Qatar Univ. Sci. J. (1995), 15 (2) : 339 - 352

ECOLOGICAL NOTES ON THE FLORISTIC COMPOSITION AND ENDEMIC SPECIES OF SAINT CATHERINE MOUNTAINS, SOUTH SINAI, EGYPT

BY

Abdel-Raouf A. Moustafa and Wafaa M. Kamel
Botany Department, Faculty of Science, Suez Canal University, 41522, Ismailia, Egypt

دراسة المجموعة النباتية والنباتات المتوطنة في منطقة سانت كاترين بجنوب سيناء - مصر .

عبد الرؤوف عبد الرحمن مصطفى ووفاء محمد كامل

استهدفت الدراسة تسجيل ووصف البيئات الطبيعية لكل الأنواع النباتية التي تنمو في منطقة جبال سانت كاترين بجنوب سيناء ودراسة العلاقة بين اختلاف عدد الأنواع النباتية المسجلة (في خمسة وأربعون موقعاً) مع كمية المطر المتساقطة في الفترة ما بين ١٩٩٢ - ١٩٩٤ . كما استهدفت الدراسة التوزيع الجغرافي الدقيق لعشرة انواع نباتية متوطنة ومهددة بالانقراض .

وقد أوضحت الدراسة العلاقة الموجبة بين كمية المطر المتساقطة وعدد الأنواع النباتية المسجلة حيث أن زيادة كمية المطر أدت الى زيادة معنوية في عدد الأنواع طردياً . وكذلك أوضحت الدراسة أهمية الرطوبة وتركيب قوام التربة وكذلك اختلاف طبيعة سطح التربة وأهميتها جميعا في انتشار النباتات على جبال المنطقة .

Key Words : Endemic species, Soil surface, Saint Catherine mountains, Precipitation.

ABSTRACT

The present study is aimed at (1) giving complete list of all plant species growing in Saint Catherine mountains, (2) studying the relationship between species number and the amount of precipitation at the time of study (1992 - 1994), and (3) reporting on the geographical distribution of the ten most endangered and endemic species in the study area. Presence / absence tests were applied to forty-five stands distributed in Saint Catherine mountains. Distribution and ecological data (including a detailed description of the microhabitats) of 221 species are given. The results show a positive correlation between the number of species and amount of precipitation in the mountain ecosystems and revealed the distribution pattern of ten endemic and endangered species growing within very limited area

INTRODUCTION

Many ecological studies have emphasized the importance of rainfall as a causal factor in determining the structure and composition of desert vegetation [1, 2, 3]. The rainfall effect has been described [2] as "the master input" or "driving variable" in the desert ecosystem, with topography as an important related factor because of its effects on the runoff of water and potential or free water evaporation. The relationship between vegetation and climatic factors have been fairly well described for the Southern Sinai area. The investigation of this relationship and the diversity of the floristic composition in Saint Catherine mountains are the subject of this study.

Sinai can be distinguished floristically into five main phytogeographical chorotypes [4, 5, 6]. Three of these chorotypes are of the the Saharo-Arabian complex territories where Saharo-Arabian species dominate the

list of species in all of them. The fourth chorotype consists of the Irano- Turanian species that occupy the southern Sinai Massif including the majority of Saint Catherine mountains. The fifth element is represented by the Sudanian species along the Gulf of Aqaba consisting mainly of by *Acacia* species.

The flora of Sinai comprises 900 species within 250-300 associations [4]. In a recent study [14] 984 species were recorded belonging to 465 genera of vascular Cryptogams and flowering plants in the study area.

The S. Sinai, including Saint Catherine mountains that is characterized by large outcrops of smooth-faced rocks, is floristically rich. In general, the flora of S. Sinai comprises 419 species as recorded by [4]. This area is characterized by a high number [28] of endemic species representing 14.9% of the total S. Sinai flora.

The plants in Saint Catherine mountains are subject to overgrazing and extensive felling, the latter being a serious problems threatening the plant life in the area. The bedouins use the plants for medicine and fuel purposes. Consequently, the number of plant species is decreasing and the pastoral plant communities are disappearing. The object of our study eas four-fold: (1) recording the species growing in the period (1992 - 1994), (2) describing their favorable habitats, (3) investigating the correlation between species numbers and amount of precipitation, and (4) indicating the geographical distribution of the most endangered and endemic species in the study area.

STUDY AREA

The study area includes the highest mountains in Egypt, Gebel Catherina (26224m), and Gebel Musa (2285m) (Fiigure 1). Its general altitude level is at 1500 - 2624m above sea level with several scattered high peaks. Its geomorphology forms a part of a highly rugged mountain with acid plutonic and volcanic rocks belonging to the pre-cambrian basement complex of the southern part of the Sinai Peninsula.

The Catherine pluton is located at the centre of the high mountainous area. It comprises a biotite granite with some alkaline affinities and beblongs to the youngest granite intrusive phase in the Arabo-Nubian

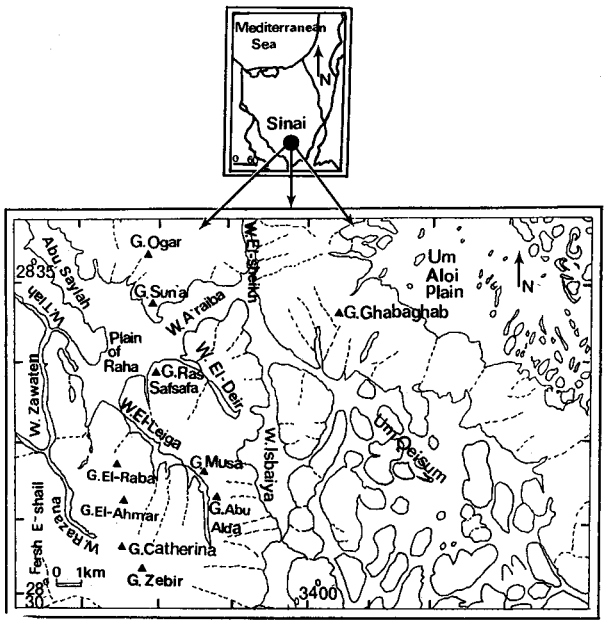

Figure 1. Map showing the location of the study area (Saint Catherine area) in South Sinai. Mountain tops (G = Gebel) represented by triangles. Dashed lines indicated drainages into wadis (W).

Massif. The mountaine has five main landform types: slopes, terraces, gorges, springs and ridges. Landforms are dominated by several plant communities that are determined by the soil surface and the moisture availability.

Sinai is a part of the Saharo-Arabian desert [15,4]. In general, its climate is influenced by the Mediterranean cyclone in the north and by the orographic impact of the high elevations in its south. Saint Catherine area is the coldest region owing to its higher elevation and its precipitation is characterized by its scantiness, seasonality and inconsistency. It occurs mainly in winter [October - April]. According to metrological data (Figure 2) the mean annual precipitation at Saing Catherine for a period of twenty-five years (1970 - 1994) is 45 mm/annum. Higher mountains, such as Gebel Catherina, receive higher amounts of precipitation (100 mm/annum) as rain and snow. In some parts of Saint Catherine, floods resulting from connective rains have been observed during winter and spring. Figure 3 shows the climatic data for 1985 - 1994 (including mean values of minimum and maximum temperatures and relative humidity). The minumum temperature occurs during January - February (- 6 ° C), while the highest temperature occurs during June - August (34 ° C). The relative humidity ranges among 28.7% (June) to 58% (February).

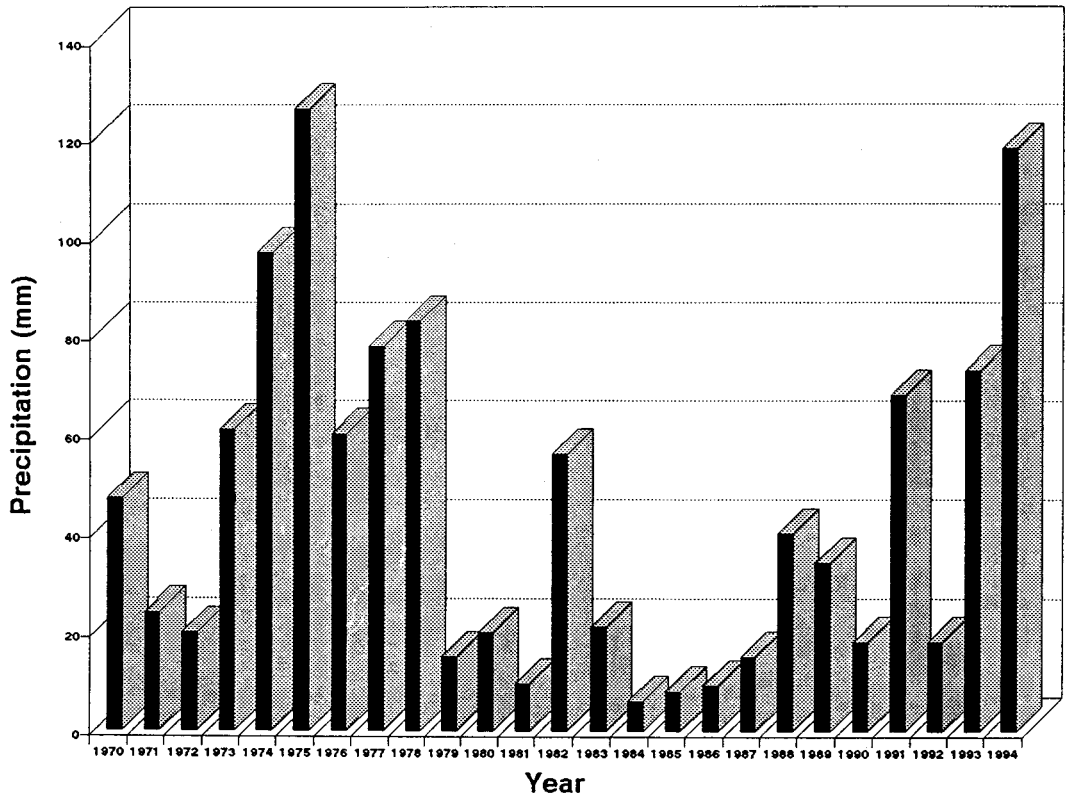

Figure 2. Annual precipitation in Saint Catherine area at the time period of 1970–1994.

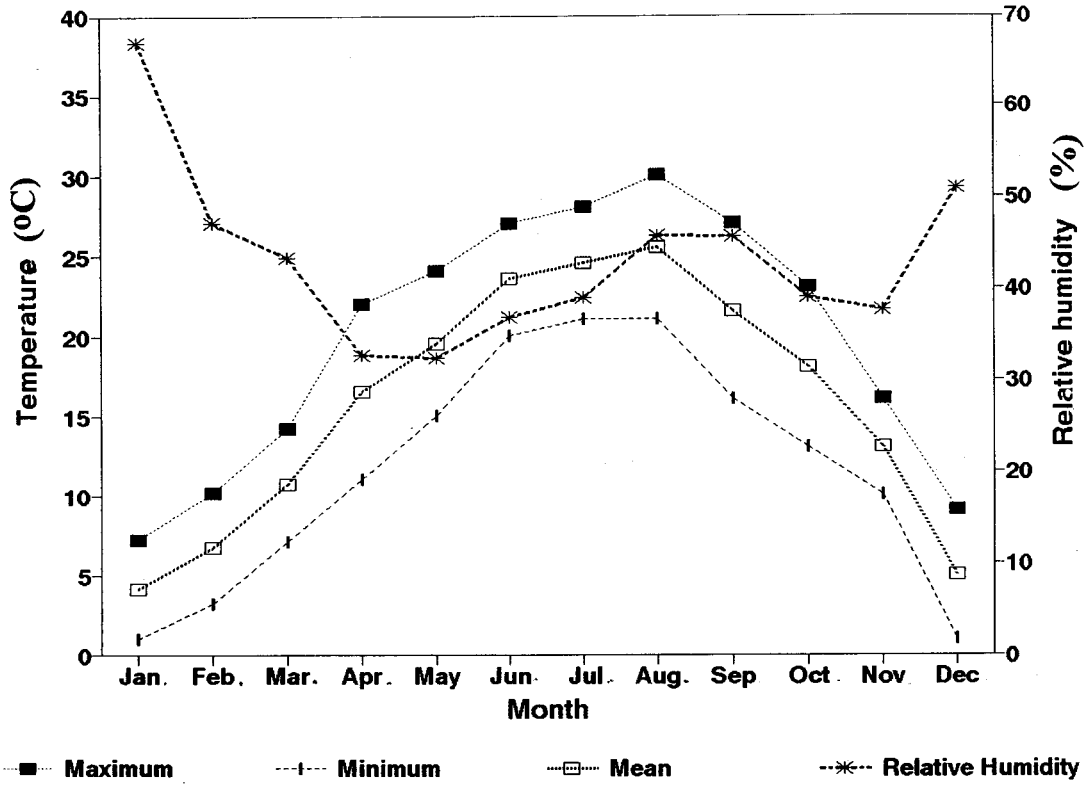

Figure 3. Climatic data of ten years (1985–1994) including mean values of min. and max temperatures and relative humidity.

MATERIALS AND METHODS

The presence / absence of species in forty five stands have been sampled qualitatively throughout the study area. The homogeneity of each stand in its topography, landform variation, and vegetation types were the main factors in the selection of stands. Recording was carried on regular monthly visit for each stand during the growing season of the three consecutive years (1992 to 1994). The nature of the soil surface was described using Hausenbuiller's scale (gravel = 2 - 75 mm, cobbles = 75 - 250 mm, stones = 250 - 600 mm and boulders = above 600 mm). For plant identification a number of works [13, 17, 18, 19, 20, 21, 22, 23] were consulted. The families, genera, and species are arranged alphabetically. Detailed description for the life forms and microhabitats are included. Climatic data including temperature, relative humidity and precipitation were recorded in the Environmental Research Center at Saint Catherine.

RESULTS

The following is the list species occurring in the study area. Their life form is indicated by abbreviatation : (CH) = chamaephyte ; (H) = hemicryptophyte ; (T) = therophyte ; (Pg) = perennial grass; (PH) = phanerophyte; and (G) = geophyte followed by notes on their habitats and distribution.

ACANTHACEAE

Blepharis ciliaris (L.) B. L. Burtt
(H), sand-silt ground, vast and coarse wadis and rarely on steppe slopes.

ADIANTACEAE

Adiantum capillus - veneris L.
(H), in dripping springs mostly in shady sites and narrow moisten ponds in wadi El-Leiga.

AMARANTHACEAE

Aerva javanica (Burm. f.) Juss. ex Schult.
(CH), dominating wadis with fine sand and gravelly deposits of hot climate.

ASCLEPIADACEAE

Asclepias sinaica (Boiss.) Muschl. Syn. *Gomphocarpus sinaicus Boiss.*
(CH), in crevices of smooth-faced outcrops of hard rocks and on terraces of rocky surfaces.
Pergularia tomentosa L.
(CH), sandy, stony slopes and wadi beds.
Solenostemma orghel (Del.) Hayne, Syn. *Solenostemma oleifolium* (Nect.) Bullock & Bruce .
(CH), gravelly, coarse beds of vast wadis in the eastern of S. Sinai.

BORAGINACEAE

Alkanna orientalis (L.) Boiss.
(CH), distrubed terraces of low elevations (1400-1750 m).
Anchusa humilis (Desf). I. M. Johnst. Syn. *Hormuzakia aggregata* (Lehm.) Gussul .
(T), dominated coarse and gravelly plains, irrigated fields and gardens.
Anchusa milleri Willd.
(T), stony slopes, rocky creviices in steppe slopes and shaded wadis.
Asperugo procumbens L.
(T), soil pockets at low elevations (1100 - 1600m).
Heliotropium bacciferum Forssk.
(CH), dominating wadis of sandy-silty soils and stony slopes at lower elevations (1100 - 1600 m).
Heliotropium lasiocarpum Fisch. & C. A. Mey, Syn. *Heliotropium europaeum* L. v. *temuiflorum Boiss.*
(T), ridge habitats and irrigated fields.
Lappula spinocarpos (Forssk.) Asch. & Schweinf.
(T), soil pockets and stony slopes.
Lappula sinaica (DC.) Asch & Schweinf.
(T) in crevices of smooth - daced outcrops and irrigated fields.
Microparacaryum intermedim (Fresen.) Hilger & Podl.
(H), sandy slopes and rocky surfaces of high elevations (1600 - 2624 m).
Myosotis discolor Pers.
(T), dominating vast plains with coasrse and sandy ground.
Paracaryum rugulosum (DC.) Boiss.
(H), stony elecated slopes (1600 - 2400 m) and wadis with stony-gravelly and fine soil.
Paracaryum intermedium (Fresen.) Lipsky
(T), stony slopes in steppes and wadis with boulders and cobbles.
Trichodesma africamm (L.) R. Br.

(CH), ridges and foothills of lower lands of wadi Feiran and irrigated fields.

CAMPANULACEAE

Campanula dulcis Decne.
(T), steppe and stony slopes.

CAPPARACEAE

Capparis spinosa L.
(CH), in the canyons walls and in crevices through wadi beds and moist sites.
Capparis sinaica Veill.
(CH), walls and crevices of hard rock outcrops and large wadis.

CARYOPHYLLACEAE

Arenaria deflexa Decne.
(H), in crevices of granite outcrops.
Bufonia multiceps Dence.
(CH), wadi beds of moist sites.
Gymnocarpos decander Forssk.
(CH), dominating rocky and stony slopes of Saint Catherine mountains of low elevation (1300 - 1800m).
Gyposphila capillaris (Forssk). C. Chr. subsp. confusa Zmarzty, Syn. Gypsophila arabica Barkoundah.
(CH), dominating stony slopes and closed wadis.
Gypsophila capillaris (Forssk.) C. Chr.
(CH), dominating stony slopes.
Minuartia picta (Sm.) Bornm.
(T), stony slopes.
Minuartia meyeri (Boiss.) Bornm.
(T), vast, coarse plains.
Paronychia sinaica Fresen.
(CH), steppe slopes of hard rocks.
Silene arabica Boiss.
(T), stony slopes of hiigh elevations.
Silene vivianii Steud subsp. vivianii.
(T), slope with loose soil 1900 - 2200 m.
Spergula fallax (Lowe) E. H. L. Krause Syns. Spergula flaccida Asch, Spergula jallui
Maire, *Spergula atheniensis* Asch.
(T) in crevices and gorges habitate of higher elevations (2200 - 2624 m).

CHENOPODIACEAE

Agathophora alopecuroides (Delile) Fenzl ex Bunge.
(CH), highly elevated slopes (2200 - 2600 m) with loss substrate.
Anabasis articulata (Forssk.) Moq.
(CH), gravelly plains and metamorphic ridge habitats.
Halexylon salicornicum (Moq.) Bunge ex Boiss. syn.
Hammada elegans (Bunge) Botsch.
(CH), dominating vast plains with gravels and coarse sands.

CISTACEAE

Helianthemum kahiricum Delile.
(CH), coarse and stony wadis and plains of coarse nature.
Helianthemum lippii (L .) Dum. Cours.
(CH), fine deposits, stony wadiis and vast plains.

CLEOMACEAE

Cleome amblyocarpa Barratte & Murb. syn. *Cleome africana* Botsch.
(T), vast wadis of rocky surfaces.
Cleome chrysantha Decne.
(CH), coarse sand habitats and wadis in S. Eastern Sinai.
Cleome droserifolia (Forssk.) Delile.
(CH), on gentle shopes with depressions, vast wadis and low terraces of S. Eastern Sinai.

COMPOSITAE

Achillea frograntissima (Forssk.) Sch. Bip.
(H), wadis with gravels and stony texture.
Artemisia herba - alba Asso.
(CH), stony slopes and elevated ridges.
Artemisia judaica L.
(CH), sandy and silty valleys.
Centaurea aegyptiaca L .
(T), sandy silty steppe slopes.
Centaurea eryngioides Lam.
(CH), in crevices of smooth-faced outcrops and slopes 1900 - 2400 m.
Centaurea pallescens Del.
(CH), rocky and coarse slopes.
Centaurea scoparia Sieber ex Spreng.
(CH), stony ridge habitats.
Conyza stricta Willd. Syn. *Conyza triloba* Decne.
(CH), crevices of smooth - faced of hard rocks.
Cotula cinerea Delile.
(T), sandy fields ans sandy wadis.
Crepis sancta (L.) Bornm.

(T), soil pockets of gentle slopes.
Echinops glaberrimus DC.
(H), rocky and stony slopes and gorges.
Filago desertorum Pomel.
(T), stony slopes and plains with loosely soil.
Ifago spicata (Forssk.) Sch. Bip. subsp. albescens Chrtek, Syn. Ifago rueppellii (Fresen.) Danin.
(T), dominating fissured rocks.
Iphiona scabra DC.
(CH), gravelly wadis and rocky crevices.
Lactuca orientalis (Boiss) Boiss.
(CH), terraces and ridges of stony sites.
Lasiopogon muscoides (Desf.) DC
(T), slopes of rocky surfaces.
Launaea capitata (Sprengel) Dandy
(CH), wadis silty grounds.
Launaea nudicaulis (L.) Hook. f.
(CH), rocky surfaces and gravelly soil.
Launaea spinosa (Forssk.) Sch. Bip. ex O. Kuntze
(CH), ridges of smooth-faced and hard rocks.
Onopordun ambiguum Fresen.
(H), stony slopes (1700-2200 m).
Phagnalon nitidum Fresen.
(CH), in boulders and cervices of hard rocks.
Phagnalon sinaicum Bornm. & Kneuck.
(CH), crevices between boulders and moist sites of medium elevations (1500-1800 m).
Pulicaria crispa (Forssk.) Oliv.
(CH), wadi beds of silty gravely soil and irrigated fields.
Reichardia picroides (L.) Roth
(CH), irrigated fields.
Reichardia tingitana (L.) Roth
(T), soil pockets of steep slopes.
Scorzonera pseudolanata Grossh.
(CH), loose plains ans slopes.
Senecio flavus (Decne.) Sch. Bip.
(T), irrigated fieldsand gardens.
Senecio glaucus L.
(T), irrigated fields and disturbed sites.
Tanacetum santolinoides (DC.) Feinbrun & Fertig
(CH), rocky sites and cervices of hard rocks and narrow wadis or gorges.
Varthemia montana (Vahl) Boiss.
(CH), rocky surfaces of 1800-2400 m.

CRUCIFERAE

Alyssum marginatum Steud. ex Boiss.
(T), steppe crevices in smooth-faced outcrops.
Arabidopsis pumila (Willd.) Busch
(T), rocky and sandy slopes.
Clypeola jonthlaspi L.
(T), in crevices of smooth-faced rocks.
Diplotaxis acris (Forssk.) Boiss.
(T), stony slopes and between fissured rocks.
Diplotaxis harra (Forssk.) Boiss.
(H), stony slopes and irrigated fields.
Farsetia aegyptia Turra
(CH), stony-sandy slopes and ridges.
Isatis microcarpa Boiss.
(T), stony slopes and crevices.
Malcolmia africana (L.) R. Br.
(T), stony slopes and ridges.
Matthiola arabica Boiss.
(CH), gorges, ridges and foothills of rocky surfaces and coarse soil.
Morettia canescens Boiss.
(CH), plains of sandy silty soils.
Moricandia sinaica (Boiss.)
(CH), plains and terraces.
Savignya parviflora (Delile) Webb
(T), sandy, irrigated and disturbed sites.
Schouwia thebaica Webb
(T), sandy slopes and alluvial fans.
Sisymbrium irio L.
(T), irrigated fields and gardens.

CUCURBITACEAE

Citrullus colocynthis (L.) Schard.
(H), wadis with sandy and silty soil and sandy fields.
Cucumis prophetarum L.
(H), vast wadis, slopes of sandy and gravelly soils and irrigated fields.

CUSCUTACEAE

Cuscuta pedicellata Ledeb.
(T), irrigated fields and gardens.

CYPERACEAE

Schoenus nigricans L.
(H), fresh water springs in closed waids and moist habitats.

DIPSACACEAE

Petrocephalus arabicus Boiss.
(CH), in crevices of smooth-faced hard rocks (1800-2400 m).

EPHEDRACEAE

Ephedra pachyclada Boiss.
(CH), sandy fields and wadis at foothills and ridges habitats.

EQUISETACEAE

Equisetum ramosissimum Desf.
(CH), fresh water springs, dominating frish water sites in wadi El-Legia and moist gorges.

EUPHORBIACEAE

Andrachne aspera Spreng.
(H), gentle slopes and near springs.
Andrachne telephioides L.
(CH), stony and rocky wadi beds.
Chrozophora obliqua (Vahl) A. Juss. ex Spreng., Syn. *Chrozophora tinctoria* (L.) Raf.
(CH), gentle slopes, vast wadis and stony habitats.
Euphorbia hierosolymitana Boiss., Syn. Euphorbia bivonae Steudel,
(CH), stony and closed wadis at high elevations (1900–2400 m).
Euphorbia chamaepelpus Boiss. et Gaill.
(CH), irrigated gardens and fields and rocky soil.
Euphorbia grossheimii (Prokh.) Prokh.
(CH), rocky slopes and ridges.
Euphorbia obovata Decne.
(CH), terraces and steppe wadis.
Euphorbia retusa Forssk.
(CH), soil pockets and wadi beds.
Euphorbia sanctae-catharinae Fayed
(CH), stony, closed elevated wadis, dominating sandy ridges and slopes.

FUMARIACEAE

Fumaria parviflora Lam.
(T), irrigated gardens and wet wadis.

GERANIACEAE

Erodium touchyanum Delile, Syn. Erodium deserti (Eig) Eig
(T), plains and cultivated fields.
Erodium laciniatum (Cav.) Willd.
(H), plains and ridge habitats with sandy and stony soils.

GLOBULARIACEAE

Globularia arabica Jaub. & Spach
(CH), in crevices of smooth-faced outcrops of hard rocks.

GRAMINEAE

Aristida adscensionis L., Syn. *Aristida caerulescens* Desf.
(T), rocky, stony slopes and crevices.
Avena barbata Pott. ex Link subsp. *wiestii* (Steud.) Mansf.
(T), sandy soil, irrigated fields and gardens.
Bromus pectinatus Thunb., Syn. *Bromus sinaicus* (Hackel) Tackh.
(T), coarse soils of wide valleys.
Bromus tectorum L., (Pg), cultivated and disturbed fields.
Cynodon dactylon (L.) Pers.
(Pg), irrigated gardens and silty waids.
Hordeum murinum L. subsp. *glaucum* (Steud.) Tzvelev, Syn. *Hordeum glaucum* Steud.
(T), irrigated fields and gardens.
Oryzopsis miliacea (L.) Asch. & Schweinf.
(Pg), plains and terraces of rocky surfaces.
Poa sinaica Steud.
(Pg), rocky slopes and irrigated fields.
Schismus barbatus (L.) Thell.
(T), irrigated fields and gardens.
Sorghum virgatum (Hackel) Stapf.
(Pg), irrigated fields.
Stipa parviflora Desf.
(Pg), crevices in smooth-faced outcrops of hard rocks and rocky soils.
Stipagrostis ciliata (Desf.) de Winter
(Pg), plains of sandy and coarse sand.
Stipagrositis raddiana (Savi) de Winter
(Pg), plains of sandy and silty soils.

GUTTIFERAE

Hypericum lanuginosum Lam.
(H), rocky gorges of high elevation (1800–2200 m).

JUNCACEAE

Juncus acutus L.

(H), moist sites and near springs.
Juncus inflexus L.
(H), fresh water springs.
Juncus rigidus Desf.
(H), ridges and marshes of fresh water (Wadi El-Leiga).

LABIATAE

Ballota damascena Boiss.
(CH), stony slopes and high terraces.
Ballota kaiseri Tackh.
(CH), stony slopes, and shaded gorges.
Ballota saxatilis C. Presl
(CH), stony and shaded areas with high elevations.
Ballota undulata (Fresen.) Benth.
(CH), gorges habitats and gentle slopes of high elevations (2000–2460m).
Lavandula coronopifolia Poir.
(CH), terraces and stony wadis.
Lavandula pubescens Decne.
(CH), stony gorges and rocky wadis.
Marrubium alysson L.
(T), weeds in sandy fields and disturbed areas.
Mentha longifolia (L) Huds., Syn. *Mentha lavandulaceae* Willd.
(H), springs of fresh water and moist sites.
Mentha microphylla C. Koch
(H), springs of fresh water.
Nepeta septemcrenata Benth.
(CH), in crevices of smooth-faced outcrops of hard rocks especially high elevated slopes of Gebel Musa.
Origanum syriacum L.
(CH), wadi beds, gorges habitats and down stream of closed wadis.
Phlomis aurea Decne.
(CH), Shaded-gorges and closed wadis.
Salvia palaestina Benth.
(CH), in crevices of smooth-faced outcrops of hard rocks.
Saliva spinosa L.
(CH), steppes on stony and rocky slopes in wadis.
Stachys aegyptiaca Pers.
(CH), terrraces habitats of smooth faced rocks.
Teucrium decaisnei C. Presl, Syn. *Teucrium pilosum* (Decne.) Aschers.
(CH), in crevices smooth-faced of hard rocks.
Teucrium polium L.
(CH) shaded gorges and crevices.
Thymus decussatus Benth.
(CH), silty gorges and ridges.
Ziziphora capitata L.
(T), rocky and stony slopes of high elevations (2200–2460m).

LEGUMINOSAE

Mimosoideae

Acacia tortilis (Forssk.) Hayne, subsp. *raddiana* (Savi.) Brenan, Syn. *Acacia raddiana* Savi.
(PH), wadis in gravel plains, alluvial fans, mountainous areas of magmatic and metamorphic rocks
Acacia tortilis (Forssk.) Hayne, ubsp. *tortilis*
(PH), vast wadis and alluvial fans.

Caesalpinoideae

Ceratonia siliqua L.
(PH) in cultivated gardens and fields especially down stream parts of wadis.
Senna italica Mill.
(CH), gravelly and stony wadis and terraces.

Papilionoideae

Astragalus bombycinua Boiss.
(T), low terraces, gentle slopes and vast plains with coarse sand.
Astragalus sieberi DC.
(CH), dominating the upper stream of the wadis and plains.
Astragalus spinosus (Forssk.) Muschl.
(CH), dominating steep slopes, ridges and low terraces of 1600–2400m.
Astragalus asterias Steven, subsp. radiatus (Batt.) Greuter, Syn. *Astragalus stella* sensu
Tackholm
(T), plains, ridges habitat and irrigated fields.
Astragalus tribuloides Delilel, (CH), ridges and upper streams of wadi systems.
Bituminaria bituminosa (L.) C. H. Stirt., Syn. *Psoralea bituminosa* L.
(CH), crevices of smooth-faced granite and narrow wadi.
Colutea istria Mill.
(CH), in wadis and crevices of steep slopes growing in vast wadis and plains.
Crotalaria aegyptiaca Benth.
(CH), valley of metamorphic rocks covered with coarse sands and gravels.

Cullen plicatum (Delile) C. H. Stirt., Syn. *Psoralea plicata* Del.
(CH), crevices of smooth-faced granite and narrow wadis.
Lotononis platycarpa (Viv.) Pic. Serm.
(H), dominating steep slopes, ridges, and disturbed sites in wadi beds.
Medicago sativa L.
(CH), irrigated lawns and disturbed sites.
Melilotus messanensis (L.) All.
(T), weeds in gardens and fields.
Onobrychis ptolemaica (Delile) DC.
(CH), in crevices of smooth-faced outcrops of hard rocks, rocky slopes and wadis
Retama raetam (Forssk.) Webb. & Berthel
(PH), sand fields, limestone hills, gravelly and pebbly ground in large wadis and plains.
Tephrosia purpurea (L.) Pers., subsp. *apollinea* (Delile) Hosni & El-Karemy, Syn. *Tephrosia apollinea* (Delicle) Link.
(CH), gentle slopes of sandy wadis in S. Eastern Sinai.
Trigonella stellata Forssk.
(T), stony slopes and rocky crevices in wadi bed systems.

LILIACEAE

Colchicum guessfeldtianum Asch. & Schweing.
(CH), on high elevations with stony and rocky surface.

MALVACEAE

Malva parviflora L.
(T), disturbed fields and irrigated gardens.
Malva neglecta Wallr., Syn. *Malva rotundifloia* sensu Tackholm
(T) disturbed fields and terraces.

MORACEAE

Ficus palmata Forssk., Syn. *Ficus pseudosycomorus* Decne.
(PH), narrow wadis, near fresh water springs and fissures in cliffs of smooth-faced hard rocks.

PAPAVERACEAE

Glaucium arabicum Fresen.
(CH), plains and foothills of stony and rocky soils.
Glaucium grandiflorum Boiss. & A. Huet
(CH), stony and gentle slopes.
Papaver decaisnei Elkan
(T), narrow wadis and stony slopes.
Roemeria hybrida (L.) DC. subsp. *dodecandra* (Forssk.) Maire
(T), low terraces and irrigated fields.

PLANTAGINACEAE

Plantago sinaica (Barneoud) Decne.
(CH), terrace and gorge habitats and between crevices of boulders.

POLYGONACEAE

Atraphaxis spinosa L.
(CH), dominating highly steep slopes covered by loose soils and coarse sands.
Polygonum equisetiforme Sm.
(CH), wadis with stony soils and irrigated fields.
Rumex cyprius Murb.
(T) vast plains and wadis with sandy surface.
Rumex vesicarius L.
(T), rocky areas and plains.

PRIMULACEAE

Primula boveana Duby
(H), gorges springs on granite cliffs of northern slopes at high elevations and springs at 2200–2600m.

RESEDACEAE

Caylusea hexagyna (Forssk.) M.L. Green.
(G), low terraces, gentle slopes and disturbed sites including fields and gardens.
Ochradenus baccatus Delile.
(PH), dominating the upper streams of large wadis covered with stones and coarse sands.
Reseda arabica Boiss.
Reseda decursiva (Forssk.) Maire
(T), dominating low terraces and stony slopes.
(T), stony slopes and rocky soils.
Reseda stenostachya Boiss.
(T), stony slopes and ridges covered with cobbles and stones.

RHAMNACEAE

Ziziphus spina-christi (L.) Desf.
(PH), cultivated in gardens expecially of vast wadis.

ROSACEAE

Crataegus sinaica Boiss.
(PH), gorges, rocky surfaces and closed sites of 2000–2400 m.
Rosa arabica Crep.
(PH), near fresh water and rocky gorges and caves at 2000–2400m.
Rubus sanctus Schreb.
(PH), marsh of fresh water.

RUBIACEAE

Callipeltis cucullaris (L.) Steven
(T), steppes on stony slopes.
Crucianella membranacea Boiss.
(T), sandy soils and steppes.
Galium setaceum Lam.
(T), stony and rocky slopes with crevices.
Galium sinaicum (Delile ex Decne.) Boiss.
(CH), terraces and crevices of smooth-faced rock outcrops.
Galium spurium L.
(CH), in crevices of steep slopes and between boulders.

SCROPHULARIACEAE

Anarrhinum pubescens Fresen.
(H), stony slopes and low terraces with cobbles substrate.
Kickxia aegyptiaca (L.) Nabelek
(H), dominating crevices and between fissured rocks at 1800–2200 m.
Kickxia macilenta (Decne.) Danin
(H), shaded gorges and low terraces in the fissured rocks.
Linaria haelava (Forssk.) Delile
(T), sandy and stony steep slopes and ridges.
Scrophularia deserti Delile
(H), gravelly wadi beds.
Scrophularia libanotica Boiss.
(H), crevices of highly elevated gorges at 2200–2600m.
Scrophularia xanthoglossa Boiss.
(T), sandy ridges and stony slopes.
Verbascum sinaiticum Benth.
(CH), gravelly wadis and terraces and disturbed sites.
Veronica anagallis-aquatica L.
(H), fresh water springs and gorges.
Veronica biloba Schreb.
(T), elevated gorges and terraces.

SOLANACEAE

Hyoscyamus muticus L.
(CH), large wadis with silty ground and disturbed sites.
Hyoscyamus pusillus L.
(CH), silty wadis and disturbed sites.
Lycium shawii Roem. & Schult.
(PH), shaded gorges and terraces of rocky surfaces.
Solanum nigrum L.
(T), irrigated fields, and disturbed sites.
Solanum sinaicum Boiss.
(T), rocky waids, irrigated sites, and disturbed area especially low terraces and wadis.

TAMARICACEAE

Reaumuria hirtella Jaub. & Spach
(CH), soil derived from chalk and gentle slopes.
Tamarix aphylla (L.) H. Karst.
(PH) vast wadis with sandy-silt soils.

UMBELLIFERAE

Deverra tortuosa (Desf.) DC. Benth. ex Asch. & Schweinf., Syn. *Pituranthos tortuosus* (Desf.) Bentham
(CH), in crevices of smooth-faced a outcrops of hard rocks and gravelly wadis.
Deverra triradiata Hochst. ex Boiss., Syn. *Pituranthos triradiatus* (Hochst. ex Boiss.) Asch. & Schweinf.
(CH), gravelly wadis and in crevices of slopes.
Scandix stellata Banks & Sol.
(T), rocky and smooth surface a outcrops.

URTICACEAE

Forsskaolea tenacissima L.
(H), stony slopes, sandy ridges and closed or narrow wadis at 1400–1800 m.
Parietaria alsinifolia Delile
(T), dominating down stream parts of wadi beds, closed wadis and in crevices.

ZYGOPHYLLACEAE

Fagonia arabica L. v. *viscidissima* Maire
(CH), dominating stony slopes and ridges with cobbles.
Fagonia bruguieri DC.
(CH), sandy slopes and wadis.
Fagonia mollis Delile
(CH), dominating ridges of stony nature and cobbles.
Fagonia scabra Forssk., Syn. *Fagonia sinaica* Boiss.
(CH), salty and fine deposits soils.
Pegamum harmala L.
(H), disturbed places of wadis and low terraces.
Tribulus terrestris L.
(T), weeds in gardens and disturbed sites.
Zygophyllum album L.f.
(CH), wet saline soils near coastal areas.
Zygophyllum coccineum L.
(CH), salty soils near coastal areas.
Zygophyllym simplex L.
(H), salty soils and terraces of loose soil and disturbed sites.

GEOGRAPHICAL DISTRIBUTION OF THE ENDEMIC SPECIES

Figures (4, 5, 6, 7) show the geographical distribution of ten threatened endemic species growing in Saint Catherine mountains. These are:

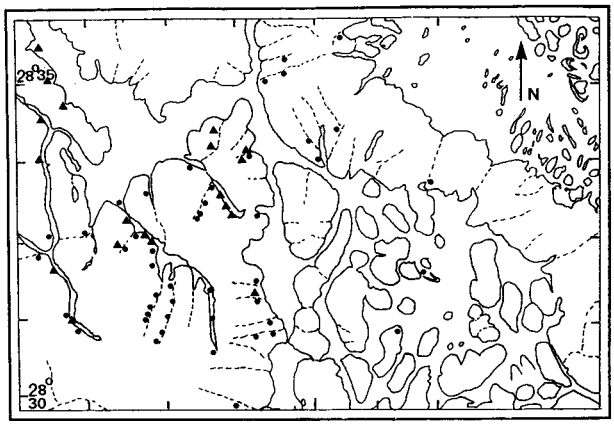

Figure 4. The distribution of *Nepeta septemcrenata* (small circles) and *Kickxia macilenta* (triangles).

Nepeta septemcrenata recorded at Gebel Catherina, Gebel Musa, Ras Safsafa, and Wadi Razana. It dominates rocky surfaces gorges and is more common in rocky crevices. Its ditribution is limited to elevations of 2200–2500m.

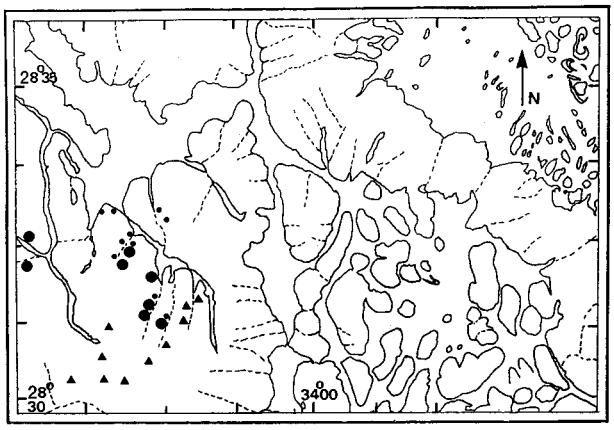

Figure 5. The distribution of *Silene leucophylla* (triangles), *Primula boveana* (large circles) and *Rosa arabica* (small circles) dominating gorges.

Kikxia macilenta is restricted to narrow wadis such as Wadi El-Deir, Wadi El-Leiga and in closed wadis and gardens as Wadi Gebal.

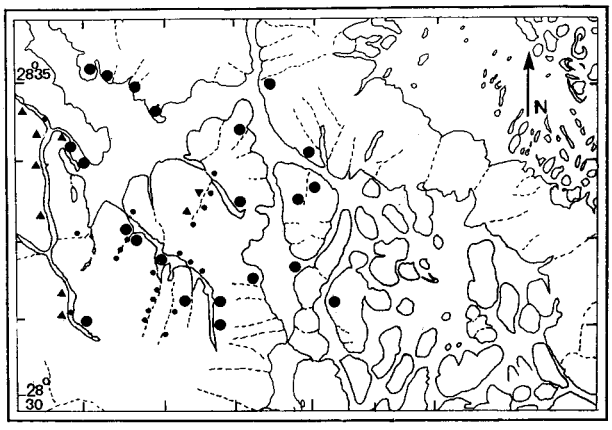

Figure 6. The distribution of *Anarrhimum pubescens* (triangles), *Ballota kaiseri* (small circles), and *Bufonia multiceps* (large circles).

Silene leucophylla is concentrated on the high plateau (2400m) of Gebel Catherina where the soil is very rich and loose.

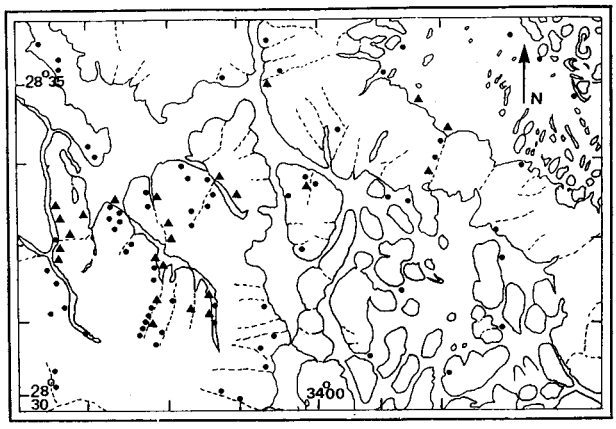

Figure 7. The distribution of *Phlomis aurea* (triangles) and *Pterocephales arabicus* (small circles).

Primula boveana dominates caves and shaded gorges. Its distribution is limited to closed gorges of Ain Shinara (Gebel Catherina), Khaf EL-Gola (slopes of El-Leiga) and few isolated localities of Wadi Zawaten. It occurs mainly on rocky outcrops of high moisture content (wet and shaded rocks) with very low temperatures (3–10°C) at elevations of 2200–2400m.

Anarrhinum pubescens occurrs in the main gorges of Gebel Musa, the narrow gorges of Wadi Gebal (including Wadi Razana & Wadi Zawaten), and Wadi Tlah.

Ballota kaiseri is restricted to gorges of Gebel Musa and slopes of El-Rabah and Gebel El-Ahmar, at elevations of 1800–2400m.

Bufonia multiceps is distributed throughout the main wadis such as Wadi El-Legia, Wadi Tlah, Wadi El-Deir and foothills of Gebel Sun'a.

Phlomis aurea dominates most of the gorges and slopes of Gebel Catherina and Gebel Musa.

These gorges are shaded and charactdrized by high moisture content and coarse sand deposits with elevations of 1800–2400 m.

Pterocephalus arabicus may be found in the same habitats of *Phlomis aurea* but with less abundance and is more restricted to lower elevations (1800–2100 m).

DISCUSSION

Most of Sinai belongs to the Saharo-Arabian phytogeographical region. Its vegetation is characterized by sparseness in plant cover, dominance of a limited number of plant species and associations and paucity of trees. The high mountains are dominated primarily by Irano-Turanian species and a high number of endemic species. The unique geomorphological formations of Saint Catherine mountains result in a greater variations in its microclimate and floristic composition than elsewhere.

In the present study 221 plant species were identified during the study period (1992–1994) throughout Saint Catherine mountains. These one categorized into six life forms chamaephytes, hemicryptophytes, therophytes, perennial grass, phanerophytes, and geophytes with the former being the most dominant (46.6%) followed by the therophytes (29.8%) and hemicryptophytes (14.1%). Chamaephytes dominate slopes, foothills and wadi bed systems whereas therophytes grow in soil pockets and sandy wadis.

In the present study, the number of species correlated positively with precipitation. This is in agreement with eardier findings [3], [24]. In the first year 165 species were collected, increasing on the second year to 187 and reaching to 221 on the third year. The increase in species number is due to an increase in the annual species that correlated positively with precipitation ($r = 0.984$, $P = 0.001$). Figure 8 shows the relation between the amount of precipitation and species number.

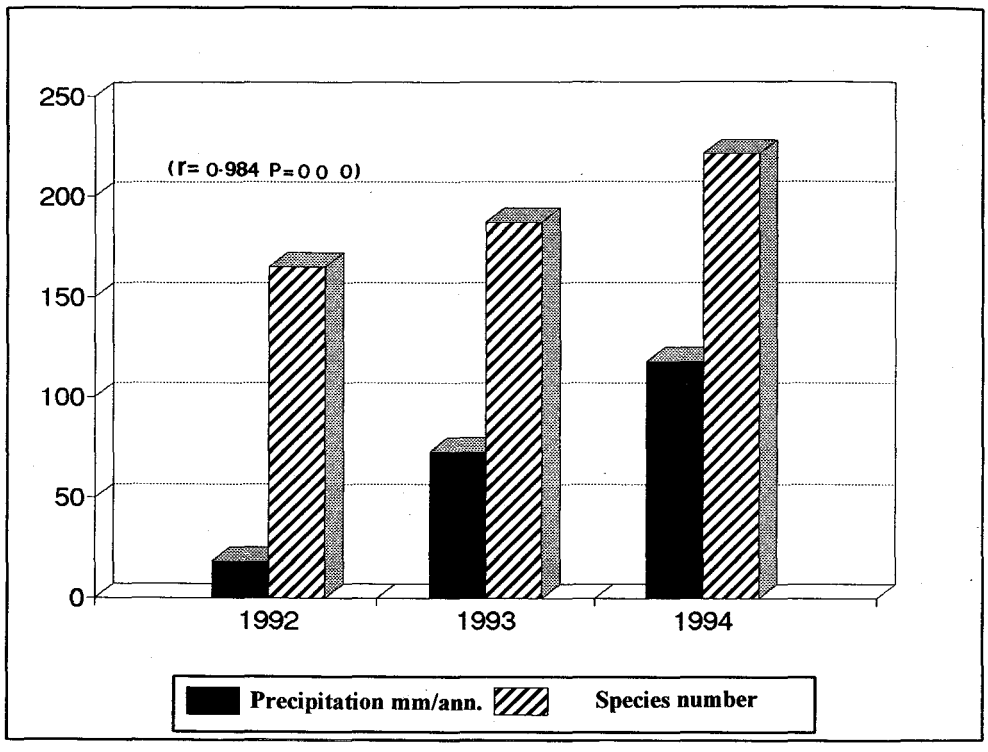

Figure 8. The relation between species number and amount of precipitation at the time period of 1992–1994 in the study area.

Orographic precipitation predominates in southern Sinai including Saint Catherine mountains. It falls on the summits, cliffs and gorges and is subsequently transported to upstream tributaries of the wadi system [25]. Mean annual precipitation fluctuates every 10 year (Figure 2). The intensity and annual variation in precipitation, soil structure, topography and vegetation physiognomy affect the moisture available to the plants [26], [27]. However, in Saint Catherine mountains the moisture available is controlled by the nature of soil surface and texture. The effect of soil surface is related to its capacity of water storage. Also, the amount of evapo-tranpiration lost from soil surfaces depend on the density of vegetative cover and the percentage of cobbles, stones and boulders. There has been emphasis on moisture availability increase with increasing coarseness of the soil surface (a cover of cobbles and stones that conserve more moisture than a cover of gravels)[1]. We conclude that moisture regimes, temperature, configuration of soil surface (mainly in relation to shelter and exposure) and its mechanical structure and adjacent rocks affect the distribution of plant life in the study area. In addition overgrazing, excessive felling and human influence affect the species richness and rarity of the endemic species.

REFERENCES

[1] **Hillel, D. and T. Tadmor,** 1962. Water regime and vegetation in the central Negev highlands of Israel. Ecology, 43: 33 – 41.

[2] **Noy-Meir, I.** 1973. Desert ecosystems: environment and producers. Annu. Rev. Ecol. Syst., 4: 25–51.

[3] **Zohary, M. 1973.** Geobotanical Foundations of the Middle East. Gustav Fischer Verlag. (2 Vols.), 739 pp. Stuttgart.

[4] **Danin, A. 1983.** Desert Vegetation of Israel and Sinai. Jerusalem: Cana Publishing House, 148 pp.

[5] **Danin, A.** 1986. Flora and Vegetation of Sinai. Proceedings of the Royal Society of Edinburgh, 89B: 159–168.

[6] **Danin, A., and U. Plitmann,** 1987. Revision of plant geographical territories of Israel and Sinai. Plant Systematics and Evolution, 159:43–53.

[7] **Tackholm, V.** 1932. Some new plants from Sinai and Egypt. Svensk Bot. Tidsk, 26: 370–380.

[8] **Tackholm, V.** 1969. Alfred Kaiser's Sinai Herbarium. Publication Cairo University Herbarium, 2: 1–181.

[9] **Migahid, A. M., A., El-Shafei, A. A., AbdelRahman, and M. A. Hammouda,** 1959. Ecological observation in Western and Southern Sinai. *Bulletin de la Societe de Geographie d' Egypte,* 32: 166–206.

[10] **Boulos, L.** 1960. Flora of Gebel El-Magara, North Sinai. Herbarium, Min. Agric. U.A.R., Special publ., 24 pp.

[11] **El Hadidi, M. N.** 1969. Observations on the flora of Sinai mountain region. Bull Soc. Geogr. Egypte, 40: 123–155.

[12] **El Hadidi, M. N.** 1989. Annotated list of the flora of Sinai (Egypt). 1. Introduction, the taxa of Pteriodophyta and Gymnospermae. Taeckholmia, 12: 1–6.

[13] **Boulos, L.** 1995. Flora of Egypt-Checklist. Al-Hadra Publishing, Cairo, Egypt 283 pp.

[14] **El Hadidi, M. N. J. Kosinova, and J. Chrtek,** 1970. Weed flora of Southern Sinai. Act. Univ. Carol. Biologica, 1969: 367–381.

[15] **McGinnies, W. G., B. J., Goldman, and P. Paylore,** 1968. Deserts of the World. University of Arizona Press, Tucson.

[16] **Hauesnbuiller, R. L.** 1985. Soil science. Principles and practices. WM.C. Brown Company Publisher. 610 pp.

[17] **Zohary, M.** 1966. Flora Palaestina Part I. The Israel Academy of Sciences and Humanities, Jerusalem.

[18] **Zohary, M.** 1972. Flora Palaestina Part II. The Israel Academy of Sciences and Humanities, Jerusalem.

[19] **Feinbrun-Dothan, N.** 1978. Flora Palaestina, Part III. Jerusalem.

[20] **Feinbrun-Dothan, N.** 1976. Flora Palaestina, Part IV. Jerusalem.

[21] **Tackholm, V.** 1974. Students' Flora of Egypt (2nd Edn). Cairo: Cairo University Press. 888 pp.

[22] **Tackholimia** 1989. Annotated List of the Flora of Sinai (Egypt). Taeckholmia No. 12, The Palm Press, Cairo, Egypt, 100 pp.

[23] **Danin, A.** 1993. Contributions to the flora of Sinai. IV. Comments on the "Annotated list of the flora of Sinai" (1989). Willdenowia, 23: 167–175.

[24] **Danin, A. and Osrhan, G.** 1990. The distribution of Raunkiaer life forms in Israel in relation to the environment. Journal of vegetation Science, 1: 41–48.

[25] **Kassas, M. and Girgis, W. A.** 1970. Plant life in the Nubian desert east of the Nile. Bulletin de l'Institut du Desert d' Egypt, 31: 47–71.

[26] **Kassas, M. 1957.** On the ecology of the Red Sea coastal land. Journal of Ecology, 45: 187–203.

[27] **Kassas, M.** 1960. Certain aspects of landform effects on plant water resources. Bulletin de la Societe de Geographie d' Egypte, 29: 5–52.