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Plant diversity and landforms of Mousa's Mountain in Southern Sinai, Egypt

Abdelraouf A. Moustafa[1], Alia El-Sayed[1], Ganna H. Goher[1], Samira R. Mansour[1] and Monier M. Abd El-Ghani[2]

[1]Botany Department, Faculty of Science, Suez Canal University, Ismailia, Egypt
[2]Department of Botany and Microbiology, Faculty of Science, Cairo University, Giza, Egypt

Mousa Mountain is a sacred, towering peak in Egypt's southern Sinai Peninsula that rises to around 2,285 meters. It is characterized by its rocky topography and arid environment and considered a home to a unique and resilient ecosystem despite the extreme conditions. The primary aim of this paper is to demonstrate the main plant species and vegetation structure, as well as to identify the endemics, and rare species, and identify the most significant ecological factors impacting the vegetation and threatening the species on this mountain. Ten main stands are in Mousa Mountain's five major regions. Different parameters were measured for each stand: elevation slope degree, exposure degree, and landform type. The nature of the soil surface has been described. Soil samples were obtained to conduct quantitative physical and chemical investigations. About 114 species were collected from this location, belonging to approximately 31 families. The families with the highest representation were Asteraceae, Poaceae, and Lamiaceae. The Mousa Mountain is home to six highly endangered species, divided into four families: Caryophyllaceae, Lamiaceae, Polygalaceae, and Dipsacaceae. Fifteen species are categorized as endangered, with the majority belonging to the families Adiantaceae, Polygonaceae, Rosaceae, Rubiaceae, Scrophulariaceae, Solanaceae, Zygophyllaceae, and Lamiaceae. There are eight species marked as endemic, belonging to the Lamiaceae, Scrophulariaceae, Papaveraceae, Fabaceae and Polygalaceae. It is evident that therophytes and chamaephytes are the dominant life forms, forming more than 70% of species structure. The gorges were the most diversified landform with the least coefficient of variation, and the least diversified landform was the Farsh with the highest coefficient of variation. To ensure the preservation of these unique and diverse landforms, it is imperative to implement conservation strategies that prioritize the protection of this habitat, while addressing the specific challenges faced by Farsh habitats.

Keywords: Endemic species, Mousa Mountain, Soil analysis, Threats, Vegetation Structure

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CORRESPONDENCE TO
Abdelraouf A. Moustafa,
Botany Department, Faculty of Science,
Suez Canal University, Ismailia, Egypt
Email: raoufmoustafa2@hotmail.com
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INTRODUCTION

The Sinai Desert includes around 6 % of Egypt's total geographical area and is classified as a "Saharan type" desert (Abd El-Ghani *et al*., 2017). It is a significant phytogeographic zone because it borders the Mediterranean, Irano-Turanian, Saharo-Arabic, and Sudanese regions. Furthermore, the great diversity of climate (mean annual precipitation decreases from about 100 mm in the north, near the Mediterranean, to 50-30 mm in the south; rock and soil types allow for the existence of approximately 900 species and 200-300 associations. The northern region of the peninsula is covered in sand, with the dominance of limestone hills and gravel plains. South Sinai, a harsh to extremely arid area, is ecologically unique due to the variation in landforms, geologic structures, and climate, which has resulted in diversity in vegetation types, characterized primarily by the sparseness and dominance of shrubs and sub-shrubs, as well as the scarcity of trees (El-Wahab *et al.*, 2018).

The southern region is distinguished by a diverse range of landforms with varying meteorological and vegetational characteristics. Plains, wadis, oases and springs, salt marshes, and sand dunes are the most common features (Abd El-Ghani *et al*., 2017). Southern Sinai, on the other hand, is home to a complicated series of high, steep igneous and metamorphic mountains that include Egypt's highest peaks, including Gebal Catherine (2641m), Gebal Musa (2285m), and Gebal Serbal (2070m). The western coastal plain, El-Qaa, borders the Gulf of Suez. The surrounding mountains are extremely rich in biodiversity and support mostly Irano-Turanian steppe vegetation characterized by *Seriphidium herba-album* and *Gymnocarpos decanter*. South Sinai Mountains are a rich source of endemism. South Sinai Mountains such as G. Catherine, G. Serbal, and G. Mousa maintain a distinctive plant variety with many endemism and rare species. (Moustafa *et al.*, 2014). Floristically, the Sinai Peninsula is divided into four phytogeographical chorotypes: Saharo-Arabic, Irano-Turanian, Sudanian, and Mediterranean (Salama *et al.*., 2018). The origin of the vegetation is primarily Irano-Turanian, dominated by *Artemisia Seriphidium herba-alba* and accompanied by *Atraphaxis spinosa, Agathophora alopecuroides* and *Gymnocarpos decandrum* at high elevations. Lower elevations are dominated by *Artemisia herba-alba, Zilla spinosa* and *Fagonia mollis* on stony alluvium and cobble deposits. The vegetation is primarily subshrubs and trees, with only a few annuals. The vegetation is limited and includes a variety of chasmophytic and unique species. There are six distinct landforms in the region: gorges, slopes, terraces, ridges, wadis, and plains. Narrow wadis and gorges are relatively floristically rich and are dominated by phanerophytes (*Crataegus sinaica, Ficus pseudosycomorus* and *Lycium shawii)* and chamaephytes (*Phlomis aurea, Conzya stricta, Plantago sinaica,* and *Teucrium polium)*.

The character of the soil surface, altitudinal gradients, and landform types provide microhabitats dominated by characteristic vegetation. The most notable sites in the Saint Catherine Protectorate, which covers 4350 km^2, are Mousa Mountain and the Monastery of Saint Catherine boasts a rich cultural, ecological, and religious history (Grainger *et al*, 2008). The distinctive high-altitude desert ecology and religious setting are inextricably linked with Bedouin life and culture. Mousa Mountain, also known as Jabal Musa. It is a mountain on the Sinai Peninsula in Egypt. It could be the same location as the biblical Mount Sinai, where Moses received the Ten Commandments (Manley *et al.*, 2009; Abo El-Dahab *et al*., 2023). Nothing can match the wild magnificence of the view from the top of Mousa Mountain, the limitless complication of craggy peaks and diverse ridges, as well as their predominant strong red and greenish tones (Gil-Har, 1993).

Mousa’s Mountain is a popular tourist destination on the Sinai Peninsula due to its religious significance. Mousa Mountain contributes significantly to the economy of Egypt. Visits to the mountain are frequently part of major visits to the Saint Catherine Monastery, which gather visitors primarily from Sharm-El-Sheikh, Dahab, and Cairo. The approach to the summit is enclosed by the ruins of ancient chapels and is known as the Moses approach. Despite its steepness, the Moses trail, also known as Siket Sayidna Musa, is the most direct approach to the peak. This tour begins with taking the 3.700 penitential steps made by monks. While the ascent along this path is tough, it provides excellent views and advantages. The second approach to the peak is the Camel trace, also known as Siket El Bashait, which is softer but longer, taking about 2.5 hours on foot. Both roads lead to Elijah's Hollow, a natural amphitheater 750 steps from the peak. The top provides stunning views of the Sinai Peninsula, Mount Catherine, and the surrounding desert environment (Shams, 2011). The main objectives of this present paper to elucidate and update the main plant communities and vegetation structure showing the most important characteristic, endemic and rare and species and finding out the significant ecological factors affecting the vegetation and threatening the species growing on this mountain.

Study area

Location and geography

The study area is part of the Saint Catherine Protectorate, located between 33°30' and 34°30' E and 27°50' and 28°50' N, and encompasses approximately 4350 km^2 with elevations ranging from 396 to 2642 m above sea level (a.s.l). The region is distinguished by smooth-faced granite outcrops that have been filled in to form multiple mountain peaks. Its diversity in landforms (Figure 1), geologic features, and climate resulted in a variety of microhabitats, each with its own set of environmental circumstances and reasonably abundant and distinct flora (Moustafa and Klopatek, 1995; El-Alqamy, 2002). The Mousa mountain area is in the Saint Catherine Protectorate in Southern Sinai, between 28 32'21.9 N and 33 58'31.5" E. The mountain is a reasonably high peak near the city of Saint Catherine in the Sinai Peninsula, rising 2,285 meters (7,497 feet) above sea level. It is encircled on all sides by higher peaks from the mountain ranges to which it belongs. For example, it is located near Mount Catherine, Egypt's highest peak at 2,629 meters (Hobbs, 1995).

The igneous complex in the triangular southern mass now resembles a mountain range due to the removal of sandstone overburden (Moustafa *et al.,* 2020; Hany *et al*., 2022). Mousa mountain rocks evolved late in the formation of the Arabian-Nubian shield. It shows a ring complex of alkaline granites intruded into a variety of rock types, including volcanic (Hobbs, 1995). The visible rocks of Mousa Mountain (Figure 2) appear to have originated at various depths from one another and there is a church at the summit of Mousa Mountain (Figure 3). It is primarily composed of metamorphic and magmatic rocks from the Precambrian period. Several phases of intrusion and dyke swarms preceded a brief burst of younger volcanic activity; the more pastel-colored granites are significantly older than the reddish rock. These dykes (fine-grained basaltic intrusions) made their way into the coarse-grained plutonic granites, creating amazing color and form effects. Mousa Mountain has a ring complex composed of alkaline granites intruded into various rock types, including volcanics. The granite composition varies from syenogranite to alkali feldspar granite. Volcanic rocks range from alkaline to peralkaline, and they include subaerial flows, eruptions, and subvolcanic porphyry. The nature of the visible rocks on Mousa Mountain suggests that they came from different depths (Sweberg, 2020; Fouad et al., 2023).

Climatic Data

Due to its great elevation, Mousa’s Mountain has a peculiar climate. It is the coolest region in Sinai and Egypt. January and February are at the minimum

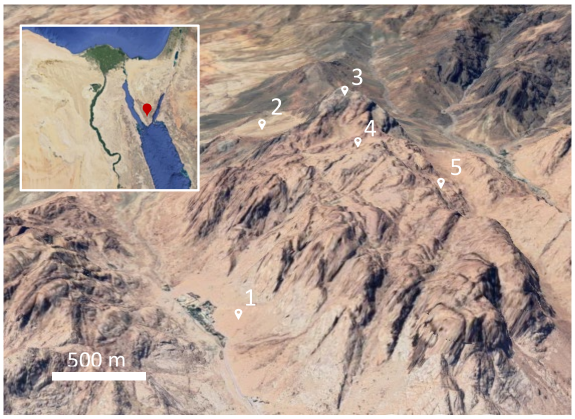

Figure 1. Location of Mousa Mountain, Saint Catherine, South Sinai Governorate 8730062. 1-Foothills "Rigid habitats", 2-Steep slope, 3-High steep slope "Summit", 4-Plain "Farsh", and 5-Gorge habitat. (Google Earth: https://g.co/kgs/9Hpm1Jd).

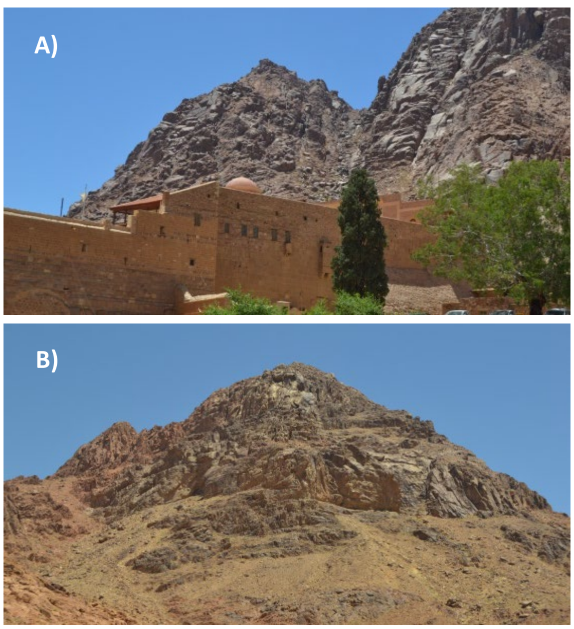

Figure 2. A) Showing the face of the mountain, or the eastern side behind the Saint Catherine Monastery. B) Showing the western side of the mountain from Wadi ElArbeen, Showing the nature of the exposed rocks in Mousa Mountain.

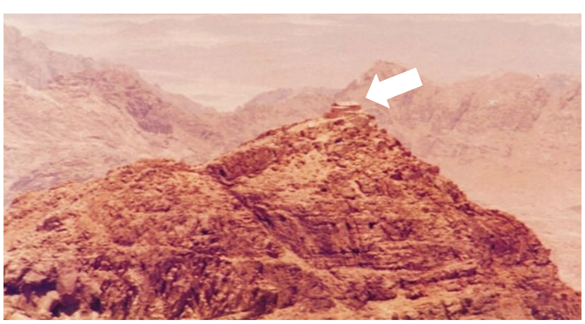

Figure 3. The church at the summit of Mousa Mountain, (see the arrow). This photo has been taken by Prof. Abdelraouf Moustafa, 1983.

temperatures (1.4 °C), while June and July have the greatest average maximum temperatures (30.8 and 31.8 ° C, respectively (Figure 4). A year-round examination of Saint Catherine's weather data reveals a wide variation in temperature. From a chilly low of 1.7°C during the coldest months to a scorching high of 32°C during the peak of summer, the city embraces a plethora of thermal conditions. Humidity remains relatively low year-round with the highest relative humidity registered at 39% and the lowest at 19% (Figure 5). Its climate is affected by the Mediterranean and the orographic effects of its elevation. Its precipitation is erratic in time and space, falling in the autumn, winter, and spring. The typical annual rainfall in the St. Catherine area is approximately 60 mm, which is the highest mean across southern Sinai. During rainy years, the high mountains receive between 20 and 30 mm of snow. Mousa Mountain, located at 1108.73 meters asl in South Sinai, has a subtropical desert climate (Classification: BWh). (Abd El Wahab *et al.*, 2018). The city's annual temperature is 22.96 °C, which is -1.94 % lower than the Egyptian average. South Sinai receives approximately 3.05 millimeters (0.12 inches) of precipitation each year, with 8.64 rainy days (2.37 % of the time).

MATERIALS AND METHODS

Location and stand selection

The main factor used to choose stands and establish their sizes was the diversity of plant life on the different landform types of Mousa Mountain. The five main sections of Mousa Mountain are home to ten significant stands. In each site, ten randomly positioned (10 × 10 m) stands were positioned to determine most of the plant communities and the species composition of the region. Each stand's landform type, exposure level, slope degree, and height (meters above sea level) were measured. The scales used to determine the character of the soil surface were the fine fraction (< 2 mm), gravel (2-75 mm), cobbles (75-250 mm), stones (250-600 mm), and boulders (> 600 mm) (Hausenbuiller, 1985). Soil samples were collected for quantitative physical and chemical investigations. Surface soil samples were collected at different depths (0–20 cm) under the canopy of dominant plant species (Table 1).

Physical-chemical soil analysis

Among the analyses carried out on soil samples are soil physical analysis (moisture content and organic matter content) and soil chemical analysis (pH, soil reaction, electric conductivity, cation and anion).

Table 1. Soil Chemical and physical properties recorded during the study from the five different landforms.

Landform	Foothill	Steep slope	High steep slope	arsh	Gorge
Gravel %	55.36	57.91	65.52	42.91	59.8
Moisture content (MC%)	1.213	1.102	2.13	1.65	1.55
Organic matter (OM%)	3.006	2.65	2.394	3.144	1.862
pH	7.65	7.7	7.9	7.45	8.25
Electrical Conductivity	1.575	1.15	0.93	1.73	0.82
Clay %	2.463	1.631	1.532	3.121	2.415
Silt %	5.213	8.421	7.32	6.411	2.311
Sand %	82.41	81.31	63.21	86.5	50.31
Slope degree	15	18	25	5	17
Elevation (m a.s.l)	1583	1990	2285	2080	1945

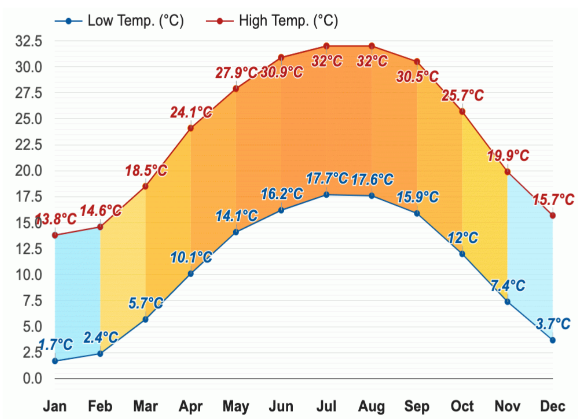

Figure 4. Average temperature Saint Catherine through the year 2024, South Sinai, Egypt Source: https://www.weather-atlas.com/en/egypt/saint-catherine-climate

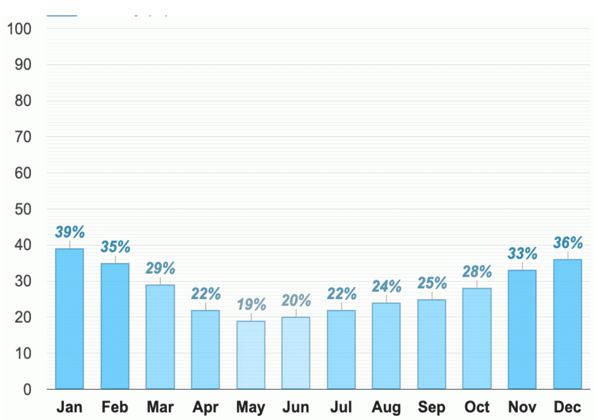

Figure 5 Average temperature Saint Catherine through the year 2024, South Sinai, Egypt Source: https://www.weather-atlas.com/en/egypt/saint-catherine-climate

Following air drying, soil samples were passed through a 2 mm filter to determine the percentage of gravel remaining after debris was removed. The following sieve meshes were used to measure the fine soil fractions: silt + clay (<0.063 mm), gravel (>2 mm), coarse sand (0,59 mm), medium sand (0.25 mm), and fine sand (0.063 mm). The sieving technique developed by Gee and Bauder (1986) was used to evaluate the particle size distribution (soil texture).

The physical, chemical, and biological qualities of the soil are influenced by the amount of organic matter present in it. Ten grams of two millimeter-mesh sieved, oven-dried soil sample were put in 40 cc tarred porcelain crucibles and fired in an electric muffle furnace at 600°C for three hours to evaluate the organic matter content of the samples. After being cooled to room temperature and weighed, these crucibles were put in a desiccator. The percentage of the weight of the oven-dried samples was used to quantify the loss (Sparks *et al*., 1996). Using the water to soil ratio of 2.5:1, soil sample water extracts were prepared according to Allen *et al*. (1976) method and subsequently assessed using a pH meter. The electric specific conductivity (EC), the reciprocal of specific resistance, was measured in a conductivity cell using a low voltage A.C. Wheatstone bridge (EC meters) after water extracts of soil samples were prepared at a 1:1 ratio of water to soil, as described by Wilde *et al.* (1972).

The titration procedure outlined by Baruah and Barthakur (1997) was used to determine the Cations. A soil extract was prepared for each soil sample using a water-to-soil ratio of 1:1, and a suitable aliquot—usually 5 ml—was taken in a conical flask. Drops of $NH_4Cl + NH_4OH$ buffer were added to the pH, and then two drops of Erithrochropme Black (EBT) indicator were added. The solution was titrated until it became blue from red using a 0.01 N EDTA solution. An appropriate aliquot of soil extract (usually 5 ml) was taken for each soil sample, and it was then added to a conical flask along with 5 ml of NaOH 0.01 N solution and a pinch of Murexide indicator powder. The solution was titrated until it turned purple from pink using a 0.01 N EDTA solution. It is exceedingly difficult to find free magnesium ions in soil extract. The amount of Mg^{++} was therefore determined by deducting (Ca++) from (Ca++ + Mg++). The titration method outlined by Baruah and Barthakur (1997) was used to determine anions. For each soil sample, a soil extract was prepared using a water-to-soil ratio of 1:1. An adequate volume, usually 5 ml, was then placed in a conical flask, and 1-2 drops of Methyl Orange indicator were added, causing the solution to change from colorless to yellow. Ultimately, titration was carried out against a 0.01 N H_2SO_4 solution until the bicarbonates' entire color changed from yellow to red.

Soil study reveals significant variation in average physical and chemical properties across five locations. The steep slope had the highest content of sand (81.31) and silt (8.421). The Summit (high steep slope) had the highest content of Gravel (65.52), moisture content (2.13), pH (7.9) and slope degree (25). The Farsh had the highest content of organic matter (3.144), EC (1.73) and clay (3.121), and had the lowest slope degree (5). The foothill and Gorge had a medium content of physical and chemical properties of the soil. The distribution of plant groups in south Sinai is primarily influenced by edaphic characteristics such as soil moisture availability, altitude, soil surface, and texture (Moustafa and Zaghloul, 1996).

Data processing and treatment

The software SPSS version 16 for windows was applied to calculate ANOVA test between landforms and life forms and the IUCN categories of conservation status. Chord diagram is a type of data visualization used to represent relationships or flows between different entities (Holten, 2006). It is especially useful for illustrating complex networks or connections. Each entity is typically represented as a segment along the circumference of a circle, and the relationships between entities are drawn as arcs or chords connecting them. The circular layout, where entities (nodes) are positioned along the circumference of a circle, and the chords (arcs or lines) inside the circle connect different entities representing the relationships or interactions between them. The thickness of the chords usually indicates the strength or frequency of the connection between the entities. RTutor version 0.99 was used for all graphics and charts. RTutor uses OpenAI's powerful large language models to translate natural language into R (or Python) code, which is then executed. Species richness was calculated as the total number of species recorded in each landform, and Shannon-Wiener diversity index was used Shannon-Wiener's diversity index to measure species diversity, because it considers both species richness and evenness into account and is not affected by sample size (Kent and Coker, 1992; Krebs, 1999). It was calculated using the following equation:

$$H' = -\sum_{i=1}^{s} pi \ln pi$$

Where, H' = Shannon-Wiener diversity index, *pi* = the proportion of individual or the abundance of i^{th} species, lnPi = $\log_e$ Pi, S = the number of species.

RESULTS

Floristic composition and structure

In the present study, 114 species were collected from Mousa Mountain. The identified species belong to 31 families (Table 2, Figure 6, Plate 1). The most represented seven families were: Asteraceae (17 species, 14,9 %), Poaceae (17 species, 14.9 %), Lamiaceae (11 species, 9,6 %), Caryophyllaceae (8 species, 7 %), Brassicaceae (7 species, 6.14 %) and Scrophulariaceae (7 species, 6.14 %) and Fabaceae (7 species, 6.14 %). On the contrary, 14 mono-specific families (consisting of a single species) were: Adiantaceae, Euphorbiaceae, Asclepiadaceae, Pteridaceae, Rosaceae, Globulariaceae, Juncaceae, Cupressaceae, Plantaginaceae, Urticaceae, Polygalaceae, Dipsacaceae, Liliaceae and Geraniaceae. The Rubiaceae family consists of 5 species. Families Zygophyllaceae, Papaveraceae and Solanaceae consist of 3 species. There are families (consisting of 2 species) such as Boraginaceae, Polygonaceae, Resedaceae, Ephedraceae, Capparaceae and Moraceae.

The collected plant species from the Mousa Mountain showed high differences in both inter and intra-specific categories of the life forms within the same family**.** Figure 7 shows the number and percentage of these different life forms. Therophytes and chamaephytes are the prevailing life forms and constitute more than 70% of species structure (87 species, 76.3% of the total flora). Chamaephytes are good indicators for harsh environmental conditions. Phanerophytes (trees) and hemicryptophytes show equal distribution among the recorded species. In terms of conservation status, International Union for Conservation of Nature (IUCN, 2024) is the most prominent tool used for extinction risk assessment. A key component for effectively preventing the extinction of a certain species is the accurate assessment of its conservation status. Mousa Mountain comprises numerous plants that are threatened and need to be conserved.

Table 2. Species distribution of different landforms (1 – 5), with their life forms and IUCN categories of conservation status (with abbreviations between parentheses). Endemic taxa are represented by an asterisk (*) before species. Abbreviations of landforms: foothills (L1), steep slopes (L2), summit (L3), Farsh (L4), and gorges (L5).

Family	Plant species	Landform	Life form	Conservation status
Adiantaceae	*Adiantum capillus-veneris* L.	5	Hemicryptophyte	Endangered
Asclepiadaceae	*Gomphocarpus sinaicus* Boiss.	1,5	Therophyte	Threatened
Boraginaceae	*Alkanna orientalis* (L.) Boiss.	1,4	Chamaephyte	Not threatened
	Microparacaryum intermedium (Fresen.) Hilge& Podl	3,4	Therophyte	Not Evaluated
Caryophyllaceae	*Arenaria deflexa* Decne	5	Chamaephyte	Critically Endangered
	**Bufonia multiceps* Decne	4,5	Chamaephyte	Critically Endangered
	**Dianthus sinaicus* Boiss	5,3	Chamaephyte	Not Evaluated
	Gymnocarpos decander Forssk.	3,2	Chamaephyte	Vulnerable
	Gypsophila capillaris (Forssk.) C.Chr.	4	Therophyte	Vulnerable
	*Minuartia meyeri (*Boiss.) Bornm;	3,4	Therophyte	Not Evaluated
	Deverra triradiata Hochst. Ex Boiss.	4,5	Therophyte	Vulnerable
	Silene linearis Dence.	5	Therophyte	Data Deficient
Capparaceae	*Capparis cartilaginea* Decne.	5,1	Phanerophyte	Least concern
	Capparis spinosa L.	5,1	Phanerophyte	Not Evaluated
Asteraceae	*Achillea fragrantissima* (Forssk.) Sch. Bip.	1,2	Chamaephyte	Vulnerable
	Artemisia inculta Delile	1,2,3	Chamaephyte	Not threatened
	Artemisia judaica L.	1	Chamaephyte	Critically Endangered
	Centaurea eryngioides Lam.	5&3&2	Therophyte	Not Evaluated
	Centaurea scoparia Siber ex Spreng.	5,1	Chamaephyte	Not Evaluated
	Centaurea sinaica DC.	1,2	Phanerophyte	Data Deficient
	Chiliadenus montanus (Vahl) Brullo.	2,3	Hemicryptophyte	Not Evaluated
	Echinops glaberrimus DC.	3,5	Therophyte	Vulnerable
	Iflago spicata (Forssk.) Sch.Bip.	5,4	Chamaephyte	Not Evaluated
	Lactuca orientalis (Boiss.) Boiss.	4,1	Therophyte	Not Evaluated
	Lactuca undulata Ledeb.	5,1	Therophyte	Endangered
	Leysera leyseroides (Desf.) Maire	4,5	Chamaephyte	Not Evaluated
	Phagnalon nitidum Fresen.	1,2	Therophyte	Least concern
	Pulicaria crispa (Forssk.) Oliv.	1,2	Therophyte	Very vulnerable
	Pulicaria arabica (L.) Cass.	4,3,5	Therophyte	Not Evaluated
	Reichardia tingitana (L.) Roth	3	Chamaephyte	Not Evaluated
	Tanacetum santolinoides (DC.) Feinbrun& Fertig	1,2	Phanerophyte	Least concern
Brassicaceae	*Zilla spinosa* (L.) Prantl.	1,2	Chamaephyte	Not Evaluated
	Diplotaxis acris (Forssk.) Boiss.	1,2,5	Hemicryptophyte	Not Evaluated
	*Diplotaxis erucoides (*L.) DC.	1	Phanerophyte	Vulnerable
	Diplotaxis harra (Forssk.) Boiss.	1,2,4	Hemicryptophyte	Not Evaluated
	Farsetia aegyptia Turra	1,2	Therophyte	Least concern
	Matthiola arabica Bioss.	2,3,5	Phanerophyte	Not Evaluated
	Sisymbrium irio L.	3,4,5	Chamaephyte	Critically Endangered
Cupressaceae	*Cupressus sempervirens* L.	3	Phanerophyte	Least concern
Dipsacaceae	**Pterocephalus sanctus* Decne.	3	Phanerophyte	Least concern
Ephedraceae	*Ephedra alata* Decne.	5	Chamaephyte	Vulnerable
	Ephedra pachyclade Boiss.	1,4	Therophyte	Not Evaluated
Ephedraceae	*Andrachne aspera* Spreng.	2,3	Chamaephyte	Not Evaluated
Geraniaceae	*Erodium laciniatum* (Cav.) Willd.	2,5,3	Therophyte	Least concern
Globulariaceae	*Globularia arabica* Jaub. & Spach	1,4	Therophyte	Not Evaluated
Poaceae	*Avena barbata* Pott ex Link in Schrad.	5	Therophyte	Vulnerable
	Avena sativa L.	5	Therophyte	Not of concern
	Avena sterilis L.	5	Therophyte	Least concern
	Aristida adscensionis L.	5,3	Therophyte	Not Evaluated
	Bromus japonicus Thumb. var. *sinaicus* sp.	4,1	Hemicryptophyte	Least concern
	Bromus pectinatus Thumb.	5	Hemicryptophyte	Least concern
	Cynodon dactylon (L.)Pers.	1,4	Therophyte	Not Applicable
	Hyparrhenia hirta (L.) Stapf	5	Therophyte	Not Evaluated
	Lolium rigidum Gaudin	1,2,3,5	Therophyte	Vulnerable
	Pennisetum glaucum (L.) R.Br.	3,5	Therophyte	Least concern
	Poa Sinaica Steud.	3,5	Hemicryptophyte	Least concern
	Polypogon semiverticillata (Forssk.) Hyl.	1,3,5	Therophyte	Least concern
	Schismus barbatus (L.) Thell.	4,3	Therophyte	Not Evaluated
	Sorghum virgatum (Hack.) Stapf	4,3	Hemicryptophyte	Not Evaluated
	Stipagrostis raddiana (Savi) De Winter	5	Therophyte	Not of concern
	Stipa parviflora Desf.	4	Hemicryptophyte	Least concern
	Festuca myuros L.	5,3	Therophyte	Vulnerable
Juncaceae	*Juncus rigidus* Desf.	5,3	Chamaephyte	Not Evaluated

Lamiaceae	*Ballota undulata* (Fresen.) Benth.	2,3	Chamaephyte	Endangered
	Ballota saxatilis C. Presl	2,3	Chamaephyte	Endangered
	Lavandula stricta Delile	5,2	Chamaephyte	Critically Endangered
	**Nepeta septemcrenata* Benth	4,5	Chamaephyte	Endangered
	**Origanum syriacum* L.	1,2,4	Chamaephyte	Near Threatened
	**Phlomis aurea* Decne.	4	Chamaephyte	Endangered
	Stachys aegyptiaca Pers.	1,2,4	Chamaephyte	Not Evaluated
	Teucrium polium L.	5,2,3	Chamaephyte	Not Evaluated
	Teucrium decaisnei C. Presl	5,2,3	Chamaephyte	Not Evaluated
	Teucrium leucocladum Boiss.	5,2,3	Chamaephyte	Not Evaluated
	Thymus decussatus Benth.	1,2,5	Therophyte	Not Evaluated
Fabaceae	**Astragalus spinosus (Forssk.) Muschl.*	1,2,5	Therophyte	Not Evaluated
	Astragalus asterias Steven.	1,2,4	Therophyte	Not threatened
	Astragalus bombycinus Boiss.	1,4	Therophyte	Vulnerable
	Astragalus sieberi DC.	4	Phanerophyte	Not Evaluated
	Lotus corniculatus L.	1,2,5	Therophyte	Least concern
	Lotus ovetious L.	1,2,5	Therophyte	Least concern
	Leobordea platycarpa (Viv.) B. -E.van Wyk & Boatwr.	4	Phanerophyte	Not Evaluated
Liliaceae	*Aspargus stipularis* Forssk.	1	Hemicryptophyte	Not Evaluated
Moraceae	*Ficus palmata* Forssk.	1,2,5	Chamaephyte	Endangered
	Ficus carica L.	2,5	Therophyte	Vulnerable
Papaveraceae	**Glaucium arabicum* Fresen.	2,5	Therophyte	Least concern
	Papaver decaisnei (Elkan) Hochst. & Steud. Ex Boiss.	3,4,5	Chamaephyte	Vulnerable
	Papaver rhoeas L.	1,2	Chamaephyte	Not Evaluated
Plantaginaceae	*Plantago arabica* Boiss.	3,5	Therophyte	Least concern
Polygalaceae	**Polygala sinaica* Botsch.	2,5	Phanerophyte	Endangered
Polygonaceae	*Rumex cyprius* Murb.	3,5	Geophyte	Not threatened
	Atraphaxis spinosa L. var. *sinaica* Boiss.	1,2	Therophyte	Vulnerable
Pteridaceae	*Cheilanthes vellea* (Aiton) F. Meull.	3,5	Therophyte	Least concern
Resedaceae	*Caylusea hexagyna* (Forssk.) M.L. Green	4	Phanerophyte	Endangered
	Reseda decursiva Forssk.	5	Therophyte	Not threatened
Rosaceae	*Crateagus x sinaica* Boiss.	5	Chamaephyte	Not threatened
Rubiaceae	*Callipeltis cucullaris* (L.) Steven	3	Therophyte	Endangered
	Crucianella membrancacea Boiss.	3	Therophyte	Not Evaluated
	Galium parisiense L.	3,1	Therophyte	Least concern
	Galium setaceum Lam.	5,1	Therophyte	Near Threatened
	Galium sinaicum (Delile ex Decne) Boiss.	4,5	Chamaephyte	Endangered
Scrophulariaceae	**Anarrhinum pubescence* Fresen.	5	Chamaephyte	Not Applicable
	**Kickxia macilenta* (Decne.) Danin	1,3,5	Hemicryptophyte	Not Evaluated
	Kickxia aegyptiaca (L.) Nábělek	3,5	Chamaephyte	Not Applicable
	Scrophularia libanotica Boiss.	4	Hemicryptophyte	Endangered
	Scrophularia xanthoglossa Boiss.	4	Chamaephyte	Endangered
	Verbascum sinaitticum Benth.	1,2	Therophyte	Least concern
	Verbascum decaisneanum Kuntze.	2,4	Phanerophyte	Endangered
Solanaceae	*Solanum nigrum* L.	1,5	Chamaephyte	Not Evaluated
	Lycium shawii Roem. & Schult.	2,5	Therophyte	Least concern
	Hyoscyamus muticus L.	5,3	Chamaephyte	Not Applicable
Urticaceae	*Parietaria alsinifolia* Delile	1,2	Chamaephyte	Least concern
Zygophyllaceae	*Fagonia arabica* L.	1,2	Hemicryptophyte	Endangered
	Fagonia mollis Delile	1,2,3	Chamaephyte	Least concern
	Peganum harala L.	1,2	Chamaephyte	Critically Endangered

Mousa Mountain is characterized by the presence of Six (5.26%) critically endangered species that are found in five different families. The main families containing these endangered species are Caryophyllaceae, Lamiaceae, Asteraceae, Brassicaceae and Zygophyllaceae. Twenty-one (18.42 %) species are considered endangered, mostly belonging to the families Adiantaceae, Polygalaceae, Resedaceae, Rubiaceae, Scrophulariaceae, Asteraceae, Zygophyllaceae, Liliaceae and Lamiaceae.

During this survey, fifteen (13.15%) species are marked as vulnerable taxa; belong to Asteraceae, Ephedraceae, Fabaceae, Caryophyllaceae, Brassicaceae, Moraceae, Polygonaceae Poaceae, and Papaveraceae. Two (1.75%) species are classified as near threatened which are distributed in Lamiaceae and Rubiaceae. Twenty-four (21 %) plant species are categorized as least concern. Plants that need more study are represented by three categories; 4 (3.5 %) not applicable species, thirty-seven (32.45 %) not evaluated species and 2 (1.75 %) data deficient species. There are eight (7.01 %) species marked as endemic, these endemic species belong to families Lamiaceae, Scrophulariaceae, Papaveraceae, Fabaceae and Polygalaceae. This data has been described in Figure 8.

The distribution of IUCN conservation categories among and within life forms

Figure 9 displays the relationship between different categories of life forms and the IUCN conservation categories of species using Chord diagram. In total, 33 species (28.9 % of the total) are not evaluated, followed by the least concern (24 species, 16.7 %), and the endemic (15 species, 13.1 %). It can be noticed that therophytes (Th) and chamaephytes (Ch) have the highest numbers of species. The majority of therophytes are least concerned (LC, 14 species, 12.3 % of the total flora), not evaluated (NE, 13 species, 11.4 %), and vulnerable (V, 9 species, 7.9 %). In the meanwhile, the largest number of chamaephytes are not evaluated (14 species, 12.3 %), followed by endemic species (E, 7 species, 6.1 %).

The distribution of life forms within landforms

The gorges (L5) have the highest number of species (61 species, 53.5 % of the total), ranked second in the foothills (L1) with 46 species (40.3 %), then the steep slopes and summit with 43 (37.7 %) and 41 species (36 %), respectively. Figure 10 shows that the Farsh (L4) has the lowest number of species (33, 28.9 %). Again, therophytes and chamaephytes dominated the life forms within the different landforms, with their highest numbers of species are in the gorges (L5).

The distribution of IUCN conservation categories among and within landforms

The highest numbers of species among the 5 landforms are the not evaluated (NE, 80 species, 70.2% of the total flora) and the least concern (LC, 48 species, 42.1 %) categories of IUCN conservation (Figure 11). Within landforms, most of the species in the gorges (L5) lie in the categories of not evaluated, least concern and vulnerable (V), while the foothills (L1) and summit (L3) are fairly represented in the categories. ANOVA test (Table 3) shows high significant correlations (p=0.001) between different life forms and IUCN categories of conservation, and the studied landforms.

Diversity indices

Results of species diversity analysis with some photos for the plants (Figure 12), revealed that the gorges (L5) were the most diversified landform with the least coefficient of variation, and the least diversified landform was the Farsh (L4) with the highest coefficient of variation (Figure 11).

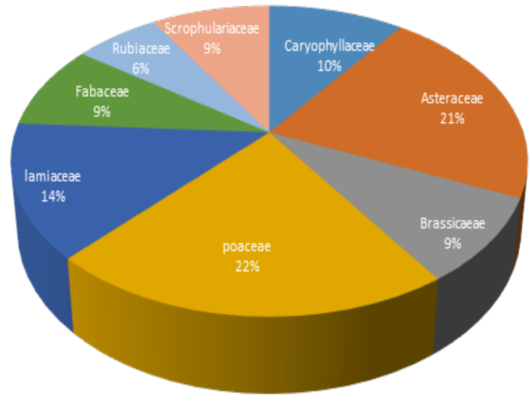

Figure 6. The most dominant families which composed of more than three species found in Mousa Mountain, Egypt.

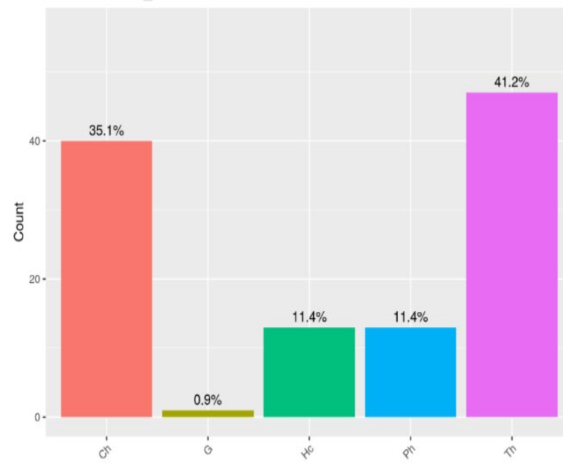

Figure 7. The life form composition of a recorded flora.

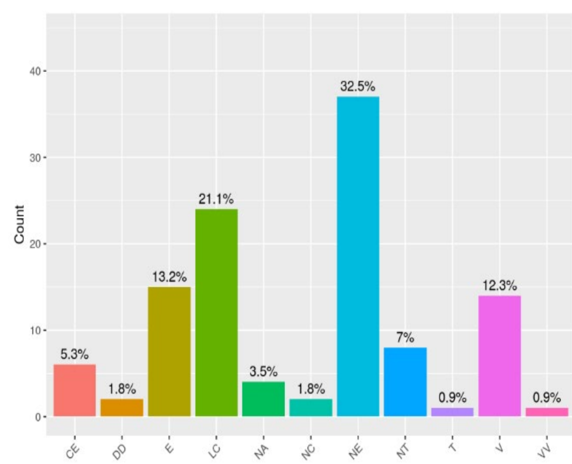

Figure 8. The numbers and percentages of different IUCN conservation categories represented in the recorded species.

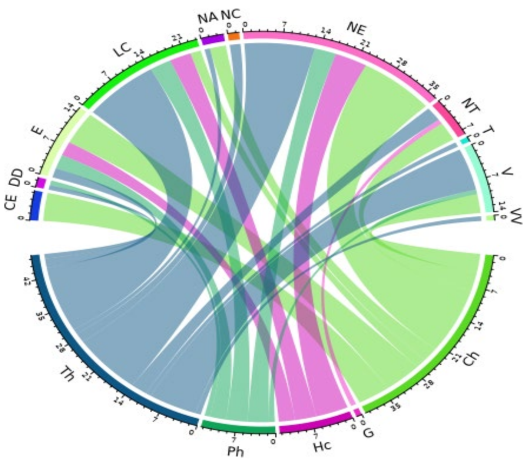

Figure 9. Chord diagram for the distribution of IUCN conservation categories within different life forms. Abbreviations of landforms: foothills (L1), steep slopes (L2), summit (L3), Farsh (L4), and gorges (L5).

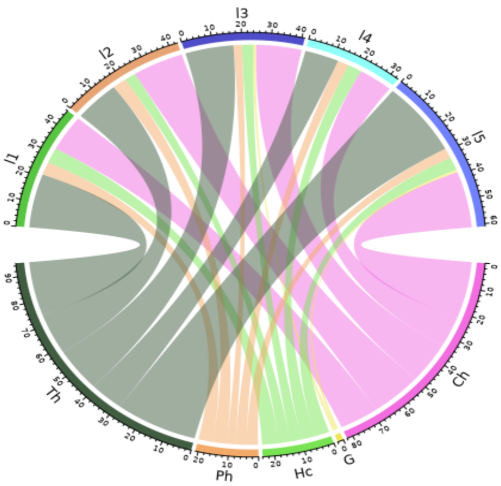

Figure 10. Chord diagram for the distribution of different life forms within the identified landforms (L1 – L5). For abbreviations, see Tables 1 and 2.

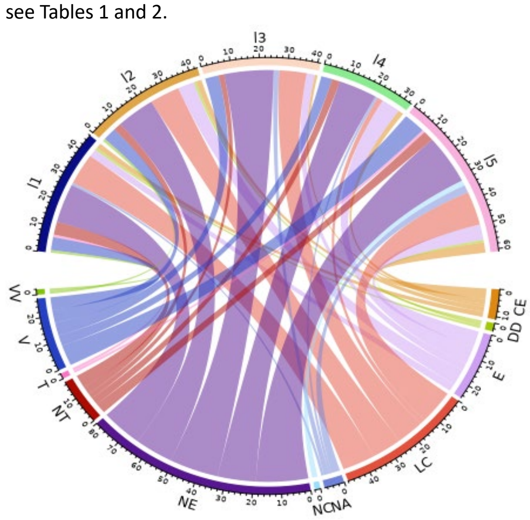

Figure 11. Chord diagram for the distribution of different IUCN conservation categories within the identified landforms (L1 – L5). For abbreviations, see Tables 2 and 3.

DISCUSSION

The present study provides valuable insights into the plant diversity and conservation status of Mousa Mountain, highlighting its significance as a hotspot for biodiversity. The findings reveal a rich flora comprising 114 species belonging to 31 families, demonstrating the mountain's unique ecological characteristics. Ecological Observations in Western and South Sinai (Mousa Mountain): This Mountain is located southeast of St. Catherine Monastery. The northern (windward) slope of this mountain is richer in vegetation than the southern slope of the opposite mountain, on the other side of the monastery. According to Salama *et al.* (2018), the floristic composition along the elevation gradient on the Mousa Mountain included 81 species, 32 vascular plant families, and 69 genera. With more than half of all species known to exist, the most prevalent genera are Asteraceae, Lamiaceae, Zygophyllaceae, Boraginaceae, Brassicaceae, and Solanaceae. The most species of Fagonia were found, with common perennials including *Seriphidium herba-alba*, *Zilla spinosa*, *Tanacetum sinaicum* and *Phlomis aurea.* Less significant species were annual herbs such *Centaurea sinaica*, *Portulaca oleracea,* and *Matthiola longipetala.* The number of species decreased from 47 to 17 at the intermediate levels and then increased to the highest levels.

Three species, *Ballota saxatilis*, *Ephedra alata*, and *Solanum sinaicum*, were consistently found in the medium elevation belts between 1700 to 1900 m. *Crataegus sinaica*, *Thymus decussatus*, *Anarrhinum pubescens*, and *Plantago Sinaica*. *Funaria hygrometrica* were found at elevations between 1900 and 2000 meters. On the contrary, this study recorded a higher number of species reach 114 species representing 31 families. This is by no means an exhaustive list. It was noted in both studies that the most prominent families are Asteraceae and Lamiaceae but unlike Salama *et al.* (2018) who recorded very low numbers of Poaceae, this study shows a high number of species. According to Abrahams (2023), Mousa Mountain, a popular tourist destination in the Sinai Peninsula, is well-known for its religious significance and contribution to Egypt's economic development. Visitors from Sharm-El-Sheikh, Dahab, and Cairo flock to the mountain for tours, which are frequently included in bigger Saint Catherine Monastery itineraries. Moses' trail, also known as Siket Sayidna Musa, is a steep but rigorous ascent with breathtaking views of the Sinai Peninsula and Mount Catherine.

Table 3. Summary of the ANOVA results of life forms and IUCN categories versus the landforms (L1-L5).

Landform	L1		L2		L3		L4		L5	
	F-ratio	*p*-value	F-ratio	*p*-value	F-ratio	*p*-value	F-ratio	*p*-value	F-ratio	*p*-value
Life forms	1662.8	0.001	1493.2	0.001	1398.8	0.001	997.7	0.001	2943.5	0.001
Conservation status	773.1	0.001	670.2	0.001	639	0.001	472.1	0.001	1266.2	0.001

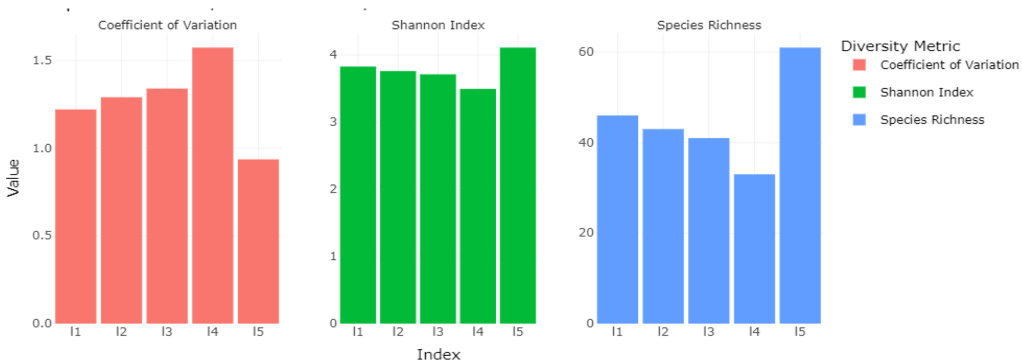

Figure 12. Species richness, Shannon-Wiener diversity index and coefficient variations among the five landforms.

Plate 1. showing some species of Mousa Mountain: A: *Glaucium arabicum,* B*: Artemisia Judaica,* c: *Lavandula stricta,* D: *Alkanna orientalis,* E: *Fagonia mollis,* F: *Ballota saxatilis,* G: *Stachys aegyptiaca,* H: *Reseda decursiva,* I: *Hyoscyamus muticus,* J: *Ephedra alata (*All photos are taken by Prof. Abdelraouf *Moustafa*)

The Camel Path, also known as Siket El Bashait, is a softer but lengthier route that takes 2.5 hours on foot. Both roads lead to Elijah's Hollow, a natural amphitheater 750 steps from the peak that provides breathtaking views of the Sinai Peninsula and surrounding countryside.

The vegetation in Mousa Mountain faces several threats that jeopardize its ecological health. Climate change affects specific species, their relationships with other organisms, and their habitats, altering how ecosystems function and the products and services supplied by natural systems for society (Moustafa *et al.,* 2023). Climate change has led to increasingly arid conditions, reducing the availability of water necessary for sustaining diverse plant species. High temperatures disrupt physiological processes, threatening the survival of some susceptible plant and animal species. Threaten keystone species, including *Phlomis aurea* and other rare important species in South Sinai (Bader and El-Shazly, 2024). Additionally, human activities such as overgrazing by livestock, high numbers of livestock can lead to soil degradation and loss of native vegetation, impacting the ecological balance, deforestation for construction, and the expansion of agriculture are contributing to habitat degradation and loss of native flora where expansion of arid land and reduced vegetation cover can exacerbate desertification processes, making it harder for plant life to thrive (Moustafa *et al*., 2024). These factors not only threaten the unique biodiversity of the region but also disrupt the delicate balance of the local ecosystem. Conservation efforts are crucial to mitigate these threats and preserve the region's natural heritage.

In addition to Mousa Mountain, there are other mountains located on the Mediterranean coast, such as Mount Alsir. According to (Yemeni and Sher, 2010), the floristic analysis of Asir Mountain in Saudi Arabia reveals a diverse plant community, dominated by the Asteraceae family. This dominance is indicative of the family's adaptability to various environmental conditions, particularly in arid and semi-arid regions. The dominance of therophytes in the study area is likely influenced by factors such as seasonal rainfall patterns and human disturbances. Hemicryptophytes and geophytes, with their underground storage organs, are also well-adapted to the region's climate, allowing them to survive periods of drought and extreme temperatures. The presence of phanerophytes, especially nanophanerophytes, suggests the influence of higher rainfall and temperature in certain areas of the mountain. However, the sparse distribution of tree cover highlights the challenges faced by woody plants in the region. The predominance of microphyllous species is a common adaptation to arid environments. Smaller leaves reduce water loss through transpiration, enabling plants to survive in water-limited conditions. The increasing population of therophytes in highly grazed and eroded areas is a concern, as it may indicate a degradation of the ecosystem. Overgrazing can lead to soil erosion, loss of vegetation cover, and increased desertification. To conserve the unique biodiversity of Asir Mountain, it is essential to implement sustainable land management practices, such as rotational grazing, afforestation, and reforestation. Additionally, public awareness campaigns can help promote environmental conservation and reduce human-induced disturbances. The research area's floristic list included 189 species from 74 groups, with the most represented being Asteraceae, Lamiaceae, and Poaceae. Thermophytes (36.5%) were the most abundant, followed by hemocryptophytes and geophytes (15 and 12.5%, respectively), chaemophytes (6.5%), mesophanerophytes (3%), megaphanerophytes (2%), nanophaneorophytes (13%), and climbers (1.5%). The leaf size spectrum revealed that microphylls (41.5%) were prominent. According to (Moustafa, 1999), The vegetation of Saint Catherine protectorate (southern part of Sinai) is subjected to a great disturbance through the unmanaged human activities, including overgrazing, overcutting, uprooting, tourism and quarrying. Many plant species are threatened due to these severe impacts of human activities. Grazing intensity as well as unmanned human activities represents a great disturbance for natural vegetation and threatening some endemic and rare species of extinction, disappearance of pastoral plant communities, paucity of trees, dominating most of the wadis with unpalatable plant species such as *Fagonia mollis*, *Artemisia judaica* and causing environmental degradation which include soil erosion.

CONCLUSION

Mousa Mountain, located in Egypt's Sinai Peninsula, is thought to represent the Mountain, where Moses received the Ten Commandments. It is a relatively high mountain near Saint Catherine, flanked by higher peaks such as Mount Catherine. The mountains' rocks developed during the late Arabian-Nubian Shield development. Mousa Mountain's vegetation faces threats from climate change, human activities like livestock overgrazing, deforestation, and agriculture expansion, which threaten its ecological balance and biodiversity. These factors disrupt the delicate balance of the local ecosystem, necessitating conservation efforts to preserve the region's natural heritage and mitigate the effects of climate change. The Mountain was divided into five landforms: foothill, steep slope, Summit, plain (Farsh) and Gorge. The study collected 114 species from Mousa Mountain, grouped into 31 families. The most represented families were Asteraceae, Poaceae, Lamiaceae, Caryophyllaceae, Brassicaceae, Scrophulariaceae, and Fabaceae. The survey identified 15 vulnerable species (13.15%), 2 near threatened species (1.75%), and 24 least concern plants (21%). The three categories identified 4 non-applicable species, 32.45% not evaluated, and 1.75% data deficient species. There are not sufficient studies on Mousa Mountain, so we recommend paying attention to it as it contains endemic species such as *Nepeta septemcrenata, Phlomis aurea* and *Glaucium arabicum* and other threatened plants that need to be conserved.

REFERENCES

Abd El-Ghani, M. M., Huerta-Martínez, F. M., Hongyan, L., Qureshi, R. (2017). Plant responses to hyperarid desert environments (pp. 473-501). New York: Springer International Publishing.

Abo El-Dahab, F., Baz, M., El-Sayed, Y., Abdel Hameed, R., Abla, A. (2023). Influence of temperature on the efficiency of Commiphora molmol and Acetylsalicylic acid against Culex pipiens (Diptera: Culicidae). *Catrina:*

The International Journal of Environmental Sciences, *27*(1), 13-22. doi: 10.21608/cat.2023.295257

Allen, S.E., H.M. Grimshaw, J.A. Parkinson. 1976. Chemical analysis. In: Chapman, S.B. ed.: Methods in plant Ecology. Blackwell Scientific Publications. Analysis. Ecology, 74(8): 2215 – 2230.

Alqamy H. M. (2002). Developing and Assessing a Population Monitoring Program for Dorcas Gazelle (Gazella dorcas) Using Distance Sampling in Southern Sinai, Egypt. M.Sc. thesis, School of Biology, Division of Environmental & Evolutionary Biology, University of St. Andrews, Scotland, 118 pp.

Al-Yemeni, M., & Sher, H. (2010). Biological spectrum with some other ecological attributes of the flora and vegetation of the Asir Mountain of Southwest, Saudi Arabia. *African Journal of Biotechnology*, *9*(34).

Ama Abrahams, 2023. Mount Sinai in Egypt (Jabal Musa), July 12th, 2023, Ama Abrahams, https://www.encounterstravel.com/blog/mount-sinai-egypt.

Badr, A., & El-Shazly, H. (2024). Climate Change and Biodiversity Loss: Interconnected Challenges and Priority Measures. Catrina: The International Journal of Environmental Sciences, 29(1), 69-78. doi: 10.21608/cat.2024.340596. https://cat.journals.ekb.eg/article_340596.html.

Baruah, T.C. and Barthakur, H.P. (1997) A Textbook of Soil Analysis. Vikas Publishing House Pvt Ltd., New Delhi.

Batanouny, K. H. 1983. Human impact on desert vegetation. In: Holzner W, Werger M J A and Ikusima I. (Eds.) Man's Impact on Vegetation, Dr. W. Junk Publishers, London.

El-Wahab, A., Zaghloul, M., Moustafa, A.E.R. (2018). Vegetation and Environment of Gebel Serbal, South Sinai, Egypt. Catrina: The International Journal of Environmental Sciences, 1(2), 9-20.

El-Wahab, A., Zayed, A.E.M., Moustafa, A.E.R., Klopatek, J., & Helmy, M. (2018). Landforms, vegetation, and soil quality in south Sinai, Egypt. Catrina: The International Journal of Environmental Sciences, 1(2), 127-138.

Fouad M., Moustafa A. A., Zaghloul, M., Arnous, M. (2023). Unraveling the Impact of Global Warming on Phragmites australis Distribution in Egypt. *Catrina: The International Journal of Environmental Sciences*, *27*(1), 59-73. doi: 10.21608/cat.2023.198301.1161

Grainger, J., & Gilbert, F. (2008). Around the sacred mountain: the St Katherine Protectorate in South Sinai, Egypt. Protected landscapes and cultural and spiritual values, 2, 21-37.

Hany, S., Shendi, E., Monsef, H., Mohamed, E., & Smith, S. (2022). Geotechnical Evaluation of Soil for the Suitability of Urban Planning Purposes, Western Bitter Lakes, Suez Canal Region, Egypt. *Catrina: The International Journal of Environmental Sciences*, *26*(1), 57-65. doi: 10.21608/cat.2022.114258.1115

Hausenbuiller, R. L. 1985. Soil science and principles practices. 3 eds., Wm C. Brown Company Publishers. Hobbs, Joseph J. "Seven. THE BEDOUIN WAY OF LIFE". Mount Sinai, New York, USA: University of Texas Press, 1995, pp. 175-216. https://doi.org/10.7560/730915-010.

Holten, D (2006). Hierarchical Edge Bundles: Visualization of Adjacency Relations in Hierarchical Data. IEEE Transactions on Visualization and Computer Graphics, 12(5), 741-748. doi: 10.1109/TVCG.2006.147

Kent M, Coker P (1992). Vegetation description and analysis. A practical approach. Wiley, New York. 363pp.

Krebs CJ (1999). Ecological Methodology. Addison Wiseley Longman, New York. 694pp.

Manley, D., & Abdel-Hakim, S. (Eds.). (2009). Traveling Through Sinai: From the Fourth to the Twenty-first Century. American University in Cairo Press.

Moustafa A.R., 1999. Impact of Grazing on Saint Catherine Vegetation, south Sinai, Egypt Conservation and Rehabilitation of Endemics and rare species, pg.26, Ecological Problems of Sustainable Land use in Deserts, May 5th – 9th 1999, Konigswinter, Germany.

Moustafa, A. A., Ramadan, A. A., Zaghloul, M. S., & Mansour, M. H. (1999). Environmental factors affecting endemic species, species richness and diversity in Saint Catherine Protectorate, South Sinai, Cairo. Egyptian Journal of Union of Arab Biologists, 9, 419-446.

Moustafa, A. and J. M. Klopatek. 1995. Vegetation and, Landforms of the St. Katherine area, Southern Sinai, Egypt. Journal of Arid Environments, 30: 385-395.

Moustafa, A. E. A., & Zaghloul, M. S. (1996). Environment and vegetation in the montane Saint Catherine area, South Sinai, Egypt. Journal of Arid Environments, 34(3), 331-350.

Moustafa, A. E. R. A., Abd El-Wahab, R. H., Zaghloul, M. S., & Ali, H. E. (2014). PLANT DIVERSITY, VEGETATION CONDITIONS AND LANDFORMS OF GEBEL SERBAL, SOUTH SINAI, EGYPT. PLANT DIVERSITY, 43(2), 27-54. (intro)

Moustafa, A., Elganainy, R., & Mansour, S. (2023). Insights into the UNSG announcement: The end of climate change and the arrival of the global boiling era, July 2023 confirmed as the hottest month recorded in the past 120,000 years. *Catrina: The International Journal of Environmental Sciences*, *28*(1), 43-51. doi: 10.21608/cat.2023.234635.1197. https://cat.journals.ekb.eg/article_318622.html.

Moustafa, A., Elganainy, R., Abdelghnai, M., & Mansour, S. (2024). Scorching Records: The Hottest May in History and Its Impact on Our Planet, Breaking Records and Intensifying the Climate Crisis. *Catrina: The International Journal of Environmental Sciences*, (), 29-42. doi: 10.21608/cat.2024.322961.1332. https://cat.journals.ekb.eg/article_399474.html.

Moustafa, A., Salman, A. A., Elrayes, A., E., & Bredemeire, M., 2020. Classification of Wadi system based on floristic composition and edaphic conditions in South Sinai, Egypt. Catrina: The International Journal of Environmental Sciences, 20(1), 9-21. DOI:

10.21608/cat.2020.85756. https://cat.journals.ekb.eg/article_85756.html.

Salama, F., Abd El-Ghani, M.M.., Gadalla, M., Ramadan, T., Galal, H., & Gaafar, A. (2018). Vegetation patterns and floristic composition along elevation gradient on Jabal Musa, South Sinai, Egypt. Catrina: The International Journal of Environmental Sciences, 17(1), 41-57.

Shams, A. (2011). Themes of traditional-modernized daily life of the Gebaliya tribe in the High Mountains of Sinai Peninsula. In Sharing Cultures 2011: Proceedings of the 2nd International Conference on Intangible Heritage (pp. 585-594).

Sweberg, M. H. (2020). Once Holy Mountain: A Biblical and Geographical Analysis of where Mt. Sinai is Located. Wipf and Stock Publishers.

Wilde, S. A., C. K. Voigt, J. G. Layer 1972. Soil and plants analysis for tree culture. edited byGordonchesters. AppliedScience publishers.

Yitzhak Gil-Har (1993). Egypt's North-Eastern Boundary in Sinai. Middle Eastern Studies, 29(1), 135–148. http://www.jstor.org/stable/4283545.