significant growth inhibition on tested Gram-positive and Gram-negative bacteria (Kundu *et al.,*2013, Su and Ho, 2013 and Muhaidat *et al.,* 2015).

The present study aims to investigate the changes in floristic composition, biological spectrum, chorological affinities and describes the vegetation as affected by altitudinal gradient at SKP mountains. As the flora of Sinai include a considerable number of medicinal plants, more attention will paid for the distribution and associated species of five medicinal plants.

*A. The study area*

The Sinai Peninsula is a triangular plateau in the northeast of Egypt, and its area (61,000 $km^2$) is about 6% of that of Egypt. According to McGinnies *et al.* (1968) Sinai Peninsula has the geographical importance and uniqueness of being the meeting place of Asia and Africa. For this reason its flora combines elements from these two continents, Saharo-Arabian, Irano-Turanian, Mediterranean and Sudanian elements. Southern Sinai is an elevated triangular plateau with an approximate area of 28000 $km^2$ which is located between the Gulf of Suez to the west and the Gulf of Aqaba to the east. This elevated plateau is composed of igneous and metamorphic rocks with the highest peaks of Gabal Saint Katherine (2641 m asl), Gabal Um Shomer (2586 m asl) and Gabal Musa (2285 m asl) (Said, 1962, Abd EL-Wahab *et al.,* 2006 and Mosallam, 2007).

The Saint Katherine Protectorate (SKP) extends over virtually the entire mountain massif of southern Sinai. It is located between 33˚ 55' to 34˚ 30' East and 28° 30' to 28° 35' North with elevation range from1300 to 2600 m asl (Fig. 1). Its area 4350 $km^2$ so it considers the fourth largest protectorate in Egypt. It includes Egypt's highest peaks, which support a unique assemblage of high altitude ecosystems, with a surprisingly diverse fauna and flora and a relatively high representation of endemic species. SKP can be distinguished into six landform types namely: basins, slopes, gorges, wadi beds, terraces and caves. This differentiation in landform results from diversity of landscape and geological structure and each of these landforms has its peculiar environmental conditions and unique flora which is rich in medicinal, rare and endemic plants (Khedr, 2007).

SKP is one of the most floristically diverse spots in the Middle East with 44% of Egypt's endemic plant species. Boulos (1995) indicated that around 1261 plant species were recorded in Sinai. However, Fayed and Shaltout (2004) recorded 472 species in SKP, of these 19 species are endemic and more than 170 are with known medicinal properties used in traditional therapy and remedies.

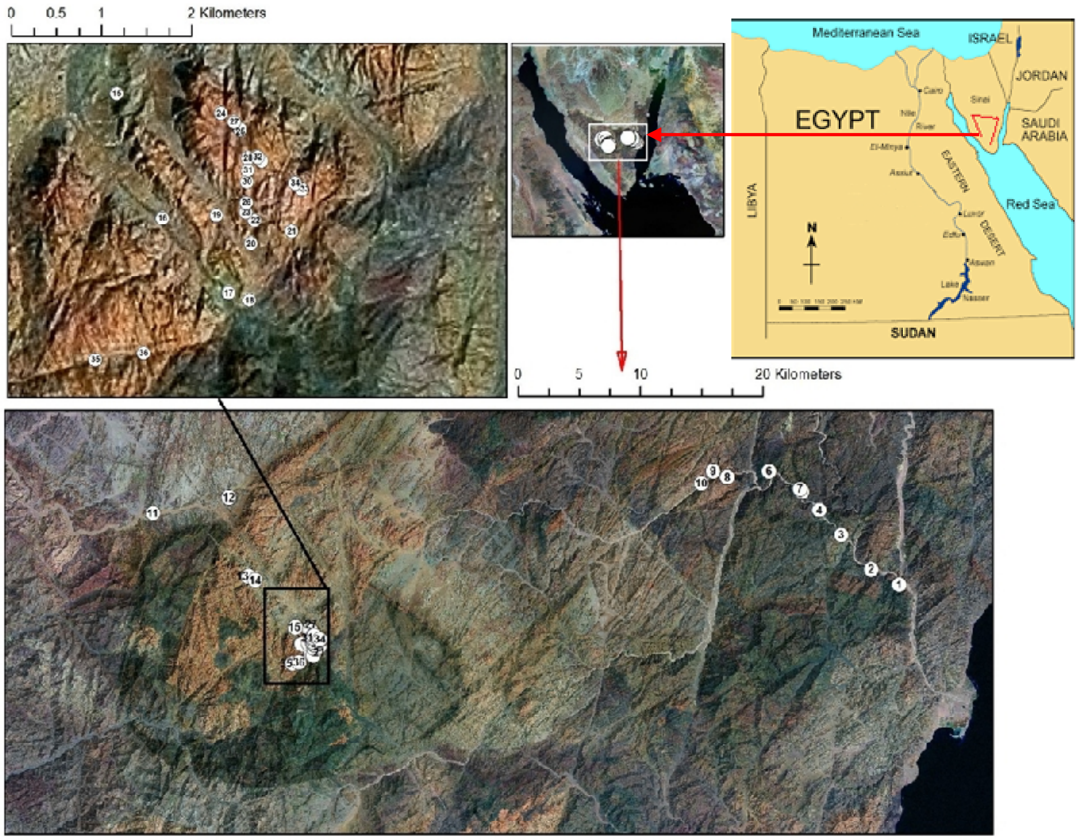


**Fig. 1.** Location map for the studied 36 altitudes at SKP mountains.

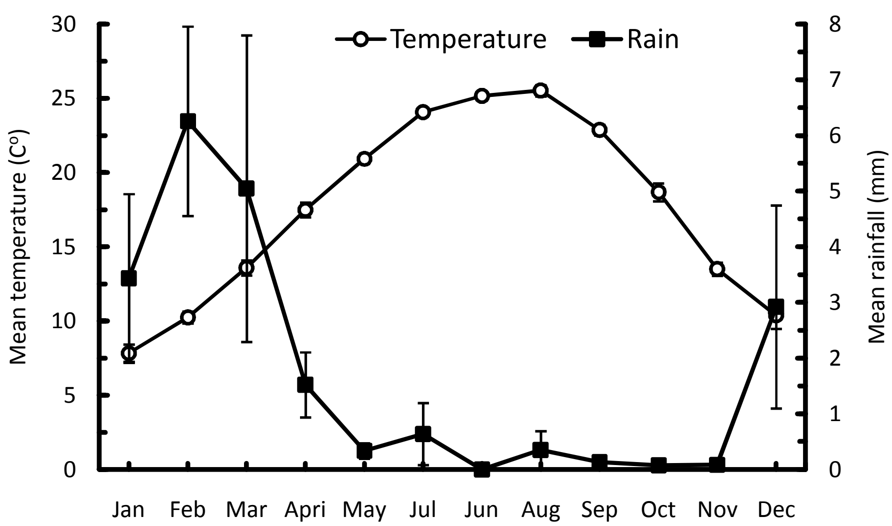


**Fig. 2.** Average temperature through the period from 2004 to 2016 and average rainfall through the period from 2004 to 2013. The vertical bars are SE, n = 13 for temperature, n = 10 for rainfall. Data obtained from SKP Meteorological Station.

Ayyad and Ghabour (1986) and Peel *et al.* (2007) indicated that Sinai Peninsula belongs climatically to the dry province. Saint Katherine is the coolest area not only in Sinai but in Egypt because of its high elevation. Fig. 2 shows the mean temperature in SKP during the period from 2004 to 2016 and mean rainfall during the period from 2004 to 2013.

Mean temperature ranged from 7.8 to 25.5 with the lowest temperature in January and February and the highest temperature in July and August. Rainfall is irregular, scanty and less than seven mm all over the year. Most of the months are rainy and the highest amount recorded in February while the lowest amount in June, July, Augusts, October and November.

## MATERIALS AND METHODS

This study has been carried out during 2016 and 2017. Thirty six altitudes were studied along SKP mountains (Fig. 1). The number of studied stands at each altitude was variable as the topography allowed, however one or few stands were studied at sharp slops, while several stands were studied at wadi beds or basins (farsh). Thus a total number of 94 stands were studied at 36 altitudes. Also, these altitudes were chosen according to the vegetation cover, however, some slopes are denuded and with no or scanty vegetation. At each altitude GPS fix was recorded in decimal degrees and datum WGS84 using Garmin 12 XL receiver. The fix was recorded to the fifth decimal digit. Arc View GIS 10.2 was used to plot the study sites. Vegetation cover was studied at each latitude; voucher specimens of each species were collected, and identified at SKP where they were deposited. The species identification was according to Boulos (1999, 2000, 2002 and 2005) and Fayed and Shaltout (2004).

### *A. Soil sampling and analysis*

Soil samples were collected from profiles of 0-10 cm depth. Its moisture content was determined by weighing before and after drying in an oven at 105°C for 24 h. The soil texture was determined by fractionation method based on the dispersion and settlement of particles in water and application of Stoke's law to separate silt, clay and sand (Allen, 1989). Soil water extract (1:5) was prepared for determination of soil reaction (pH) and electric conductivity using a glass electrode pH-meter and electric conductivity meter, respectively. Estimation of sodium and potassium were determined by flame photometer according to Jackson (1962). Calcium and magnesium were estimated by titration against EDTA (Jackson, 1967). Estimation of chlorides was carried out by $AgNO_3$ titration method (Jackson,1967). Nitrates were determined according to the method modified by Larson *et al.* (1989) from Kamphake *et al.* (1967). Sulphate were determined by a turbidimetric technique with barium chloride and acidic sodium chloride solution using spectrophotometer according to Bardsley and Lancaster (1965). Phosphates were determined colourimetrically as phospho-molybdate according to Vogler (1965).

### *B. Vegetation analysis*

Floristic data matrix of 36 altitude and 108 species was subjected for classification by cluster analysis of the computer program PAST (Hammer *et al.*, 2001). CANOCO computer program (ter Braak, 2003) was used for all ordination analysis; whereas the computer program SPSS 18.0 was used for all statistical analysis. Detrended Correspondence Analysis (DCA) was applied to check the magnitude of change in species composition along the first axis. The default settings of Canonical Correspondence Analysis (CCA) were used to relate directly the vegetation data to the corresponding measured soil parameters (ter Braak, 2003). Input data were grouped into two matrices: matrix altitude/species and matrix altitude/environmental variables. The CCA produces optimal linear adjustment of the distribution of specie's abundances depending on the environmental variables, axes extracted as linear combinations of environmental factors that best explain the variation in species distributions. However, the resulted CCA diagram shows the environmental variables in arrows that indicate the direction of maximum change of that variable across the diagram. The length of the arrow is proportional to the rate of change and also to what extend the variable is correlated with the ordination axes and thus with the community variation shown by the diagram. Therefore, CCA was performed with 14 soil variables: altitude, clay, silt, sand, Na, K, Ca, Mg, Cl, $SO_4$, $PO_4$, $NO_3$, total soluble salts (TSS) and water content (WC%). Significance of eigenvalues of the first canonical axis was tested by the Monte Carlo Permutation Test (499 permutations, ter Braak, 1994). Intraset correlations from the CCA's were used to assess the importance of the measured soil variables. The vegetation groups were subjected to One-Way Analysis of Variance (ANOVA) based on soil variables to find out whether there were significant variations among groups. Analysis of variance provides an insight into the nature of variation of natural events, into Nature in short, which is possibly of even greater value than the knowledge of the method as such (Sokal and Rohlfs, 1981).

## RESULTS

### *A. Floristic analysis*

Altogether 108 species (81 perennial, 24 annual and 3 biannual) belonging to 90 genera in 35 families were recorded. The more represented families were Asteraceae (17 species), Lamiaceae (12), Zygophyllaceae (8) Fabaceae (7), and Brassicaceae (6).

Asclepiadaceae and Scrophulariaceae represented by five species for each, while Poaceae and Solanaceae represented by four species for each. Five families, Boraginaceae, Caryophyllaceae, Malvaceae, Polygonaceae and Resedaceae represented by three species in each; whereas another four families, Cleomiaceae, Cucurbitaceae, Euphorbiaceae and Rosaceae represented by two species for each. Each of the rest 17 families was represented by only one species. Amongst genera, *Fagonia* was the largest one and represented by five species (Table 1).

**Table 1: Floristic composition, presence value, life form, duration and chorology of the recorded species in the studied area at SKP. Duration: Per= perennial, Ann= Annual and Bien= Biennial. Life form: Ch= Chamaephytes, H= Hemicryptophytes, Ph= Phanerophytes, Th= Therophytes. Chorology: SA= Saharo-Arabian, SZ= Sudano-Zambezian, IT= Irano-Turanian, ME= Mediterranean, SU = Sudanian, ES = Euro-Siberian, T = Tropical.**

| **Species** | **Family** | **Duration** | **Chorology** | **Life form** | **Presence (%) in each group** | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | **A** | **B** | **C** | **D** |
| Altitudinal range (m asl) | | | | | 210-680 | 1050-1362 | 1558-1906 | 1814-2192 |
| Number of stands/altitudes | | | | | 20/10 | 7/4 | 9/6 | 58/16 |
| Number of species (Total= 108) | | | | | 57 | 41 | 33 | 48 |
| **Species represented in the four groups:** | | | | | | | | |
| *Ballota undulata* (Fresen.) Benth. | Lamiaceae | Per | ME | Ch | 5 | 14.3 | 22.2 | 13.8 |
| *Echinops spinosus* L. | Asteraceae | Per | SA+IT | H | 25 | 28.6 | 22.2 | 41.4 |
| *Fagonia mollis* Delile | Zygophyllaceae | Per | SA | Ch | 40 | 42.9 | 66.7 | 10.3 |
| *Iphiona scabra* DC. | Asteraceae | Per | SA | Ch | 35 | 14.3 | 11.1 | 1.7 |
| *Peganum harmala* L. | Zygophyllaceae | Per | ME+IT+ES | H | 5 | 14.3 | 44.4 | 1.7 |
| *Seriphidium herba-album* (Asso) Sojak | Asteraceae | Per | IT | Ch | 30 | 42.9 | 33.3 | 79.3 |
| *Zilla spinosa* (L.) Prrantl | Brassicaceae | Per | SA | Ch | 55 | 57.1 | 44.4 | 50.0 |
| **Species represented in three groups:** | | | | | | | | |
| *Achillea fragrantissima* (Forssk.) Sch. Bip. | Asteraceae | Per | IT+SA | H | | 71.4 | 55. 6 | 8.6 |
| *Artemisia judaica* L. | Asteraceae | Per | SA | Ch | 30 | 57.1 | | 1.7 |
| *Chiliadenus montanus* (Vahl) Brullo | Asteraceae | Per | SA | Ch | | 42.9 | 88. 9 | 75.7 |
| *Stachys aegyptiaca* Pers. | Lamiaceae | Per | SA | Ch | | 14.3 | 88. 9 | 8.6 |
| *Diplotaxis harra* (Forssk.) Boiss. | Brassicaceae | Per | SA | H | 55 | 28.6 | | 5.2 |
| *Fagonia arabica* var. *arabica* L. | Zygophyllaceae | Per | SA | Ch | 55 | 14.3 | 22.2 | |
| *Gymnocarpos decandrus* Forssk. | Caryophyllaceae | Per | SA | Ch | | 14.3 | 11.1 | 20.7 |
| *Juncus rigidus* Desf. | Juncaceae | Per | SA+IT | H | | 14.3 | 11.1 | 31.0 |
| *Origanum syriacum* (Boiss.) Greater & Burdet* | Lamiaceae | Per | SA | Ch | | 14.3 | 22.2 | 19.0 |
| **Species represented in two groups:** | | | | | | | | |
| *Alkanna orientalis* (L.) Boiss. | Boraginaceae | Per | ME | H | | | 66. 7 | 22.4 |
| *Anabasis articulata* (Forssk.) Moq. | Chenopodiaceae | Per | SA+IT | Ch | 30 | 71.4 | | |
| *Anarrhinum pubescens* Fresen.* | Schrophulariaceae | Per | SA | Ch | | | 11.1 | 8.6 |
| *Blepharis edulis* (Forssk.) Pers. | Acanthaceae | Per | SA | H | 15 | 28.57 | | |
| *Centaurea eryngioides* Lam. | Asteraceae | Per | IT | H | | | 11.1 | 3. 5 |
| *Cleome arabica* L. | Cleomiaceae | Per | SA+IT | H | 5 | 14.3 | | |
| *Cleome droserifolia* (Forssk.) Delile | Cleomiaceae | Per | SA+IT | H | 75 | 14.3 | | |
| *Centaurea scoparia* Sieber ex Spreng. | Asteraceae | Per | IT | H | | | 11.1 | 41.4 |
| *Citrullus colocynthis* (L.) Schrad. | Cucurbitaceae | Per | M+SA+IT | H | 30 | 14.3 | | |
| *Fagonia boveana* (Hadidi) Hadidi & ElGarf | Zygophyllaceae | Per | SA | Ch | 10 | 57.1 | | |
| *Forsskaolea tenacissima* L. | Urticaceae | Per | SA+SZ | H | 85 | 42.9 | | |
| *Galium sinaicum* (Delile ex Decne.) Boiss. | Rubiaceae | Per | SA | Ch | | | 33.3 | 8.6 |
| *Gomphocarpus sinaicus* Boiss. | Asclepiadaceae | Per | SA | Ch | | | 44.4 | 5.2 |
| *Heliotropium arbainense* Fresen. | Boraginaceae | Per | SA | Ch | 20 | 14.3 | | |
| *Hyoscyamus boveanus* (Dunal) Asch. & Schweinf. | Solanaceae | Per | SA | H | 35 | 14.3 | | |

**Continued...**

| Species | Family | Duration | Chorology | Life form | Presence (%) in each group | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | A | B | C | D |
| Altitudinal range (m asl) | | | | | 210-680 | 1050-1362 | 1558-1906 | 1814-2192 |
| Number of stands/altitudes | | | | | 20/10 | 7/4 | 9/6 | 58/16 |
| Number of species (Total= 108) | | | | | 57 | 41 | 33 | 48 |
| **Species represented in two groups:** | | | | | | | | |
| *Iphiona mucronata* (Forssk.) Asch. & Schweinf. | Asteraceae | Per | SA | Ch | 15 | 28.6 | | |
| *Lavandula coronopifolia* Poir. | Lamiaceae | Per | SA | Ch | 10 | 42.9 | | |
| *Lycium shawii* Roem. & Schult. | Solanaceae | Per | SA+SZ | Ph | 15 | 28.6 | | |
| *Matthiola Arabica* Boiss. | Brassicaceae | Ann | SA | Ch | | | 22.2 | 37.9 |
| *Matthiola longipetala* subsp. *bicornis* (Sm.) P.W. Ball | Brassicaceae | Ann | ME+IT | Th | | | 33.3 | 24.1 |
| *Ochradenus baccatus* Delile | Resedaceae | Per | SA | Ph | 25 | 42.9 | | |
| *Phlomis aurea* Decne.* | Lamiaceae | Per | SA | H | | | 22.2 | 63.8 |
| *Plantago sinaica* (Barn.) Decne.* | Plantagonaceae | Per | ME | Th | | | 11.1 | 48.3 |
| *Pulicaria undulata* (L.) C. A. Mey. | Asteraceae | Per | SA | H | | 28.6 | | 32.8 |
| *Reseda stenostachya* Boiss.** | Resedaceae | Ann | SA | Th | 45 | 14.3 | | |
| *Retama raetam* (Forssk.) Webb. & Berthel. | Fabaceae | Per | SA+IT | Ph | 10 | 57.1 | | |
| *Scrophularia libanotica* Boiss. | Schrophulariaceae | Per | ME | Ch | | | 11.1 | 6.9 |
| *Sorghum virgatum* (Hack.) Stapf | Poaceae | Ann | T | Th | | | 11.1 | 1.7 |
| *Tanacetum sinaicum* (Fresen.) Delile ex Bremer & Humphries | Asteraceae | Per | IT | Ch | | | 33.3 | 100.0 |
| *Teucrium leucocladum* Boiss. | Lamiaceae | Per | ME+IT | Ch | | | 33.3 | 31.0 |
| *Teucrium polium* L. | Lamiaceae | Per | ME+IT | Ch | | | 11.1 | 53. 5 |
| *Verbascum sinaiticum* Benth. | Schrophulariaceae | Bien | IT+SA+SU | Ch | | 57.14 | | 37.9 |
| **Species represented in only one group:** | | | | | | | | |
| *Abutilon fruticosum* Guill. & Perr. | Malvaceae | Per | SU | Ch | 5 | | | |
| *Acacia tortilis* subsp. *tortilis* (Forssk.) Hayne | Fabaceae | Per | SA+SZ | Ph | 65 | | | |
| *Aerva javanica* (Burm. f.) Juss. ex Schult. | Amaranthaceae | Per | SA | Ch | 65 | | | |
| *Aizoon canariense* L. | Aizoaceae | Ann | ME+SA+IT | Th | 15 | | | |
| *Asphodelus tenuifolius* Cav. | Liliaceae | Ann | ME+SA+IT | Th | 20 | | | |
| *Calotropis procera* (Aiton) W.T. Aiton | Asclepiadaceae | Per | SA+SZ | Ph | 10 | | | |
| *Capparis decidua* (Fresen.) Edgew. | Cappariaceae | Per | SA+IT | Ch | 40 | | | |
| *Caylusea hexagyna* (Forssk.) M. L. Green. | Resedaceae | Ann | SA | Th | 10 | | | |
| *Chrozophora oblongifolia* (Delile) Spreng. | Euphorbaiceae | Ann | M+IT | Th | 5 | | | |
| *Crotalaria aegyptiaca* Benth. | Fabaceae | Per | SU | Ch | 20 | | | |
| *Cucumis prophetarum* L. | Cucurbitaceae | Per | SA | H | 15 | | | |
| *Cynanchum acutum* L. | Asclepiadaceae | Per | ME+IT | H | 5 | | | |
| *Diplotaxis acris* (Forssk.) Boiss. | Brassicaceae | Ann | SA | Th | 60 | | | |
| *Erodium glaucophyllum* L'Her. in Aiton. | Geraniaceae | Per | SA | H | 5 | | | |
| *Erodium laciniatum* (Boiss.) Batt. & Trab. | Geraniaceae | Ann | ME | Th | 5 | | | |
| *Fagonia glutinosa* Delile. | Zygophyllaceae | Per | SA | Ch | 10 | | | |
| *Fagonia schimperi* C. Presl | Zygophyllaceae | Per | SA | H | 20 | | | |
| *Malva neglecta* Wallr. | Malvaceae | Ann | ME+IT ES | Th | 5 | | | |
| *Moringa peregrina* (Forssk.) Fiori | Moringaceae | Per | SU | Ph | 20 | | | |
| *Onopordum ambiguum* Fresen. | Asteraceae | Bien | SA+IT | Ch | 5 | | | |
| *Otostegia fruticosa* (Benth.) Sebald. | Lamiaceae | Per | IT | H | 10 | | | |
| *Pergularia tomentosa* L. | Asclepiadaceae | Per | SA | Ch | 15 | | | |

**Continued...**

| Species | Family | Duration | Chorology | Life form | Presence (%) in each group | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | **A** | **B** | **C** | **D** |
| Altitudinal range (m asl) | | | | | 210-680 | 1050-1362 | 1558-1906 | 1814-2192 |
| Number of stands/altitudes | | | | | 20/10 | 7/4 | 9/6 | 58/16 |
| Number of species (Total= 108) | | | | | 57 | 41 | 33 | 48 |
| **Species represented in only one group:** | | | | | | | | |
| *Pulicaria incisa* (Lam.) DC. | Asteraceae | Per | SA | H | 90 | | | |
| *Rumex vesicarius* L. | Polygonaceae | Ann | ME+IT+SA | Th | 25 | | | |
| *Schouwia purpurea* (Forssk.) Schweinf. | Brassicaceae | Ann | SA | Th | 80 | | | |
| *Senecio flavus* (Decne.) Sch. Bip. | Asteraceae | Ann | ME+IT+ES | Th | 25 | | | |
| *Senna italica* Mill. | Fabaceae | Per | SA | H | 30 | | | |
| *Solenostemma arghel* (Delile) Hayne | Asclepiadaceae | Per | SA | Ph | 25 | | | |
| *Tephrosia purpurea* (Delile) Hosni & El-Karemy | Fabaceae | Ann | SA | Ch | 5 | | | |
| *Tribulus terrestris* L. | Zygophyllaceae | Ann | SA | Th | 30 | | | |
| *Trichodesma africanum* (L.) R. Br. | Boraginaceae | Ann | SA+SZ | Ch | 75 | | | |
| *Zygophyllum simplex* L. | Zygophyllaceae | Ann | SA+SZ | Th | 95 | | | |
| *Astragalus spinosus* (Forssk.) Muschl. | Fabaceae | Per | SA+IT | Ch | | 14.3 | | |
| *Datura stramonium* L. | Solanaceae | Ann | SA | Ch | | 14.3 | | |
| *Ephedra ciliata* Fischer & C. A. Mey | Ephedraceae | Per | ME | Ch | | 14.3 | | |
| *Launaea spinosa* (Forssk.) Sch. Bip. ex Kuntze | Asteraceae | Per | SA | Ch | | 42.9 | | |
| *Salvia sclarea* L. | Lamiaceae | Per | IT+ME | H | | 14.3 | | |
| *Solanum nigrum* L. | Solanaceae | Ann | SA | Ch | | 14.3 | | |
| *Stipa parviflora* Desf. | Poaceae | Per | M+IT | Th | | 14.3 | | |
| *Tamarix nilotica* (Ehrenb.) Bunge | Tamaricaceae | Per | SA | Ph | | 14.3 | | |
| *Astragalus tribuloides* Delile. | Fabaceae | Ann | SA+IT | Ch | | | 11.1 | |
| *Launaea capitata* (Spreng.) Dandy. | Asteraceae | Bien | SA+SZ | Th | | | 33.3 | |
| *Malva parviflora* L. | Malvaceae | Ann | ME+IT+ES | Th | | | 11.1 | |
| *Reichardia tingitana* (L.) Roth | Asteraceae | Ann | ME+IT | Th | | | 11.1 | |
| *Atraphaxis spinosa* L. | Polygonaceae | Per | IT | Ch | | | | 5.2 |
| *Bufonia multiceps* Decne.* | Caryophyllaceae | Per | SA | Ch | | | | 1.7 |
| *Cotoneaster orbicularis* Schltdl. | Rosaceae | Per | SA | Ph | | | | 1.7 |
| *Crataegus x sinaica* Boiss. | Rosaceae | Per | ME+IT | Ph | | | | 19.0 |
| *Deverra triradiata* Hochst.ex Boiss. | Apiaceae | Per | SA | Ch | | | | 29.3 |
| *Euphorbia chamaepeplus* Boiss. & Gaill. | Euphorbaiceae | Ann | ME+SA+IT | H | | | | 1.7 |
| *Ficus carica* L. | Moraceae | Per | SA | Ph | | | | 1.7 |
| *Helianthemum kahiricum* Delile | Cistaceae | Per | SA | Ch | | | | 5.2 |
| *Nepeta septemcrenata* Benth.** | Lamiaceae | Per | SA | Ch | | | | 24.1 |
| *Polygala sinaica* Botsch.* | Polygalaceae | Per | SA | Ch | | | | 8.6 |
| *Pterocephalus sanctus* Decne. | Dipsacaceae | Per | SA+IT | Ch | | | | 1.7 |
| *Salvia spinosa* L. | Lamiaceae | Per | IT+ME | H | | | | 1.7 |
| *Scrophularia xanthoglossa* Boiss. | Schrophulariaceae | Per | ME | Ch | | | | 24.1 |
| *Silene schimperiana* Boiss.* | Caryophyllaceae | Per | SA | Ch | | | | 3.5 |
| *Thymus decussatus* Benth.** | Lamiaceae | Per | SA | Ch | | | | 36.2 |
| *Verbascum decaisneanum* Kuntze | Schrophulariaceae | Per | IT+SA+SU | Ch | | | | 10.3 |

*: Endemic species
**: Near-endemic species

Achievement of life forms according to Raunkiear (1937) showed that the 108 recorded species were represented in four different life forms (Table 2): chamaephytes constituted the largest number of species (50 species = 46.3% of total), followed by hemicryptophytes (27 spp.=25.0%), therophytes (20 spp.=18.52%), and phanerophytes (11 spp.=10.19%). Chamaephytes were highly represented in group D, while therophytes and phanerophytes were in group A. It is worthy to mention that phanerophytic species were not appeared in group C (Table 2).

**Table 2: Life forms spectrum of the recorded species in the study area at SKP as number of species and percentages in each vegetation group. Ch= Chamaephytes, H= Hemicryptophytes, Th= Therophytes, Ph= Phanerophytes.**

| Life form | % of total | Vegetation group | | | |
|---|---|---|---|---|---|
| | | A | B | C | D |
| Ch | 50 (46.3%) | 21 (36.8%) | 22 (53.7%) | 19 (57.6%) | 30 (62.5%) |
| H | 27 (25.0%) | 16 (28.1%) | 13 (31.7%) | 8 (24.2%) | 12 (25.0%) |
| Th | 20 (18.5%) | 13 (22.8%) | 2 (4.9%) | 6 (18.2%) | 3 (6.3%) |
| Ph | 11 (10.2%) | 7 (12.3%) | 4 (9.8%) | - | 3 (6.3%) |

*B. Chorological affinities*

Chorological analysis of the surveyed flora revealed that 69 species (63.89% of the total flora) are monoregional of which 52 species (48.15%) native to Saharo-Arabian chorotype, seven species (6% of the total flora) native to Mediterranean chorotype, six species (5.55% of total flora) native to Irano-Turanian and three species (2.78% of total flora) native to Sudanian (Fig. 3). Biregional and pluriregional chorotypes extending their distribution all over the Saharo Arabian, Sudano-Zambezian, Irano-Turanian, Mediterranean, Sudanian and Euro-Siberian regions amounted to 23.15% of the recorded flora. However the Saharo-Arabian (bi- and pluri-regional) constituted 24.07%. Irano-Turanian and Mediterranean chorology were more represented in group D then group C, while Sudanian corotype was represented only in group A (Table 3).

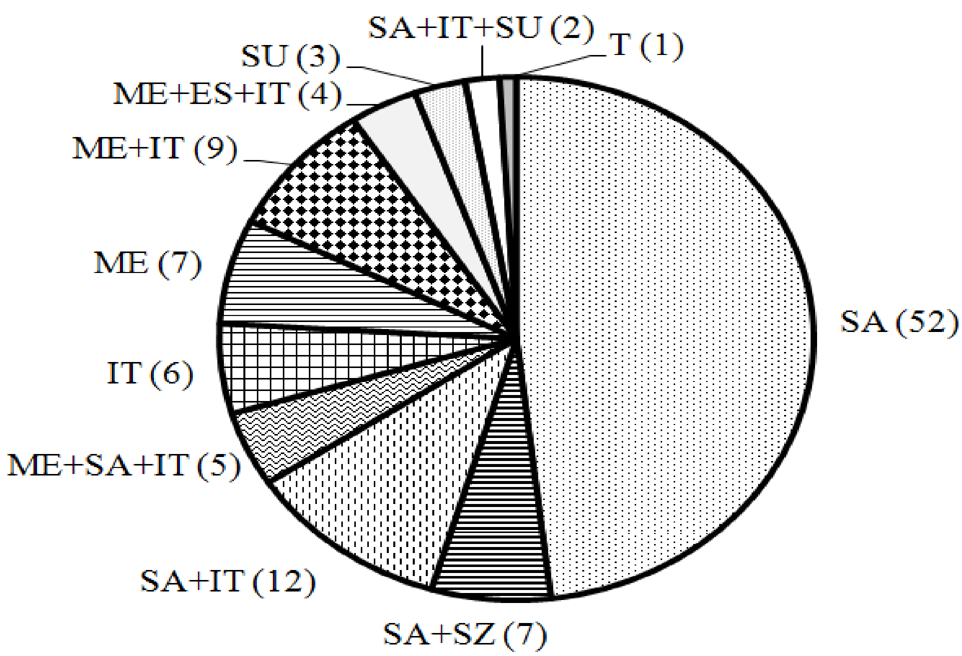


**Fig. 3.** Chorological analysis of the 108 recorded species along the altitudinal gradients at SKP. Number of species is between parentheses.

**Table 3: Chorology of the recorded species in each vegetation group at the study area of SKP. Abbreviations as in Table 1.**

| Chorotype | | Vegetation group | | | |
|---|---|---|---|---|---|
| | | **A** | **B** | **C** | **D** |
| Monoregional | SA | 28 | 23 | 13 | 24 |
| | ME | 2 | 2 | 4 | 5 |
| | IT | 2 | 1 | 4 | 5 |
| | SU | 3 | 0 | 0 | 0 |
| | T | - | - | 1 | 1 |
| | ∑ | 35 | 26 | 22 | 35 |
| Biregional | SA+IT | 7 | 8 | 4 | 4 |
| | ME+IT | 2 | 2 | 4 | 5 |
| | SA+SZ | 6 | 2 | 1 | 0 |
| | ∑ | 15 | 12 | 9 | 9 |
| Pluriregional | ME+IT+ES | 3 | 1 | 2 | 1 |
| | ME+IT+SA | 4 | 1 | 0 | 1 |
| | SA+IT+SU | 0 | 1 | 0 | 2 |
| | ∑ | 7 | 3 | 2 | 4 |

*C. Classification of vegetation*

Application of classification using cluster analysis to the floristic data yielded four vegetation groups (Fig. 4).

**Group A:** This group included ten altitudes (20 stands) ranging from 210 to 680 m asl. Fifty seven species were recorded in this group. The medicinal plant *Cleome droserifolia* was recorded in all altitudes of this group, while no another one of the studying medicinal plants were recorded in this group. *Zygophyllum simplex*, *Pulicaria incisa, Forsskaolea tenacissima* were dominant species in this group. Sporadic species (species recorded in one stand only) were represented by nine species or about 16% of the grouped species. Soils of stands comprising this group contained the highest amount of clay and $PO_4$ and the lowest content of silt, sand, Ca, Mg, K and $NO_3$.

**Group B:** This group included four altitudes (seven stands) between 1050 and 1362 m asl. Forty one species were segregated in this group. Three plants from the studying medicinal plants were recorded (*Achillea fragrantissima, Chiliadenus montanus* and *Origanum syriacum*), and *A. fragrantissima* was relatively the most abundant. *Seriphidium herba-album, Anabasis articulate* were dominant plants in this group, while the sporadic species were represented by 21 species (=51.22%). Soil samples of this group contained the highest amount of silt, Ca, Mg, Na, K, Cl, $NO_3$, $SO_4$ and TSS.

**Group C:** This included six altitudes (nine stands) which were between 1558 and 1906 m asl. It comprised 33 species including the same three medicinal species as in group B, but *O. syriacum* and *C. montanus* were have higher presence values in this group compared with others. *Stachys aegyptiaca, Alkanna orientalis* and *Fagonia mollis* were dominant species in this group. Thirteen sporadic species (about 39.39%) were recorded in this group. Soil samples contained low amount of Na, Cl, $PO_4$, $SO_4$ and TSS.

**Group D:** It included approximately 62% of the total studied stands (58 stands at 16 altitudes) and distributed along the highest elevations from 1814 m to the summits of mountains at SKP. It comprised 48 species including four from the studying medicinal plants: the three species as in groups B and C in addition to *Thymus decussatus* which represented only in this group. *Chiliadenus montanus* was well represented in this group. *Tanacetum sinaicum, Seriphidium herba-album, Phlomis aurea* were dominant plants in this group. Sporadic species, which found in only one stand, represented by 10 species or about 20.83% of the recorded species in this group. Soils of stands segregated in this group have intermediate contents of most estimated minerals; Ca, Mg, K, Cl, $NO_3$ and $PO_4$ were between A and C and $SO_4$ and TSS intermediate between A and B. Also, the highest and the lowest percentages of sand and clay, respectively, were estimated in soils of this group.

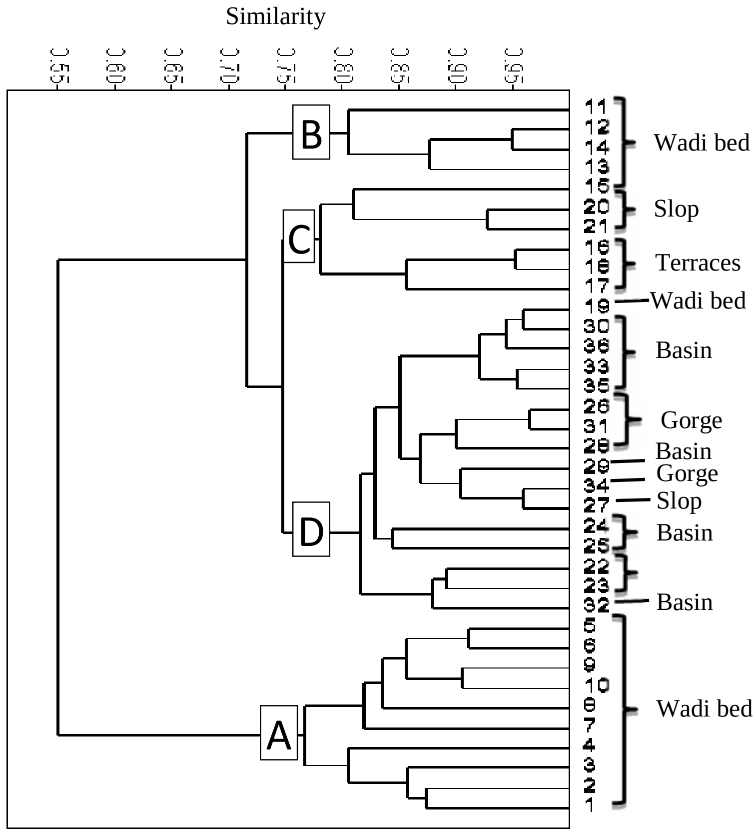


**Fig. 4.** Dendrogram showing cluster analysis of the 36 studied altitudes at SKP, with the habitat type and the four vegetation groups (A–D).

*D. Stand ordination*

When plotted on the first two Detrended Correspondence Analysis (DCA) ordination axes, the stands tend to cluster into the four vegetation groups which resulted from PAST (Fig. 5). Group A separated along axis one, group B separated intermediately between axis one and axis two, while both of groups C and D separated on axis two. The stands of groups A and B separated along the positive side of DCA axis one, while those of groups C and D separated along its positive end of the DCA axis two. The eigenvalue for the first DCA axis was 0.836 indicating that it captured the greater proportion of the variations in species composition among stands, followed by the second DCA axis (eigen value 0.194). The cumulative percentage variance of species data of the first two DCA axes was 25.1% (the total variance in the species data was 4.112).

*E. Soil–vegetation relationships*

Data of One Way ANOVA (Table 4 & 5) show that there are no significant differences in the determined soil variables within the separated vegetation groups except WC, K and Cl. The WC% in soil of group C and D was significantly higher than that in soil of group A, while concentration of Cl in soil of group A was significantly higher than that in others. The relationship between the vegetation and soil variables was studied using Canonical Correspondence Analysis (CCA). Figure 6 displays the CCA ordination biplot with vegetation groups (A–D), and the determined soil variables. It can be noted that, stands of group A were highly correlated with silt while those of group B showed a correlation with $PO_4$ and Cl. Plants composition in both groups C and D were correlated by altitude, sand, clay, WC, TSS, and K.

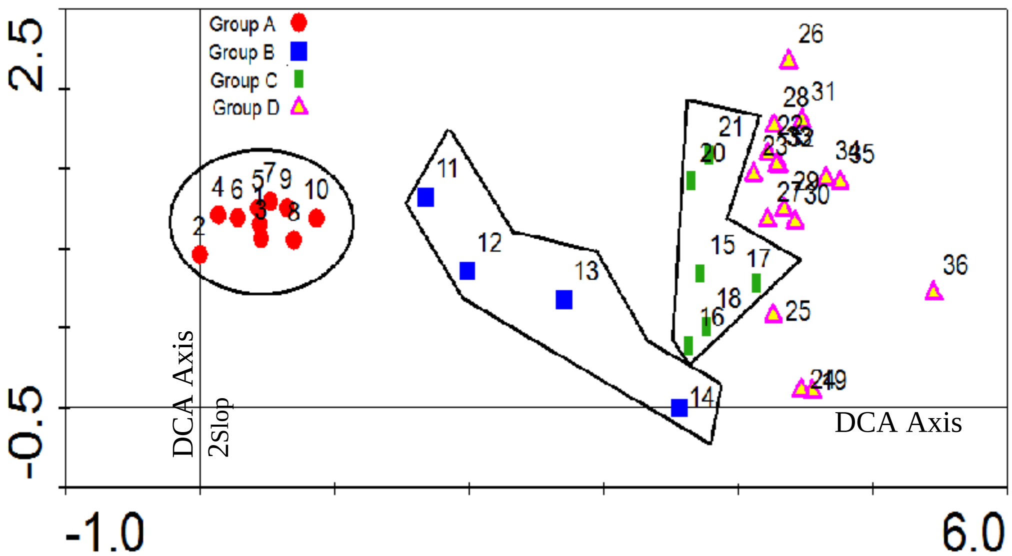


**Fig. 5.** DCA ordination diagram of the 36 altitudes on axes 1and 2 as classified by cluster analysis; A-D are the four vegetation groups.

**Table 4: The results of ordination for two CCA axes, Inter–set correlation of the soil variables, together with eigenvalues and species–environment correlation.**

| | Axis 1 | Axis 2 |
|---|---|---|
| Eigen values | 0.829 | 0.291 |
| Species-environment correlations | 0.996 | 0.947 |
| Alt | -0.994 | 0.023 |
| WC | -0.355 | 0.666 |
| Clay | -0.210 | -0.166 |
| Silt | 0.310 | -0.024 |
| Sand | -0.289 | 0.038 |
| $K^+$ | -0.085 | 0.761 |
| $Cl^-$ | 0.156 | 0.704 |
| $PO_4^{3-}$ | 0.248 | 0.180 |
| TSS | -0.149 | 0.614 |

The inter-set correlations resulted from Canonical Correspondence Analysis (CCA) of the determined soil variables were displayed in Table 4. The cumulative percentage variance of species-environment correlation was 65.9 for the first two axes. CCA axis one was positively correlated with silt, $PO_4$ and Cl and highly negatively correlated with altitude, WC, clay, sand, K and TSS, so CCA axis one can be defined as silt-altitude gradient. CCA axis two positively correlated with altitude, WC, K, sand, Cl and $PO_4$ while negatively correlated with clay and silt therefore CCA axis two defined as K-clay gradient. A test for significance with an unrestricted Monte Carlo permutation test (499 permutation) for the eigenvalue of axis one found to be significant (P=0. 05), indicating that the observed patterns did not arise by chance.

*F. Distribution of medicinal plants*

The distribution of five medicinal plants is shown in Fig. 7. *C. droserifolia* was found at altitudes lower than 700 m, so it represented by high presence value (75%) in the vegetation group A. Its associated species were *F. tenacissima*, *A. tortilis*, *A. javonica*, *P. incisa* and *Z. simplex* (presence ≥ 65%). In contrast, *T. decussatus* recorded at altitudes higher than 1800 m, therefore it was exclusively found in group D. The *T. decussatus* associated species were *S. herba-alba*, *C. montanus*, *P. aurea*, *T. sinaicum* and *T. polium.* The three other medicinal plants *A. fragrantissima*, *C. montanus* and *O. syriacum* were distributed in elevations between 1000 and 2130 m. These species were represented in groups B, C and D, but with more or less preference. The presence percentage of *A. fragrantissima* in groups B, C and D was 71.43, 55.56 and 8.62, while was 42.86, 88.89 and 75.86 for *C. montanus*, respectively. The associated species with *A. fragrantissima* were *A. Judaica*, *A. articulate*, *F. boveana*, *R. raetam* and *V. sinaiticum*, while the associated species with *C. montanus* were *F. mollis*, *S. aegyptiaca*, *A. orientalis*, *S. herba-alba* and *T. sinaicum.*

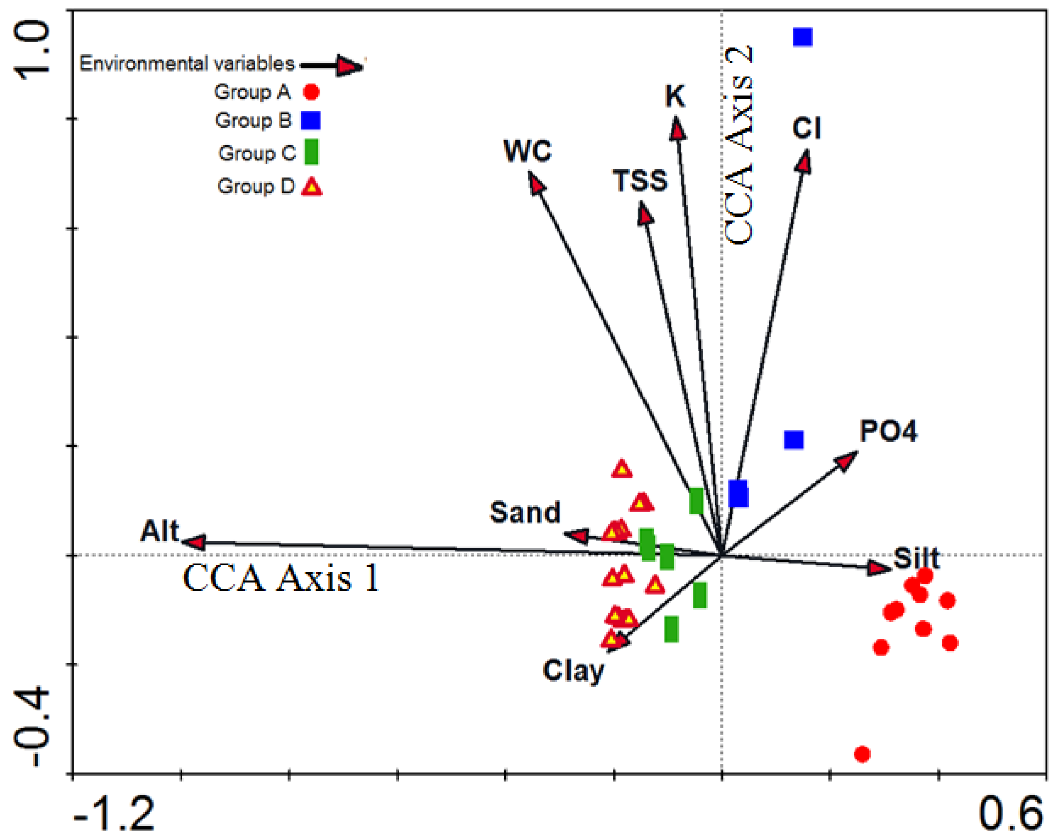


**Fig. 6.** Canonical correspondence analysis (CCA) biplot of axes 1 and 2 showing the distribution of the 36 altitudes, together with their vegetation groups and soil variables.

**Table 5: Mean values (± SE) of the soil variables across all altitudes or in each group (A-D), with F-values of one way ANOVA. TSS= total soluble salts, WC= water content.**

| Parameter | | Average across all altitudes | Vegetation group | | | | F-value |
|---|---|---|---|---|---|---|---|
| | | | A | B | C | D | |
| Silt | % | 2.049±0.113 | 1.875±0.208 | 2.500±0.510 | 2.083±0.264 | 2.031±0.156 | 0.804 |
| Clay | % | 2.014±1.060 | 4.625±3.801 | 1.875±0.361 | 1.250±0.323 | 0.703±0.227 | 0.804 |
| Sand | % | 95.938±1.072 | 93.500±3.868 | 95.625±0.625 | 96.667±0.264 | 97.266±0.126 | 0.717 |
| WC | % | 2.198±0.459 | 0.367±0.048[a] | 3.747±2.929[ab] | 1.689±0.330[b] | 3.146±0.647[b] | 3.043* |
| TSS | $mg\ g^{-1}$ dry soil | 1.353±0.075 | 1.283±0.042 | 1.841±0.511 | 1.217±0.124 | 1.327±0.094 | 2.040 |
| $Na^+$ | $mg\ g^{-1}$ dry soil | 0.165±0.016 | 0.168±0.014 | 0.217±0.121 | 0.098±0.021 | 0.176±0.020 | 1.406 |
| $K^+$ | $mg\ g^{-1}$ dry soil | 0.033±0.003 | 0.027±0.002[a] | 0.053±0.013[b] | 0.037±0.005[a] | 0.031±0.004[a] | 3.690* |
| $Ca^{2+}$ | $mg\ g^{-1}$ dry soil | 0.258±0.019 | 0.202±0.009 | 0.317±0.075 | 0.281±0.061 | 0.271±0.029 | 1.428 |
| $Mg^{2+}$ | $mg\ g^{-1}$ dry soil | 0.173±0.018 | 0.150±0.016 | 0.275±0.108 | 0.213±0.068 | 0.147±0.013 | 2.101 |
| $Cl^-$ | $mg\ g^{-1}$ dry soil | 0.554±0.029 | 0.581±0.024[b] | 0.715±0.197[ab] | 0.446±0.034[a] | 0.537±0.036[ab] | 2.310* |
| $NO_3^-$ | $mg\ g^{-1}$ dry soil | 0.064±0.011 | 0.045±0.010 | 0.107±0.069 | 0.071±0.036 | 0.062±0.014 | 0.773 |
| $SO_4^{2-}$ | $mg\ g^{-1}$ dry soil | 0.040±0.005 | 0.038±0.005 | 0.053±0.027 | 0.022±0.007 | 0.045±0.007 | 1.383 |
| $PO_4^{3-}$ | $mg\ g^{-1}$ dry soil | 0.066±0.007 | 0.073±0.015 | 0.106±0.043 | 0.048±0.012 | 0.058±0.008 | 1.700 |

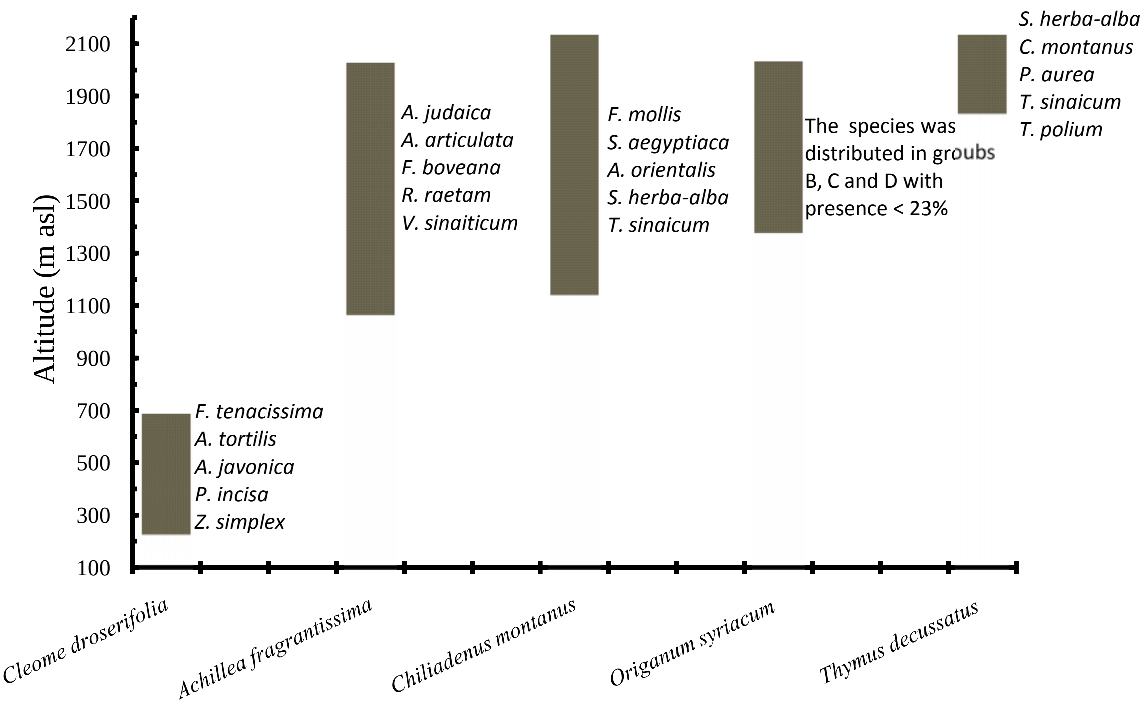


**Fig. 7.** The distribution of five anthro-pharmacological species along the altitudinal gradient at SKP mountains and the associated species.

## DISCUSSION

In this study, 108 species were recorded and as Abdel-Azeem (2009) previously found Asteraceae, Lamiaceae, Zygophyllaceae, Fabaceae and Brassicaceae were the dominant families in SKP. In his study on SKP, Mosallam (2007) was recorded 124 species, 60% of them were recorded also in this study. Omar (2010) recorded 72 species in the same region (except Wadi Zaghra) and Shabana (2013) recorded 63 species, from which 80.5% and 84% recorded in our study, respectively. In agreement with that was found by Moustafa and Zaghloul (1996) and Elmawy (2013), the results documented that chamaephytes are the dominant life form at SKP and represented by 46.3% of total recorded species. Trees in this study are few and represented by only two species. The previous studies documented also that South Sinai is characterized by the sparseness and dominance of shrub and subshrub and paucity of trees (Moustafa and Klopatek, 1995 and Helmy *et al.,* 1996).

Chorological analysis of the flora of the studied area indicates that most species are Saharo-Arabian in origin and represented by 48.15% followed by those of Mediterranean origin (6.48%). Previous work by Danin (1972, 1978 and 1986), Moustafa (1986 and 1990) and Boulos and Gibali (1993) indicated that the Irano–Turanian elements are also highly represented in Saint Katherine flora. In this study, the Irano-Turanian and Mediterranean elements are well represented in groups D and C, that because both groups constituting the highest altitudes of SKP mountains. On the other hand, there are ten endemic species, including two medicinal plants *Origanum syriacum* and *Thymus decussatus*. Ayyad *et al.* (2001) reported that four main phytogeographical regions contribute to flora of Sinai (Saharo-Arabian, Irano-Turanian, Sudanian and Mediterranean). Moustafa *et al.* (1999) indicated that most flora of Sinai belongs to the Saharo-Arabian phytogeographical region. They also found that the endemic species are representing 12.2% of the identified species in Saint Katherine area in south Sinai. Boulos, (2009) recorded 60 endemic species in the Flora of Egypt, Sinai comprises 31 endemic species, 24 from them found in Sinai only and seven in Sinai and another region/regions of Egypt. More than 70% of the endemic species in Sinai are confined to the Southern mountains of SKP. About 472 plant species have been recorded by Fayed and Shaltout (2004) as surviving and still occurring in SKP, of these 19 species are endemic (4% of the flora of SKP). Out of these 19 endemic species, Bolous (2009) reported that two species, *Thymus decussatus* and *Nepeta septemcrenata* are near-endemic.

Another different list including 16 endemic species in SKP was conducted by Zahran *et al.,* (2015). The Saint Katherine mountains considered by Zohary (1973) and Shmida (1984) as a center of endemism. In this study, seven endemic and three near-endemic species were recorded (9.3% of the total recorded species). Two from the near-endemic species *T. decussatus* (recorded in northwest Saudi Arabia) and *N. septemcrenata* (recorded in southern Palestine) and three from the endemic species, *S. schimperiana*, *B. multiceps* and *Polgala sinaica*, were recorded in group D only. The other four endemic species *O. syriacum, A. pubescens*, *P. aurea* and *Plantago sinaica* were represented in groups D and C (*O. syriacum* recorded at one altitude of group B). However, all endemic species were found mainly in group D (≈18.8% from the flora that clustered in this group) and partially in group C which inhabiting high altitudes. Zahran *et al.* (2015) reported that gorges are the most suitable habitats for the growth of endemic species, followed by slope habitats. In addition, they studied 12 endemic species in southern Sinai and found them distributing between altitudes 1383 and 2111 m asl. Some endemic species were rare, even *B. multiceps* collected from only one location and *S. schimperiana* collected twice from the surveyed area. However, mountain flora in SKP include most of endemic species, and this in agreement with Kheder, (2007) who found increased number of endemic species by increasing the altitude in Sinai.

Despite endemic species are those confined to a particular area or region, why some endemic species are rare and absent from the preferring-like habitats in the same area is still a challenging question. The possessing of some species or genera an anchorage mechanism for their diaspores may be one from the strong reasons for such rarity. Seed dispersal in many *Plantago* species is hygrochasy; where seeds of *P. coronopus* for example found to be dispersed after ten min of wetting and require another ten min to adhere to the soil surface. *Ballota* is another example of genera which known for its myxospermic diaspores (Van Oudtshoorn and Van Rooyen, 1999). There are some species with a wide range of tolerance and distributed with more or less abundance along different elevations. However, seven species appeared in all groups with different presence percentage from group to another. While the presence percentage of *Z. spinosa* was high in all vegetation groups, the presence of *I. scabra* was high in A, *B. undulate, F. mollis* and *P. harmala* were high in group C, and *E. spinosus* and *S. herba-album* were high in group D.

About 56% of plants that recorded in group A are exclusive. However, from the 32 species which appeared only in group A (210 to 680 m asl), 14 species are annual (43.75%). Most of these species are Saharo-Arabian and perform to inhabit wadi beds. In addition, most trees and shrubs that recorded in this study were presented in group A. In wadi beds, where the deep soil developed, the deep roots of such xerophytic trees penetrate, reach the water-table even during the hottest season and access to water throughout the year in their special habitats. Moustafa and Zayed, (1996) indicated that low elevation sites are climatically characterized by very dry summer with only 5-30 mm precipitation per year. The number of exclusive species decreased in the midst altitudes, so eight and four exclusive species were recorded in groups B and C, respectively. In comparison, there are 16 exclusive species appeared only in group D, which its stands were found at the highest altitudes. Increasing the number of species which restricted to low or high altitudes at SKP (exclusive plants in groups A and D), reflects the extreme environmental conditions at these altitudes.

The vegetation–environment relationships which were assessed by CCA indicated that altitude was the paramount important factor affecting the distribution of the species composition. Topography is a principal controlling factor in vegetation growth and the type of soils as recorded by O'Longhlin (1981), Wood *et al.* (1988) and Dawes and Short (1994). Elevation, aspect, and slope are the three main topographic factors that control the distribution and patterns of vegetation in mountain areas (Titshall *et al.,* 2000). Among these three factors, elevation is the most important (Day and Monk, 1974 and Busing *et al.,* 1992). Detrended Correspondence Analysis (DCA) separated the species composition into 4 groups. Group A was the most distinctive and separated one, because it included 32 exclusively faithful species not found in any of the other groups, most of them were typically xerophytes. This group included low altitudes (210-680 m asl) so the temperature is relatively high compared with other groups. Group B was intermediate between groups A from one side and C and D from the other side, because it included indifferent species without affinity to any group. Furthermore, vegetation group B occupied midst altitudes (1050–1362 m). Group C was approximately close to group D, due to reoccurring of many species (28 spp.) in both groups. In addition, habitats of high altitudes, above 1550 m, harbored 20 species don't found in lower altitudes. Generally, the soil analyses showed non-significant differences along the altitudinal gradient at SKP mountains. This may be due to the solidity of rocks and scarcity of rainfall which greatly reduce both of the mechanical and chemical weathering. However, the altitude, or the species' altitude limits, plays the major role in distribution of plants. The vegetation is sparse on steep slopes and gorges, while it is relatively denser on gentle slopes, terraces, basins and wadi beds.

Distribution of the five ethno-pharmacological species was variable between vegetation groups and along the altitudinal gradient.

Distribution of *O. syriacum* in this study was restricted to elevations between 1362 and 2032 m and that is close to what have been found by Elmawy (2013). This species found to be prefer habitats beside rocks in wadi beds and terraces, and this may be attributed to the richness of such places with moisture content. Also, the boulders protect the underlying plants from prolonged intensive solar radiation during the day hours. Seeds and achenes of some species need a continuous wetting for many days to germinate. The mucilaginous achenes of *Artemisia monosperma*, for example, adhere to the soil surface until they germinate after a minimum of ten days of continuous wetting (Koller *et al.,* 1964). *A. fragrantissima* recorded at elevations between 1050 and 2028 m with decreasing presence value by increasing altitude. In addition, this species was dominant in wadi beds. *C. montanus* grows mainly on slopes. *T. decussatus* was found usually at high altitudes, but it prefers basins (farsh) where more fine sand is accumulated and the soil retain more water. *C. montanus* (Syn., *Varthemia montana*) grows in south Sinai mainly in sandstone, magmatic and metamorphic rocks (Danin, 1983). However, this species mainly found on steep or gentle slopes. The population size of *O. syriacum* and *T. decussatus* was low compared to the other three medicinal plants.

## ACKNOWLEDGMENTS

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