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Condition Assessment of Plant Diversity of Gebel Maghara, North Sinai, Egypt

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ABSTRACT

The present study aimed to assess plant diversity and vegetation structure of Gebel Maghara at different habitats. Floristic changes with emphasis on medicinal plants and human impacts are also considered. Twenty five sites representing different localities and habitats of Gebel Maghara were surveyed for vegetation measurements, soil sampling, and human activities description. Different diversity indices were measured, and multivariate analyses were carried out using TWINSPAN for classification and CANOCO for ordination. Soil physical and chemical properties were analyzed in 40 surface soil samples. The results revealed that Maghara area is characterized by high and unique plant diversity. One hundred and ten species are recorded in Maghara area including 70 medicinal species. W. Maghara and W. Aroseya are richer in medicinal plants than other localities. Seven main vegetation groups are recognized in the area. The dominant species in these groups are *Anabasis articulata*, *Juniperus phoenicea*, *Zilla spinosa*, *Zygophyllum dumosum*, *Retama raetam*, *Artemisia monosperma*, and *Acacia pachyceras* var. *najdensis*. The vegetation group dominated by *Juniperus phoenicea* is more diverse than the others. Sand and clay fractions, total carbonate and pH are the main soil conditions controlling the distribution of plant communities in the area. Gorges and slopes are the most diverse habitats. Beta diversity between previous (1960) and current (2005) surveys reflects a large floristic change. About 121 species previously recorded since 1960 are not recognized in the current survey and many of them may be lost. In addition to aridity conditions, human impacts including mining and quarrying, over collection of vegetation for different purposes, and cultivation are considered the main threats of plant diversity in the area. The study recommends that action plans to protect the Maghara's plant diversity should be based on improved knowledge of the biodiversity, empowering local people to become more involved in decision making, improvements in local and national governance, and more effective operational mechanisms for implementing protection of plant diversity at identified hotspots rich in medicinal and/or endangered species.

Key words: Vegetation, plant diversity, species loss, medicinal plants, human impact, multivariate analysis, landforms, North Sinai.

INTRODUCTION

Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, timber, fiber and fuel. This has resulted in a substantial and largely irreversible loss in the diversity of life on Earth. Several works have underlined the importance of species diversity in ecosystems assessment, which could contribute to a firmer base for the rational management of these ecosystems (e.g., McNeely, 1992; Dallmeier and Comiskey, 1998). Species extinctions and reduction in genetic variability are taking place at rates never before witnessed (Spellerberg, 1992).

Gebel Maghara is one of the land marks in the plant diversity of Sinai and Egypt and represents one of the most important centers of medicinal plants in the area. In addition to having a relatively rich and unique flora, the study area is also anthropologically important due to the presence of different Bedouin tribes that have a very unique traditional knowledge about medicinal plants and their uses (MPCP, 2006). The area is characterized also by diversity in landforms, rock units, water resources, and aridity conditions. The widespread poverty among the local inhabitants gives plant diversity assessment of the area a great importance for the well-being of the population.

Plant diversity and vegetation of Sinai in general and Maghara area in particular is subjected to destructive impact due to the unmanaged human activities including quarrying, mining, grazing, collection of plants for different purposes. These severe impacts threaten the plant life and deteriorate the environment (Abd El-Wahab *et al.*, 2004). Thirty two of woody species growing in Sinai are considered as either endangered or vulnerable species (El-Hadidi *et al.*, 1991). Boulos and Gibali (1993) recorded 160 plant species in Sinai as threatened species. The continuous unmanaged human activities resulted in disappearance of pastoral plants, dominance of unpalatable species, paucity of trees and shrubs, disappearance of many rare and endemic species, depletion of vegetation cover, and soil erosion (Moustafa and Klopatek, 1995).

Gebel Maghara was visited on several occasions by botanists who published records of their collections. Range (1921) collected about 250 plant species from North Sinai, the majority of which were from Gebel Maghara. Boulos (1960) made an important intensive floristic check list for certain wadis and habitats of Gebel Maghara. He collected 193 plant species. Danin (1978) recorded 374 plant species in the anticlines of North Sinai including G. Maghara, G. Halal, G. Lebni, and G. Yi'allaq. Plant diversity of W. Aroseya, one of the important wadis of Maghara area, was emphasized

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by El-Khouly and Fakhry (1999). Gazar *et al*. (2000) collected 154 plant species from G. Halal. Kamel *et al*. (2008) recorded 131 plant species in the anticlines of North Sinai. Diversity of medicinal plants in North Sinai was evaluated by Abd El-Wahab *et al*. (2008). However, intensive quantitative floristic and ecological studies on Gebel Maghara with emphasis on changes for conservation are still needed.

The present study aimed to assess plant diversity and vegetation structure in relation to environmental factors of Gebel Maghara at different habitats. Floristic changes with emphasis on medicinal plants and human impacts are also considered during the period between 1960 and 2005. This study presents baseline information on threats to the Maghara's plant diversity and sites of biodiversity significance in the context of increased concerns of the global community to better protect dry land ecosystems.

MATERIALS AND METHODS

Site Description

Gebel Maghara is situated in the northern part of Sinai Peninsula between latitudes 30° 40` and 30° 48` N and longitudes 33° 17` and 33° 30` E (Fig. 1). It represents one of several isolated mountains of the Isthmic or Tih desert of North Sinai, the highest of which are G. Yi'allaq (1094 m a.s.l.), G. Maghara (731 m a.s.l.), G. Halal (890 m a.s.l), and G. Libni (441 m a.s.l.) (Said, 1990). G. Maghara has a length of 45 km, a width of 20 km, and consists mainly of Jurassic rocks, surrounded by marine Lower Cretaceous exposures (Shata, 1956).

Maghara area is characterized by arid climate. The highest temperature is in June-August, and the lowest in January-February. The mean annual temperature is 20°C and the relative humidity is 47%. The mean annual

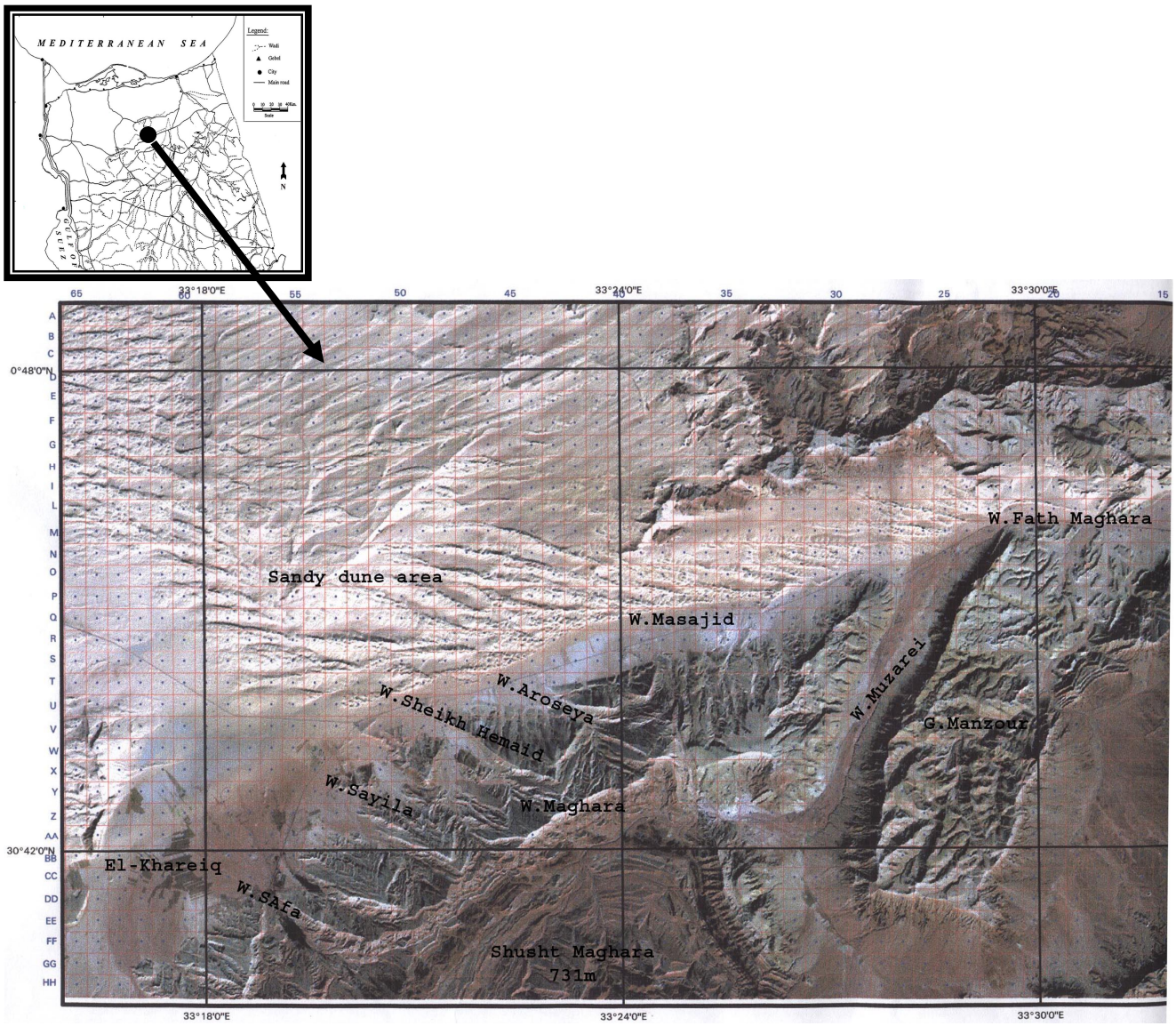

Figure (1): Location map and satellite image of Gebel Maghara showing main surveyed localities.

Rainfall is about 40 to 50 mm, mainly distributed during December-February (Table 1). During the rest of the year it is practically rainless. The study area is characterized by high evaporation rate (9mm/day), which plays an important role in enriching the soil and rocks with an important source of water, namely the dew at the first hours of the morning. Large areas of limestone slopes characterized by rocky outcrops are covered mainly by different types of lichens that depend mainly on dew as a major source of water. The area is exposed to northeastern and northern winds with a mean velocity of about 11 knots. Temperature and rainfall of certain stations in North Sinai including Maghara area are listed in Table (2).

Table (1): Climatic data of Maghara area (1955).

Month	Air temperature °C		Relative humidity (%)	Rainfall (mm)	Evaporation (mm/day)
	Mean daily max	Mean daily min			
Jan.	19	8.7	47	12	5.2
Feb.	19.4	9.7	55	9.7	5.9
Mar.	21.8	10.4	40	8	8
Apr.	28.3	14.2	32	0	10.4
May.	29.4	16.2	40	0	12.3
Jun.	32.9	18.9	45	0	13.5
Jul.	33.2	19.5	48	0	11.3
Aug.	33.3	20.4	53	0	10.8
Sep.	30.2	18.7	57	traces	9.6
Oct.	28.7	17.7	59	1.7	8.6
Nov.	27.3	16.2	47	traces	6.5
Dec.	19.3	10	52	12.3	5.9
Annual mean	26.9	15.05	47	43.7	9

Table (2): Available climatic data of three stations at coastal area, North Sinai: Bier El-Abd, El-Arish, and Rafah (1996-1998) and three stations of inland desert area Middle Sinai: Maghara (1955), El-Melaz and Nakhel (1996-1998).

Station	Temperature (°C)		Rainfall (mm)
	Max	Min	
Bir El-Abd	27.1	13.7	40.2
El-Arish	26.2	14.5	84
Rafah	26.7	13.8	157.4
Maghara	26.9	15.05	43.7
El-Melaz	26.8	12.6	23
Nakhel	28.2	9.7	15.4

Gebel Maghara anticlines are characterized by large outcrops of smooth-faced limestone and dolomite. In addition to these anticlines, two major types of habitats characterizing the area; they are sandy plains, which surround the mountainous area, and large system of wadis, which flow eastwards into a large sand and gravel-plain. W. Masajid is the longest and widest wadi in the area, located in the northern side of G. Maghara. The wadi is bounded from the north by sandy plain and sandy dunes and from the south by Gebel Maghara. Many tributaries pour in W. Masajid including from west to east: W. Safa, W. Sayila, W. Sheikh Hemaid and W. Aroseya (Fig. 1). Landmarks of G. Maghara include also W. Maghara, El-Khareiq plain, W. Muzarei, W. Fath Maghara, and W. Mashaba (Fig. 1). W. Maghara is another long wadi. It runs more or less parallel to W. Masajid but at higher elevation. El-Khareiq Plain is an open sandy and gravelly plain bounded by limestone hills from the southeast, and from the north by undulating sandy plain containing scattered sand dunes. W. Muzarei lies in the eastern side of G. Maghara and is characterized by number of tributaries of which W. Moerab represents the main one. Wadi Fath Maghara is an open wadi, gravelly to sandy. Flood of Wadi Masajid pours in this wadi. W. Mashaba is located south of G. Maghara and is characterized by few small sand dunes scattered in sandy and gravelly plain. The area is characterized by number of wells such as Bir Um Werib located at the upstream of W. Um Werib, Bir El-Lagama close to W. Fath Maghara, and tens of new wells in El-Khareiq plain.

Vegetation and Soil Sampling

During spring and summer seasons of 2005, vegetation survey was carried out in ten localities in Maghara area. These localities are: (1) W. Masajid, (2) W. Maghara, (3) W. Aroseya, (4) W. Sheikh Hemaid, (5) W. Sayila, (6) W. Safa, (7) El-Khareiq plain, (8) W. Muzarei, (9) W. Fath Maghara, and (10) W. Mashaba. These main localities covered most of habitat and vegetation diversity in the area. The main habitats represented in this survey include: plains, sand dunes, fans, wadis, gorges, and slopes.

Vegetation measurements, soil sampling, and human activities description were carried out in 25 sites representing different localities and habitats in Maghara area. In these sites, 127 plots (3-7 plots/site) were randomly chosen. The plot size varies from 5m x 5m in wadi channels, gorges, and slopes characterized by diffuse vegetation and 20m x 20m in fans, plains and other habitats characterized by sparse vegetation. Forty surface soil samples were collected (0-20 cm depth) from different sites to investigate the edaphic conditions of the area. Geographic location (latitude and longitude), and altitude were recorded in each site using GPS receiver.

Floristic and Vegetation measurements

Description of vegetation and habitat in each site was carried out including listing of species and estimating the total vegetation cover in addition to recording the human interference and their signs on plant life. In each quadrate, vegetation cover as a basal canopy cover was measured (Gopal and Bhardwaj, 1981).

Identification and nomenclature were carried out according to T?ckholm (1974) and Boulos (1995, 1999, 2000, 2002 & 2005). Medicinal plants listed in this study refer to species having medicinal (including veterinary), aromatic, and culinary importance (e.g.,

Bailey and Danin, 1981; Boulos, 1983; Bown, 1995; Batanouny *et al*., 1999; Hanafi and Abdel-Wahab, 2000; Abd El-Wahab *et al*., 2004).

Plant Diversity Measurements

Diversity is a measure of community structure, which can be defined as (1) the number of different species that occur in an area or sample, (2) the number of individual organisms that are present, and (3) the distribution of these organisms among the different species (Barbour *et al*., 1987). Various indices put different weight on the importance of these components because they were originally developed to examine widely differing concepts (Huston, 1994). There are two components to diversity: richness and evenness. Richness is the measure of the number of species within a sample where the more species in a community the higher the diversity. Evenness is a measure of the relative abundance of the different species within a community. The more nearly equal the species relative abundances the higher the diversity. Margalef index, Shannon-Weiner *H′*, and species richness were measured using GenStat for Windows 10th Edition computer general statistics package software (Payne *et al*., 2007).

Margalef index emphasizes the richness component of diversity. The equation of this index is:

$$Dmn = (S - 1) / \log(N)$$

where S is total number of species and N is total number of individuals.

Shannon-Weiner H' highlights the evenness component of diversity. It is evaluated by:

$$H' = - \sum_i (n_i / N) \times \log(n_i / N)$$

where n_i are the individuals, N is total number of individuals.

Species richness is the total number of species per unit area.

Floristic change measurements

Floristic changes between the two surveys of G. Maghara as a whole and of different wadis were also determined using Beta diversity (β_T), Wilson-Shmida index ($\beta_T = \{g(H) + L(H)\}/2\ \alpha$) (Wilson and Shmida, 1984; Magurran, 1988). This index adds the number of species gained $\{g(H)\}$ to the number of species lost $\{L(H)\}$ along a habitat gradient (H), standardized by the average sample richness α.

Soil analyses

Soil samples were air dried and then passed manually through a 2mm sieve to evaluate gravel percent. Particle size analysis by pipette method and hygroscopic moisture were analysed according to Klute (1986). Soil organic matter, pH (1:2.5 suspension), EC (1:1 water extract), total carbonate, and water soluble cations and anions (1:1 water extract) were analyzed in the different soil samples according to Sparks *et al*. (1996).

Statistical and Multivariate Analyses

Statistical analyses of the data including One-way ANOVA were carried out (Zar, 1984) using SPSS software (Statistical Package for Social Sciences, version 11.5). Multiple range Duncan test was performed to separate the means. Multivariate analyses were carried out according to Gauch (1982) using PC-ORD software version 4 (McCune & Mefford, 1999). Rare species with presence less than 3% and/or plant cover less than 1% were excluded in order to mitigate noise, and summarize redundancy (Gauch, 1982). Cover of 50 plant species measured in 127 plots was classified using Two-way Indicator Species Analysis (TWINSPAN) (Hill, 1979). Ordination using Canonical Corresponding Analysis (CCA) (ter Braak, 1986) was employed to interpret the species/environment relationships. Ordination analysis was carried out using measurements of vegetation and soil conditions in 40 plots representing the main habitats in the study area.

RESULTS

Plant Diversity, How it was in the past "1960"

According to the available literatures, the floristic survey carried out by Boulos (1960) represents the most intensive previous study for G. Maghara. Five main wadis were only visited in this previous study; W. Maghara, W. Aroseya, W. Muzarei, W. Fath Maghara, and W. Mashaba. Boulos (1960) collected and identified 193 plant species in Maghara area belonging to 155 genera and 54 families (Table 3). The common representative families were Compositae (25 species), Gramineae (21 species), Leguminosae (16 species), Cruciferae (14 species), Liliaceae (11 species), Labiatae and Chenopodiaceae (9 species each). The 193 species included 89 annuals, and 104 perennials distributed as follow: 55 perennial herbs, 26 sub shrubs, 22 shrubs, and one tree (Table 3).

Most of these species were recorded in sandy soil habitat (98 species), followed by habitats with large fragments as a soil surface (64 species). The lowest number of species were recorded in open sandy ground (9 species), moist ground (8 species), and high plateaus and slopes (7 species). Boulos list included one endemic species (*Rorippa integrifolia*), and one tree species (*Juniperus phoenicea*). *Adonis cupaniana* recorded by Boulos in W. Mashaba as a common in sand habitats is not listed in the Egyptian flora. The highest recorded number of species was in W. Maghara (101 species) followed by W. Muzarei (76 species). About 15 to 20 species were only recorded in W. Aroseya, W. Fath Maghara, and W. Mashaba (Fig. 2).

The floristic list included 63 medicinal plants belonging to 58 genera and 30 families. They were mainly recorded in W. Maghara (40 species), W. Muzarei (30 species), and W. Aroseya (27 species) (Fig. 3). Most of the medicinal plants were perennials (73%) (Table 3).

Plant Diversity, How it looks now "2005"

During the current survey "2005" one hundred and ten plant species were recorded in Maghara area. These species belong to 96 genera and 42 families. The common representative families are: Compositae (11species), Chenopodiaceae (9 species), Leguminoseae (8 species) and Cruciferae, Gramineae, and Zygophyllaceae (7 species each), and Labiatae (6 species). According to growth forms, the 110 recorded species are classified into 28 annuals, 29 perennial herbs, 26 sub shrubs, 21 shrubs, and 6 trees. None of the recorded species is endemic. On the other hand, the floristic composition is characterized by dominance of annuals and perennial herbs (52%) followed by shrubs and subshrubs (45%) (Table 3). Only 5% of the recorded species are trees; *Acacia pachyceras* var. *najdensis, Acacia tortilis, Juniperus phoenicea, Tamarix aphylla,* and *Tamarix nilotica*.

The highest number of species was recorded in W. Maghara (54 species), followed by El-Khareiq plain (51 species), and W. Aroseya (49 species). W. Mashaba and W. Fath Maghara showed the lowest number of the recorded species (13 and 15 species, respectively). Number of species in the other localities varies from 27 to 37 species (Fig. 2).

Diversity of Medicinal Plants

Flora of the area includes 70 medicinal plant species, which represents 64% of the current recorded species. These medicinal plants consist of 14 annuals, 18 perennial herbs, 32 sub shrubs and shrubs, and 6 trees. Most of the annuals are recorded in El-Khareiq plain. The medicinal plant species include *Acacia pachyceras var. najdensis, Asclepias sinaica, Ballota undulata, Juniperus phoenicea,* and *Lavandula pubescens, Acacia tortilis, Anabasis articulata, Artemisia monosperma, Cleome amblyocarpa,* and *Panicum turgidum*.

The recorded medicinal plants include 32 species with biological activity, 38 species used in folk medicine, 46 species with active components, 6 species used in market, and 3 species used in medicine production. Different types of lichens are recognized covering the majority of different anticlines outcrops.

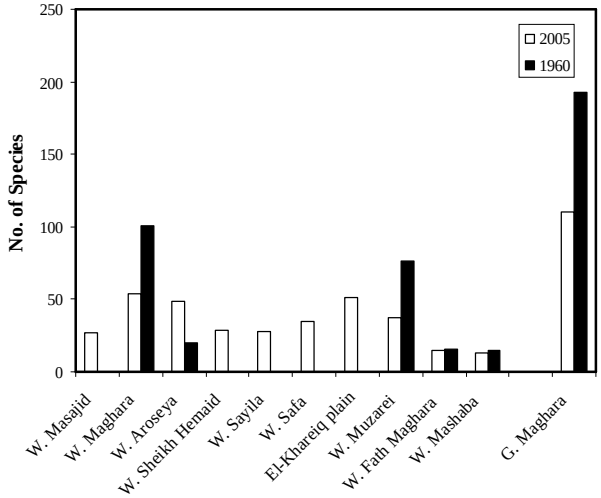

Figure (2): Number of species at different wadis of G. Maghara recorded in the current survey (2005) and in Boulos (1960).

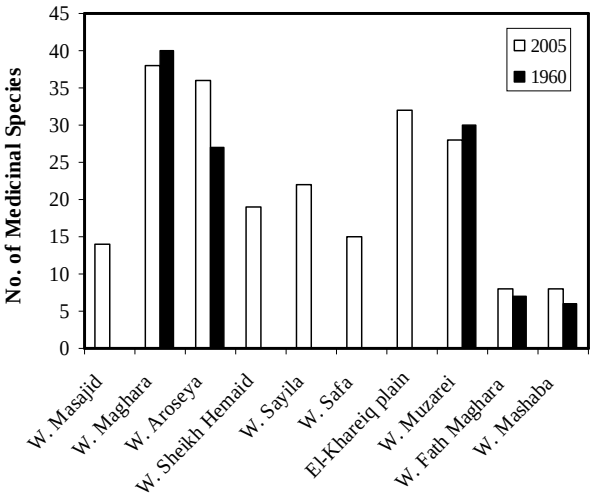

Figure (3): Number of medicinal species at different wadis of G. Maghara recorded in the current survey (2005) and in Boulos (1960).

Gebel Maghara is considered the main source for collecting lichens for medicinal uses. W. Maghara, W. Aroseya, and El-Khareiq plain are richer in medicinal plants (32-38 species) than W. Muzarei and W. Sayila,

Table (3): Floristic composition and growth forms of plant species recorded at Gebel Maghara in the current survey (2005) and the previous survey (Boulos, 1960).

	No. of Families	No. of Genera	No. of Species	Growth form				
				Annual	Per. Herb	Sub Shrub	Shrub	Tree
1960-2005	57	182	**231**	100	65	34	26	6
Current 2005	42	96	**110**	28	29	26	21	6
Boulos 1960	54	155	**193**	89	55	26	22	1
Not recorded in 2005	36	94	**121**	72	36	8	5	0
Not recorded in 1960	21	32	**38**	11	10	8	4	5
Common species	33	67	**72**	17	19	18	17	1
Medicinal plants (1960-2005)	33	76	**86**	22	24	16	18	6
Medicinal plants (2005)	30	64	**70**	14	18	15	17	6
Medicinal plants (1960)	30	58	**63**	17	18	13	14	1

and W. Sheikh Hemaid (19-28 species). The lowest richness of medicinal plants was recorded in W. Fath Maghara and W. Mashaba. (8 species) followed by W. Masajid (14 species) (Fig. 3).

Plant Diversity in the Main Localities

Analysis of variance of Shannon-Weiner *H'*, Margalef index, and species richness showed highly significant variations between the different 10 localities (Table 4). Shannon-Weiner *H'* measurements showed that W. Safa, W. Sayila, and W. Aroseya are more diverse localities than W. Masajid, W. Maghara, W. Sheikh Hemaid, El-Khareiq plain, W. Muzarei, W. Fath Maghara, and W. Mashaba. While W. Safa showed the highest diversity (1.52 ± 0.04 standard error), W. Masajid showed the lowest diversity (0.41 ± 0.17). Similar results were observed with Margalef index, where W. Safa and W. Aroseya have the highest species diversity (1.71 ± 0.67 and 1.69 ± 0.22, respectively). The Margalef index of the other localities varies from 0.51 ± 0.08 in W. Maghara to 1.03 ± 0.2 in W. Sheikh Hemaid (Table 4). Species richness measurements in different localities showed that W. Safa is characterized by the highest species richness (6.5 ± 1.5 species/100m^2) followed by W. Aroseya (5.5 ± 0.83 species/100m^2). Species richness of W. Sayila, W. Muzarei, W. Fath Maghara, and W. Mashaba varies from 3 to 5 species/100m^2. The lowest species richness was recognized in W. Masajid, El-Khariq plain, and W. Maghara (2.56 ± 0.71, 2.7 ± 0.36, and 2.78 ± 0.26 species/100m^2, respectively) (Table 4).

Plant Diversity in the Main Habitats

Six main habitats were recognized in G. Maghara. These habitats are plains, sand dunes, fans, wadis, gorges, and slopes. Alpha diversity indices within these habitats are described in Table 6. Species richness in different habitats varies from 2.20 to 7.50 species per 100m^2 in gorges. Gorges are characterized by higher species richness (7.50 ± 1.55 species/100m^2) than the other habitats that varies from 2.20 ± 0.53 species/100m^2 in fans to 3.92 ± 0.48 species/100m^2 in slopes (Table 5). Results of Shannon-Weiner *H* and Margalef indices were in the same trend as species richness indicating that gorges are the most diverse habitat in G. Maghara followed by slopes and wadis. On the other hand, Margalef index showed that plains, slopes, and wadis are lower in diversity than sand dunes and fans (Table 5).

Vegetation Structure

Generally, vegetation of G. Maghara is dense in wadi channels, gorges and highly fractured slopes, and sparse in sand dunes, plains, and fans. Three main different habitats are recognized in this area; sandy plains, wadis, and anticlines. The sandy plains are located surrounding the mountainous areas. The dominant species characterizing these habitats include *Anabasis articulata, Panicum turjidum,* and *Artemisia monosperma*.

Table (4): Variation of diversity indices among different localities. Mean values of each diversity index with similar letters indicate no significant variation according to Duncan's multiple range tests.

	Shannon-Weiner H	Margalef	Species richness
W. Masajid	0.41a	0.54a	2.56a
W. Maghara	0.66abc	0.51a	2.78a
W. Aroseya	1.22bcd	1.69b	5.50bc
W. Sheikh	0.56ab	1.03ab	2.56a
W. Sayila	1.30cd	1.00ab	5.00ab
W. Safa	1.52d	1.71b	6.50c
El-Khareiq plain	0.71abc	0.94ab	2.70a
W. Muzarei	0.87abcd	0.65a	3.00ab
W. Fath Maghara	0.88abcd	0.88a	3.20ab
W. Mashaba	0.94abcd	1.20ab	3.17ab
F	3.72	5.51	4.44
p	0.0004	<0.0001	<0.0001

Table (5): Variation of diversity indices among different landforms. Mean values of each diversity index with similar letters indicate no significant variation according to Duncan's multiple range tests.

	Shannon-Weiner H	Margalef	Species richness
Plain	0.61a	0.76a	2.47a
Sand Dune	0.76a	1.04ab	2.67a
Fan	0.43a	1.33ab	2.20a
Wadi	0.88a	0.85a	3.65a
Gorge	1.68b	1.74b	7.50b
Slope	0.95a	0.80a	3.92a
F	*4.49*	*2.42*	*6.93*
P	*0.001*	*0.040*	*<0.0001*

The second type of habitats is wadis that mainly originate from the anticlines, then split and convert till pour in the plains surrounding the mountainous areas. *Retama raetam, Acacia tortilis, Acacia pachyceras* var. *najdensis* and *Tamarix nilotica* or *Tamarix aphylla* grow in large wadis, e.g., W. Masajid.

The third type of habitats is several anticlines with limestone, chalk, dolomite, and marl outcrops. The dominant plant species characterizing slopes and gorges of these anticlines include *Zygophyllum dumosum, Reseda arabica, Retama raetam, Lycium shawii,* and *Juniperus phoenica.*

Variation in the average plant cover is recognized in the area between different habitats reflecting the climatic variations and mainly the aridity conditions of the area. The average plant cover percentage is 10%. This percentage decreases in sandy dunes and non fractured slopes to <1%, and increases to more than 20% in wadi channels, gorges, and alluvial fans.

Multivariate classification analysis (TWINSPAN) revealed that at the fourth level of classification, the area is characterized by 7 main vegetation groups. Indicators of classification at each level are listed along with the number of plots representing each group in

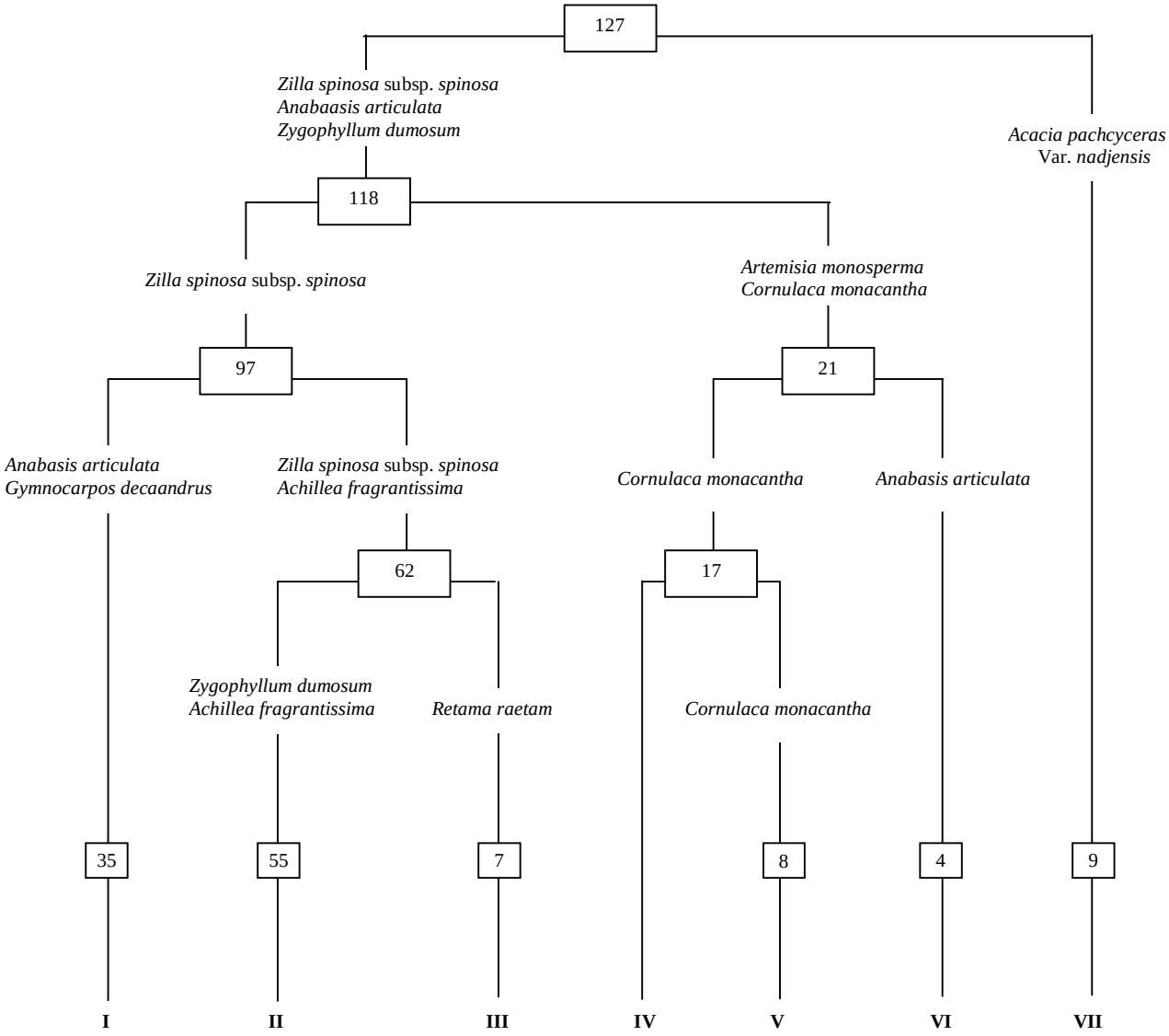

Figure (4): TWINSPAN classification of 127 plots based on the canopy cover of 50 plant species. Indicator species and number of plots at each level are shown.

Figure (4). These groups are named according to the dominant species based on the presence and cover percentages in each group (Table 6) as follow:

Group I: Anabasis articulata

This vegetation group is dominated by *Anabasis articulate*. The associated species include *Gymnocarpos decandrus, Stachys aegyptiaca*, and *Zygophyllum dumosum*. Further classification showed that this group can be classified into three subgroups. *Subgroup 1* is dominated with *Anabasis articulate* and associated with *Panicum turgidum*. This subgroup is recognized in W. Fath Maghara and surrounding plains. Vegetation cover ranges from10 to 15%. *Subgroup 2* is pure community of *Anabasis articulata* growing mainly in W. Masajid. Low plant cover is recognized in this subgroup (1-3%). *Subgroup 3* is dominated with *Anabasis articulata* and associated with *Gymnocarpos decandrus, Stachys aegyptiaca*, and *Zygophyllum dumosum*. W. Maghara and W. Sayila are the main wadis supporting this subgroup. Vegetation cover varies from 5 to 10%.

Group II: Juniperus phoenicea

This vegetation group is dominated by *Juniperus phoenicea* and co-dominated with *Globularia arabica, Thymelaea hirsuta*, and *Lavandula pubescens*. The associated species include *Chiliadenus montanus, Achillea fragrantissima*, and *Stachys aegyptiaca*. *Juniperus phoenicea* is one of the endangered medicinal species and represents the only conifer tree growing naturally in Egypt. Tens of old *Juniperus phoenicea* trees are only growing in fractured limestone of northfacing slopes and gorges at the upstream of W. Aroseya. This Mediterranean species is found nowhere in Egypt outside the limestone anticlines of North Sinai that include Gebel Maghara, Gebel Halal, and Gebel Yi'allaq. Plant cover varies from 5 to 10% in this area.

Group III: Zilla spinosa subsp. *spinosa*

This group is dominated by *Zilla spinosa* subsp.

spinosa and co-dominated with *Lycium shawii* and *Acacia tortilis*. The associated species include *Achillea fragrantissima, Zygophyllum dumosum, Chiliadenus montanus,* and *Thymelaea hirsuta*. Most of the localities in Maghara area support this community including W. Sayila, W. Maghara, W. Safa, and El-Khareiq plain. Vegetation cover varies from 10 to 20%.

Group IV: Zygophyllum dumosum

This vegetation group is dominated by *Zygophyllum dumosum*. The associated species include *Ochradenus baccatus, Lycium shawii,* and *Zilla spinosa* subsp. *spinosa*. This community is recognized in limestone slope habitat at wide range of altitude (300-700m a.s.l) characterized by high content of total carbonate.

Group V: Retama raetam

This dominant species in this group is *Retama raetam*. The associated species include *Thymelaea hirsute, Zilla spinosa, Peganum harmala,* and *Haloxylon salicornicum*. El-Khareiq plain and W. Mashaba support this community with total plant cover varies from 10 to 15%. It is also represented in the downstreams of tributaries of W. Muzarei with high plant cover varies from 20 to 40%.

Group VI: Artemisia monosperma

This vegetation group is dominated by *Artemisia monosperma*. The associated species include *Anabasis articulate, Retama raetam,* and *Cornulaca monacantha*. Further classification revealed that this group is classified into three subgroups. *Subgroup 1* is characterized by pure community of *Artemisia monosperma*. *Subgroup 2* is dominated with *Artemisia monosperma* and *Cornulaca monacantha*. *Subgroup 3* is dominated with *Artemisia monosperma* and *Anabasis articulata*. El-Khareiq plain supports the first two subgroups, whereas W. Mashaba is a good example for the third subgroup. Vegetation cover ranges from 5-10%.

Group VII: Acacia pachyceras var. najdensis

This vegetation group is dominated by *Acacia pachyceras* var. *najdensis*. The main associated species is *Fagonia arabica*. Fan of W. Sheikh Hemaid represents the main habitat supporting this vegetation group. A total plant cover reaches 15 to 20%.

Variation of diversity indices among different vegetation groups was highly significant. Shannon-Weiner *H'*, Margalef index, and species richness measurements showed that vegetation group II dominated with *Juniperus phoenicea* was the most diverse one (1.71, 1.87, and 7.40, respectively). Based on Shannon-Weiner *H'* and species richness measurements, vegetation group VII dominated by *Acacia pachyceras* var. *najdensis* is characterized by the lowest plant diversity (0.34 and 1.56. respectively). On the other hand, Margalef index showed that vegetation group IV dominated by *Artemisia monosperma* is the lowest group in plant diversity (Table 7).

Analysis of variance of soil conditions among different vegetation groups showed significant variation in sand, silt, total carbonate, and SOM fractions, Soil pH, and Ca and bicarbonate water soluble ions (Table 8). Soils supporting vegetation groups I, V, and VI are characterized by high content of sand fraction that varies from 545.4 to 814.1 g kg^{-1}. On the other hand, soils of vegetation groups II, IV, and VII have the highest content of gravels (380.5 ± 14.1, 428.5 ± 84.6, and 294.2 ± 68.4 g kg^{-1}, respectively). Most of G. Maghara soils are calcareous. The highest content of total carbonate was determined in soils of W. Aroseya supporting vegetation group II (560.9 ± 3.2 g kg^{-1}). Wadis supporting vegetation groups III, IV, and VII have the highest content of SOM, Ca, and bicarbonate (Table 8).

Ordination analysis using CCA indicates these relationships between soil conditions and vegetation groups. CCA shows the species-environmental variables relationships by calculating axes that are products of the species composition and linear combinations of the environmental variables. To explain these relationships, CCA axes number I and II with high eigenvalues (0.90 and 0.82, respectively) are considered in the interpretation. The percentages of variance accounted for species-environment relations are 8.2% on axis I, and 7.4% on axis II. Intraset correlations as indicators of important environmental variables in structuring the ordination are listed in Table 9. Environmental variables are represented as lines radiating from the centroid of the ordination. The longer the environmental line the stronger the relationship of that variable with the community (Figs. 5 and 6). The positions of species/sites points relative to the environmental lines interpret their relationships. Sand and Clay fractions, pH, TC, and bicarbonate have high correlation with CCA axes. Bicarbonate has high negative correlation on axis one. Soil pH, and TC content have high positive correlation with axis one. CCA axis two was positively correlated with sand, clay, Ca, and Mg and negatively correlated with TC content (Table 9).

Based on these results CCA axes could be considered as follow:

CCA axis I: pH and Total Carbonate gradients

The distribution of vegetation groups along the total carbonate gradient (4.36-56.09 g kg^{-1}) exhibits significant variation. Of the seven vegetation groups, groups II, III, and IV attain high occurrence in gorges and slopes characterized by high content of total carbonate.

Vegetation group VII is more correlated with bicarbonate content and pH (Figs. 5 and 6).

CCA axis II: Sand and clay gradients

Sand gradient varies from 155.1 to 814.1 g kg^{-1} is directly related to CCA axis II and indirectly to CCA axis I. CCA axis II is represented also by clay, which exhibit a relatively narrow range (24.5-69.1 g kg^{-1}).

Table (6): Cover (C) and presence (P) percentages of different species in different vegetation groups of Gebel Maghara. *: medicinal plant.

Species	Vegetation Group													
	I		II		III		IV		V		VI		VII	
	C%	P%	C%	P%	C%	P%	C%	P%	C%	P%	C%	P%	C%	P%
* *Acacia pachyceras*O. Schwartz var. najdensis (Chaudhry) Boulos	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**16.0**	**88.9**
* *Acacia tortilis* (Forssk.) Hayne	0.0	0.0	0.0	0.0	2.3	10.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
* *Achillea fragrantissima* (Forssk.) Such. Bip.	0.0	0.0	1.0	40.0	1.1	54.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
* *Anabasis articulata* (Forssk.) Moq.	2.7	85.7	0.0	0.0	0.1	21.6	0.0	0.0	0.0	0.0	0.4	19.0	0.0	0.0
* *Artemisia monosperma* Delile	0.0	2.9	0.0	0.0	0.0	13.5	0.0	0.0	0.0	0.0	**1.4**	**100.0**	0.0	0.0
* *Asclepias sinaica* (Boiss.) Muschl.	0.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
* *Asparagus stipularis* Forssk.	0.0	2.9	0.0	20.0	0.0	5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Asphodelus viscidulus Boiss.	0.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Astragalus spinosus (Forssk.) Muschl.	0.0	11.4	0.0	0.0	0.0	5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
* *Ballota undulata* (Fresen.) Benth.	0.0	0.0	0.1	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Centaurea pallescens Delile	0.0	8.6	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0
* *Chiliadenus montanus* (Vahl) Brullo	0.1	8.6	0.2	40.0	0.5	23.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
* *Citrullus colocynthis* (L.) Schrad.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	4.8	0.0	0.0
* *Cleome amblyocarpa* Barratte & Murb.	0.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0
* *Colutea istria* Mill.	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
* *Cornulaca monacantha Delile*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38.1	0.0	11.1
* *Deverra tortuosa* (Desf.) DC.	0.0	0.0	0.0	0.0	0.2	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
* *Diplotaxis harra* (Forssk.) Boiss.	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
* *Echinops spinosus* L.	0.0	2.9	0.0	40.0	0.0	8.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
* *Fagonia arabica* L.	0.0	5.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.3	0.0	4.8	0.0	33.3
Fagonia glutinosa Delile	0.0	5.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
* *Fagonia mollis* Delile	0.0	2.9	0.0	0.0	0.1	16.2	0.1	15.4	0.0	0.0	0.0	0.0	0.0	0.0
* *Farsetia aegyptia* Turra	0.0	2.9	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
* *Globularia arabica* Jaub. & Spach.	0.1	5.7	0.3	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gymnocarpos decandrus Forssk.	0.4	31.4	0.0	0.0	0.0	8.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
* *Gypsophila capillaris* (Forssk.) C. Chr.	0.0	0.0	0.0	0.0	0.1	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
* *Haloxylon salicornicum*(Moq.) Bunge ex Boiss.	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.7	28.6	0.0	0.0	0.0	0.0
* *Haplophyllum tuberculatum* (Forssk.) Juss.	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
* *Hyoscyamus muticus* L.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0
* *Juncus rigidus* Desf.	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
* *Juniperus phoenicea* L.	0.0	0.0	**2.8**	**60.0**	0.0	0.0	0.0	0.0	0.1	14.3	0.0	0.0	0.0	0.0
* *Lavandula pubescens* Decne.	0.0	0.0	2.6	60.0	0.2	10.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
* *Lycium shawii* Roem. & Schult.	0.0	2.9	0.0	0.0	2.7	27.0	0.6	15.4	0.0	0.0	0.0	0.0	0.0	0.0
* *Nitraria retusa* (Forssk.) Asch.	0.0	0.0	0.0	0.0	0.5	8.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
* *Noaea mucronata* (Forssk.) Asch. & Schweinf.	0.1	11.4	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
* *Ochradenus baccatus* Delile	0.0	0.0	0.0	0.0	0.2	10.8	1.7	15.4	0.0	0.0	0.0	0.0	0.0	0.0
* *Panicum turgidum* Forssk.	0.6	14.3	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	0.1	4.8	0.0	0.0
* *Peganum harmala* L.	0.2	5.7	0.0	0.0	0.0	8.1	0.0	0.0	0.1	28.6	0.0	0.0	0.0	0.0
* *Pergularia tomentosa* L.	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Poa annua L.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0
* *Reaumuria hirtella* Jaub. & Spach	0.1	11.4	0.0	20.0	0.1	10.8	0.0	7.7	0.0	0.0	0.0	0.0	0.0	0.0
Reseda arabica Boiss.	0.0	0.0	0.1	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
* *Retama raetam (*Forssk.) Webb & Berthel	0.2	2.9	0.6	20.0	0.0	5.4	0.0	0.0	**11.7**	**71.4**	0.4	14.3	0.0	11.1
* *Seriphidium herba-album* (Asso) Soj?k	0.0	0.0	0.1	20.0	0.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
* *Stachys aegyptiaca* Pers.	0.2	25.7	0.9	40.0	0.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
* *Stipagrostis scoparia* (Trin. & Rupr.) DeWinter	0.0	5.7	0.1	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	4.8	0.0	0.0
* *Tamarix nilotica* (Ehrenb.) Bunge	0.0	0.0	0.0	0.0	1.9	11.8	0.0	0.0	0.0	0.0	0.1	4.8	0.0	0.0
* *Thymelaea hirsuta* (L.) Endl.	0.1	8.6	**4.3**	**60.0**	0.6	26.5	0.3	15.4	0.1	42.9	0.0	0.0	0.0	11.1
* *Zilla spinosa* (L.) Prantl subsp. *Spinosa*	0.0	5.7	0.2	20.0	6.8	100.0	1.5	38.5	0.7	42.9	0.0	9.5	0.0	0.0
Zygophyllum dumosum Boiss.	0.6	25.7	0.3	20.0	0.3	32.4	**4.5**	**100.0**	0.0	0.0	0.0	0.0	0.0	0.0

The habitats characterized by high sand and clay fraction are dominated with group I: *Anabasis articulata*, V: *Retama raetam*, and VI: *Artemisia monosperma* (Fig. 5 and 6).

Changes in Plant Diversity

The plant species recorded in both previous and current surveyes include 72 species of which 17 annuals and 55 perennials. On the other hand, 121 species previously reorded were not recognized in the current survey, and 38 species of the current list were not observed by Boulos (1960). Based on these findings, G. Maghara harbors about 231 plant species of which 110 plant species were only recorded in the present. The non recorded species includes 72 annuals, 36 perennial herbs, 8 subshrubs and 5 shrubs. The non recorded woody species include two medicinal species, *Convolvulus oleafolius* and *Thymus bovei* (Table 3). The missing list includes also the only endemic species, *Rorippa integrifolia*.

The list of 38 species recorded only in 2005 include 11 annuals, 10 perennial herbs, 8 sub shrubs, 4 shrubs, and 5 trees. Some of these species are weeds recorded only in the cultivatd fields in El-Khareiq plain (e.g., *Anagallis arvensis*, *Melilotus indicus*, and *Solanum nigrum*), while others were recorded in wadis not visited by Boulos (1960) (e.g., *Acacia pachyceras*, *Acacia tortilis*, *Centaurea aegyptiaca*, *Fagonia Arabica*, and *Tamarix aphylla*). The complete list of 231 plant species recorded in Maghara area in the period between 1960 and 2005 is reported in Appendix 1.

Table (7): Variation of diversity indices among different vegetation groups. *F* ratio and its significance are included. Mean values of each diversity index with similar letters indicate no significant variation according to Duncan's multiple range tests.

Vegetation Group	Shannon-Weiner H	Margalef	Species richness
I	0.78^{ab}	0.69^{ab}	3.06^{a}
II	1.71^{c}	1.87^{d}	7.40^{c}
III	1.06^{b}	1.10^{bc}	4.54^{b}
IV	0.46^{a}	0.29^{a}	2.08^{a}
V	0.65^{ab}	0.89^{abc}	2.43^{a}
VI	0.57^{a}	0.75^{abc}	2.24^{a}
VII	0.34^{a}	1.36^{cd}	1.56^{a}
F	7.06	6.71	12.26
p	<0.0001	<0.0001	<0.0001

To represent floristic change between different surveys at different wadis, beta diversity (β_T) was determined using Wilson and Schmida index. Beta diversity for G. Maghara as a whole was 0.525. Changes on locality levels were higher than changes of G. Maghara as a whole. The highest change was recorded in W. Fath Maghara (β_T = 0.833), whereas the lowest one was recorded in W. Maghara (β_T = 0.623). Beta diversity of W. Aroseya, W. Muzarei, and W. Mashaba are 0.735, 0.646, and 0.690, respectively.

Conservation Status

Based on abundance, flora of G. Maghara comprises only 5% as dominant or local dominat species, 12% as associated species, and 4% as weeds. The rest of

Table (8): Soil conditions at different vegetation groups. *F* ratio and its significance are included. Mean values of each diversity index with similar letters indicate no significant variation according to Duncan's multiple range tests.

Soil Conditions	Vegetation Group							*F*	*p*
	I	II	III	IV	V	VI	VII		
Gravel g kg^{-1}	175.3^{ab}	380.5^{b}	195.1^{ab}	428.5^{b}	41.6^{a}	31.1^{a}	294.2^{ab}	3.11	0.016
Soil Composition									
Sand g kg^{-1}	545.4^{bc}	155.1^{a}	300.2^{ab}	225.4^{ab}	555.4^{bc}	814.1^{c}	331.3^{ab}	6.13	0.0002
Silt g kg^{-1}	229.4^{ab}	238.2^{ab}	292.9^{b}	275.1^{b}	225.3^{ab}	106.3^{a}	315.3^{b}	2.69	0.031
Clay g kg^{-1}	49.5	36.6	49.9	69.1	42.5	33.2	24.5	0.57	n.s
Total Carbonate g kg^{-1}	167.1^{ab}	560.9^{d}	346.2^{bc}	412.9^{cd}	171.8^{ab}	43.6^{a}	306.6^{bc}	7.80	<0.0001
SOM g kg^{-1}	8.7^{ab}	9.3^{ab}	10.8^{abc}	17.5b^{c}	5.2^{ab}	2.7^{a}	22.4^{c}	2.76	0.028
Hygroscopic Moisture%	0.80	0.93	1.07	1.22	0.48	0.34	1.25	1.69	n.s
pH (1:2.5)	8.30^{bc}	8.13^{bc}	8.16^{bc}	7.76^{ab}	8.06^{bc}	8.35^{c}	7.43^{a}	3.71	0.006
EC (1:1) dS m^{-1}	2.80	0.70	3.98	10.37	0.73	0.76	5.20	1.34	n.s
Water Soluble Ions (1:1)									
Na^{+} meq l^{-1}	17.49	2.87	33.94	63.57	2.88	2.45	42.11	0.75	n.s
K^{+} meq l^{-1}	3.29	1.34	2.70	2.98	1.06	0.79	12.61	1.15	n.s
Ca^{2+} meq l^{-1}	9.41^{a}	3.00^{a}	12.15^{a}	52.30^{b}	3.65^{a}	4.88^{a}	19.10^{ab}	2.30	0.057
Mg^{2+} meq l^{-1}	2.63	1.10	5.95	18.65	1.20	1.56	12.60	2.00	n.s
Cl^{-} meq l^{-1}	21.57	5.25	29.50	101.13	3.50	3.60	47.75	1.38	n.s
HCO_3^{-} meq l^{-1}	9.73^{a}	9.08^{a}	10.73^{a}	9.65^{a}	10.22^{a}	7.26^{a}	23.84^{b}	2.94	0.021

the flora (79%) are threatened species including 19% rare and very rare species, 3% vulnerable, 4% endangered, and 53% non recorded species of which many species may be lost (Figure 7).

Flora of G. Maghara includes 86 medicinal plants of which 70 species were recorded in 2005. About 35% of the medicinal plants are either dominant or associated species. On the other hand, 65% of the medicinal plants are considered as threatened species of which 16 species are either rare or very rare and 17 medicinal species are either vulnerable or endangered species (Table 3). The vulnerable species are *Acacia tortilis, Achillea fragrantissima, Asparagus stipularis, Ballota undulate, Haplophyllum tuberculatum, Lavandula pubescens, Pulicaria undulata,* and *Seriphidium herba-alba*. The endangered plants are *Acacia pachyceras* var. *najdensis, Anastatica hierochuntica, Asclepias sinaica, Chiliadenus montanus, Citrullus colocynthis, Juniperus phoenicea, Teucrium polium, Teucrium leucocladum*, and *Ureginea undulata*.

Table (9): Intraset correlations (ter Braak, 1986) for 15 variables and different CCA axes

Variable	Correlations		
	Axis 1	**Axis 2**	**Axis 3**
Gravel g kg^{-1}	0.111	-0.295	-0.175
Soil Composition			
Sand g kg^{-1}	-0.221	0.401	0.403
Silt g kg^{-1}	-0.087	-0.051	-0.085
Clay g kg^{-1}	0.147	0.389	0.246
Total Carbonate g kg^{-1}	0.315	-0.526	-0.495
SOM g kg^{-1}	-0.433	-0.134	-0.015
Hygroscopic Moisture%	-0.205	-0.1	-0.05
pH (1:2.5)	0.551	-0.118	0.224
EC (1:1) dS m^{-1}	-0.067	0.336	0.121
Water Soluble Ions (1:1)			
Na^{+} meq l^{-1}	-0.103	0.25	0.095
K^{+} meq l^{-1}	-0.508	0.347	-0.283
Ca^{2+} meq l^{-1}	-0.052	0.442	0.004
Mg^{2+} meq l^{-1}	-0.273	0.462	-0.073
Cl^{-} meq l^{-1}	-0.139	0.239	0.122
HCO_3^{-} meq l^{-1}	-0.717	-0.136	-0.063

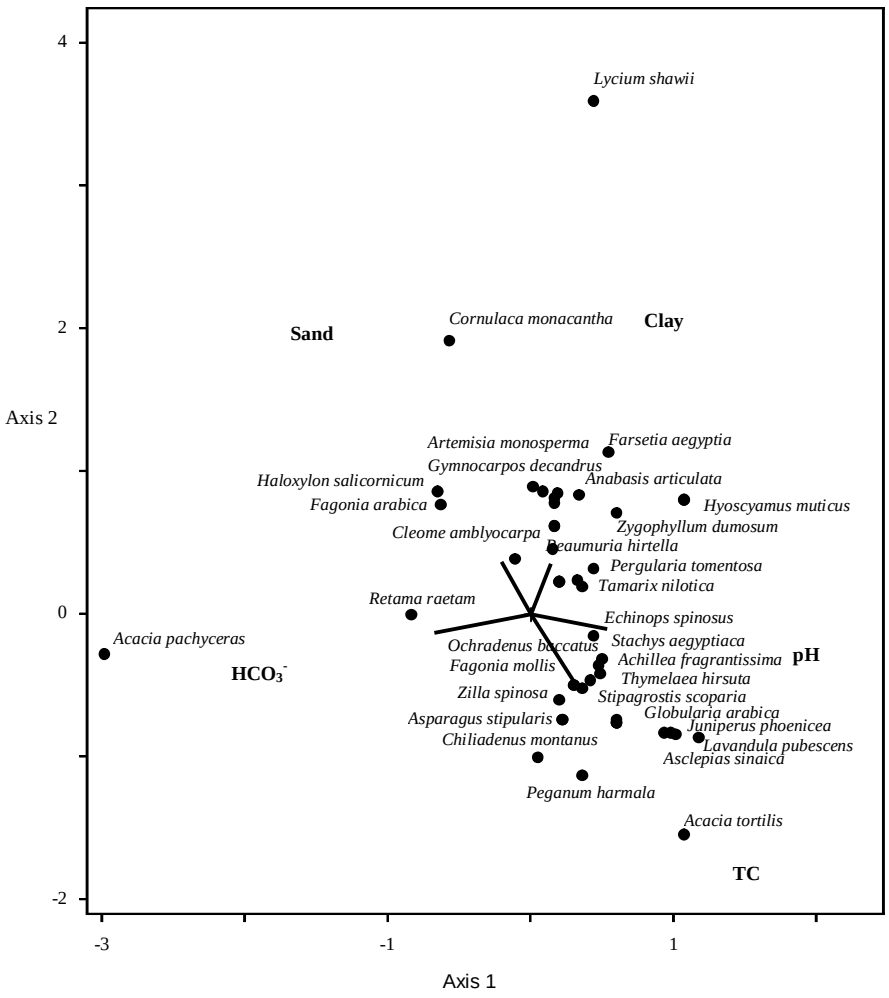

Figure (5): Biplot of CCA showing species – environmental variables relationships along axes 1 and 2.

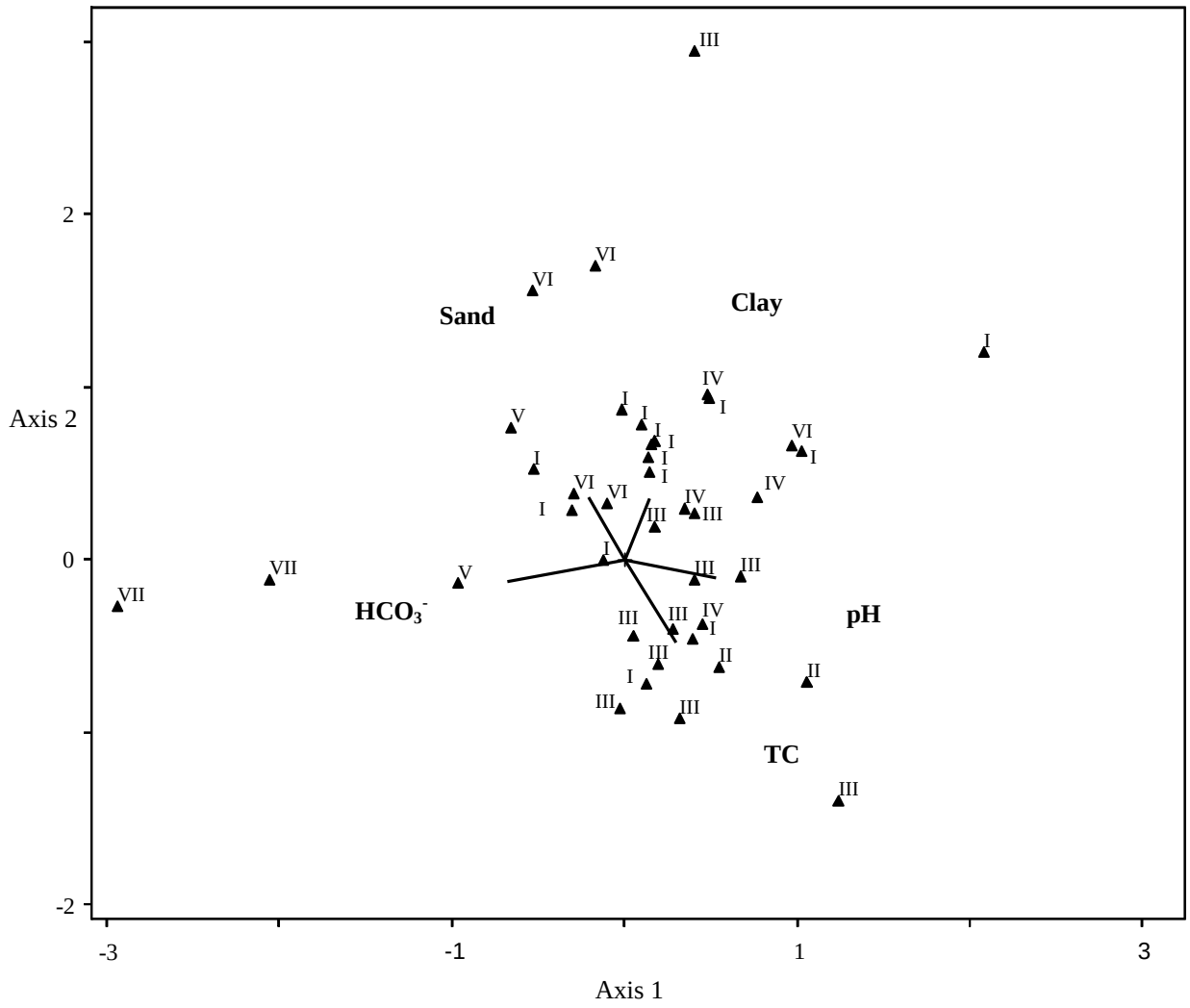

Figure (6): Biplot of CCA showing vegetation groups – environmental variables relationships along axes 1 and 2.

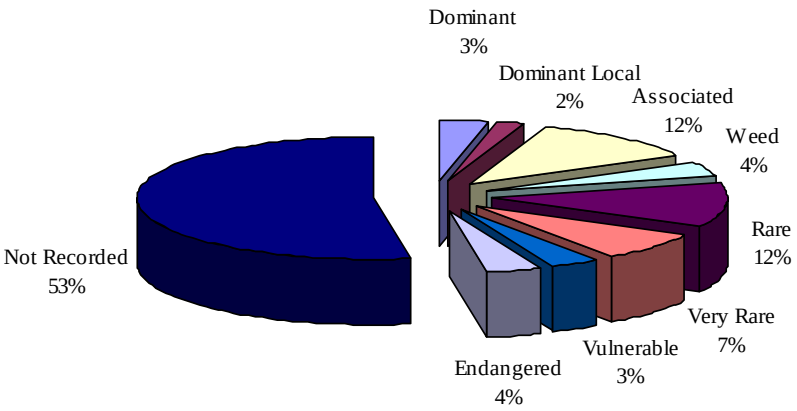

Figure (7): Conservation status of the 231 plant species recorded in Maghara area between 1960 and 2005.

DISCUSSION

Assessment of plant diversity is crucial for conservation and management of ecosystems (McNeely, 1992, UNEP, 1995). In addition, studying floristic changes could contribute to measure the effects of human impacts and direct the conservation strategy.

Gebel Maghara is a unique area characterized by diversity in landform, climatic conditions and plant life. Flora of G. Maghara comprises 231 species, of which one hundred and ten species were recently recorded including 70 medicinal species (60%). The most obvious characteristic of Maghara flora is paucity of trees. In agreement with El-Khouly and Fakhry (1999), W. Aroseya represents the most diverse wadi in the area. It is characterized by a good drainage system collecting water from an extensive catchment area. Gorges are the most diverse habitat in the study area due to their rugged topography and heterogeneity of soil conditions in addition to abundant of soil moisture (Moustafa and Zaghloul, 1993, Ayyad *et al.*, 2000).

Seven vegetation groups are dominating the area. The most diverse one of them is group II dominated by *Juniperus phoenicea*. Although W. Aroseya represents the only wadi supporting this community, it was not reorded by El-Khouly and Fakhry (1999). On the other hand *Juniperus phoenicea* was recorded in G. Maghara by Range (1921), Boulos (1960), and Kamel *et al*., (2008). El-Khouly and Fakhry (1999) recorded *Chiliadenus montanus* and *Lavandula pubescens* as dominant species in W. Aroseya. The current study showed that these species are endangered species. This indicates a rapid change in plant diversity. Many of the medicinal and palatable species used to be common or associated species are now threatened and replaced by unpalatable shrubs and subshrubs such as *Anabasis articulata* and *Zygophyllum dumosum* (Moustafa and Klopatek, 1995, Moustafa *et al*., 2001, Abd El-Wahab *et al*., 2008).

The calcareous soils characterizing G. Maghara play an important role in distribution of plant communities in the area. The high carbonate concentrations are not conductive to optimum root growth of many plants (Brady and Weil, 1996). Only fractured limestone slopes were supporting vegetation, which indicate the important role of soil moisture in plant life (Whittaker, 1972, Moustafa and Zayed, 1996). The significant correlations between soil composition and plant diversity in desert soils were reported (El-Ghareeb and Shabana, 1990, Ayyad and Fakhry, 1996, Zaghloul, 1997, Ayyad *et al*., 2000, Abd El-Ghani and Amer, 2003, Abd E-Wahab *et al*., 2006)

Maghara area harbors important refugee sites for isolated small size populations of medicinal plants with extremely high conservation value. It could be considered as an important area to enrich the surrounding ecosystems of North Sinai. The biodiversity indicators of G. Maghara include *Acacia tortilis*, *Acacia pachyceras* and *Juniperus phoenicea*. They are multipurpose trees and offer great services to the ecosystem. The main populations of *Acacia tortilis* were recorded in the middle and downstream of W. Aroseya. *Acacia pachyceras* var. *najdensis* is endangered species growing mainly in limited populations in fan and wadi habitats mainly in W. Masajid and W. Sheikh Hemaid characterized by high disturbance due to quarrying and mining activities. *Juniperus phoenicea* is one of the endangered species. Populations of *Juniperus phoenicea* were only recognized on slopes and fractures of high elevated slopes in W. Aroseya. Due to the medicinal values of the tree, it is subjected to cutting and overcollection of leaves and fruits for medicinal uses. In addition, many of perennial herbs and woody plants become threatened due to increasing aridity and human activities. About 121 species previously recorded by Boulos (1960) are not recognized in the current survey and many of them may be lost. This change could be interpreted by the increase of aridity conditions that make the ecosystem fragile and sensitive to human impacts (Batanouny, 1983). The main threats affecting the biodiversity in Maghara area include pollution due to the dewatering and deposits and debris resulted from coal mining activities, exploitation of woody and medicinal species that are subjected for overcollection and overcutting for different purposes (e.g., fuelwood, medicine, trade, etc.), unmanaged quarrying activities, and unsustainable agricultural practices.

Recommendations

The study recommends that action plans to protect the Maghara's plant diversity be based on improved knowledge of the biodiversity; empowering local people to become more involved in decision making; improvements in local and national governance; and more effective operational mechanisms for implementing protection of plant diversity at identified hotspots rich in medicinal and/or endangered species. The recommended action plans should also consider improving of rangelands using indigenous palatable perennials; increasing availability of alternative energy sources to reduce the demand for fuel wood by local communities; domesticating of endangered plants by *ex situ* cultivation; and improving the social and economic well-being of Bedouins in the area.

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Appendix (1): Plant Species List of Gebel Maghara recorded in the current survey (2005) and in Boulos (1960). Growth form, distribution, abundance, and conservation status of each species within Maghara area are given. Distribution numbers refer to certain localities as follow: 1 = W. Masajid, 2 = W. Maghara, 3 = W. Aroseya, 4 = W. Sheikh Hemaid, 5 = W. Sayila, 6 = W. Safa, 7 = El-Khareiq plain, 8 = W. Muzarei, 9 = W. Fath Maghara, and 10 = W. Mashaba. *: medicinal, Dom. Loc.: Dominant Local.

Family	Species	Growth form	Distribution		Conservation Status
			Current 2005	Boulos 1960	
Adiantaceae	*Cheilanthes vellea* (Aiton) F. Muell.	*Per. Herb*	0	2	Not Recorded
Aizoaceae	*Aizoon canariense* L.	*Annual*	0	9	Not Recorded
	Mesembryanthemum nodiflorum L.	*Annual*	1,7	0	Rare
Alliaceae	*Allium artemisietorum* Eig & Feinbrun	*Per. Herb*	0	8	Not Recorded
	Allium desertorum Forssk.	*Per. Herb*	0	2	Not Recorded
Amaranthaceae	*Aerva javanica* (Burm. f.) Juss. ex Schult.	*Shrub*	8	8	Very Rare
Asclepiadaceae	* *Asclepias sinaica* (Boiss.) Muschl.	*Shrub*	2,3	2,3	Endangered
	Caralluma sinaica (Decne) Berger.	*Per. Herb*	0	2	Not Recorded
	* *Pergularia tomentosa* L.	*Subshrub*	2,6	2	Rare
Asparagaceae	* *Asparagus aphyllus* L.	*Per. Herb*	3,4,5	0	Rare
	* *Asparagus stipularis* Forssk.	*Shrub*	3,4,5	3	Vulnerable
Asphodelaceae	*Asphodelus tenuifolius* Cav.	*Annual*	0	2	Not Recorded
	Asphodelus viscidulus Boiss.	*Annual*	1,7,9	0	Rare
Boraginaceae	*Anchusa milleri* Sperng.	*Annual*	0	2	Not Recorded
	Arnebia decumbens (Vent.) Coss. & Kralik	*Annual*	0	8	Not Recorded
	Arnebia tinctoria Forssk.	*Annual*	0	8	Not Recorded
	Echiochilon fruticosum Desf.	*Shrub*	0	10	Not Recorded
	Heliotropium ramosissimum (Lehm.) Sieb.	*Subshrub*	2,3,7,10	2,10	Associated
	Lappula spinocarpos (Forssk.) Asch. Ex	*Annual*	0	2	Not Recorded
	* *Moltkiopsis ciliata* (Forssk.) I. M. Johnst.	*Subshrub*	7,8	8	Associated
Capparaceae	* *Cleome amblyocarpa* Barratte & Murb.	*Annual*	2,7,10	8	Associated
Caryophyllaceae	*Gymnocarpos decandrus* Forssk.	*sub-shrub*	2,3,4,5,6	8	Associated
	* *Gypsophila capillaris* (Forssk.) C. Chr.	*Annual*	2,3	3	Rare
	Herniaria cinerea DC.	*Annual*	0	2	Not Recorded
	Herniaria hemistemon J. Gay	*Per. Herb*	0	8	Not Recorded
	* *Paronychia arabica* (L.) DC.	*Annual*	0	2,8	Not Recorded
	Paronychia sinaica Fresen.	*Per. Herb*	2,6,8	2	Very Rare
	* *Polycarpaea repens* (Forssk.) Asch. &	*Per. Herb*	0	10	Not Recorded
	* *Polycarpon succulentum (Delile) J. Gay*	*Annual*	0	8	Not Recorded
	Pteranthus dichotomous Forssk.	*Annual*	0	3	Not Recorded
	* *Silene villosa* Forssk. V. ismailitica	*Annual*	0	10	Not Recorded
	Silene vivianii Steud. Subsp. *viscida* (Boiss.)	*Annual*	0	2,3	Not Recorded
	Spergularia diandra (Guss.) Boiss.	*Annual*	0	2	Not Recorded
Chenopodiaceae	* *Agathophora alopecuroides* (Delile) Fenzl	*sub-shrub*	3,5	0	Rare
	* *Anabasis articulata* (Forssk.) Moq.	*Shrub*	1,2,4,5,6,7,8,9,10	9	Dominant
	Anabasis setifera Moq.	*Shrub*	6,8	8	Rare
	Atriplex farinosa Forssk.	*sub-shrub*	1,6	0	Rare
	Atriplex leucoclada Boiss.	*sub-shrub*	1,2,6	2	Rare
	* *Chenopodium murale* L.	*Annual*	7	8	Weed
	* *Cornulaca monacantha Delile*	*Shrub*	7	9	Associated
	* *Haloxylon salicornicum*(Moq.) Bunge ex	*Shrub*	2,3,8,9	8	Dom. Loc.
	* *Noaea mucronata* (Forssk.) Asch. &	*Shrub*	1,2,3,4,7,8,9	8	Associated
	Salsola tetrandra Forssk.	*Shrub*	0	8	Not Recorded
Cistaceae	*Helianthemum aegyptiacum* (L.) Mill.	*Annual*	0	3	Not Recorded
	Helianthemum kahiricum Delile	*Subshrub*	0	9	Not Recorded
	Helianthemum lippii (L.) Dum. Cours.	*Subshrub*	0	8	Not Recorded
	Helianthemum sancti-antonii Schweinf. ex	*Subshrub*	6	0	Very Rare
	Helianthemum ventosum Boiss.	*Subshrub*	0	8	Not Recorded
Colchicaceae	*Androcymbium palaestinum* Baker	*Per. Herb*	0	2,8	Not Recorded
Compositae	* *Achillea fragrantissima* (Forssk.) Such.	*Subshrub*	1,2,3,4,5,6,8	2	Vulnerable
	Anthemis melampodina Delile subsp. *deserti*	*Annual*	0	2	Not Recorded
	* *Artemisia monosperma* Delile	*Subshrub*	1,2,3,4,6,7,8,9,10	0	Dominant
	Asteriscus hierochunticus (Michon) Wiklund	*Annual*	0	2	Not Recorded
	Atractylis serratuloides Sieber ex Cass.	*Subshrub*	1,7	0	Rare
	* *Calendula arvensis* L.	*Annual*	0	8	Not Recorded
	Carduus getulus Pomel	*Annual*	0	10	Not Recorded
	Carthamus glaucus M. Bieb.	*Annual*	0	2	Not Recorded
	Centaurea aegyptiaca L.	*Per. Herb*	4,5,6	0	Associated
	Centaurea eryngioides Lam.	*Per. Herb*	0	2,3	Not Recorded

Family	Species	Growth form	Distribution		Conservation Status
			Current 2005	Boulos 1960	
	Centaurea pallescens Delile	*Per. Herb*	1,2,4,5,7,9,10	0	Associated
	Centaurea sinaica DC.	*Annual*	0	2,8	Not Recorded
	* *Chiliadenus montanus* (Vahl) Brullo	*Shrub*	2,3,4,5,6	2	Endangered
	Echinops galalensis Schweinf.	*Per. Herb*	8	8	Rare
	* *Echinops spinosus* L.	*Per. Herb*	1,2,3,4,5,6	0	Associated
	Filago desertorum Pomel	*Annual*	0	8	Not Recorded
	Gymnarrhena micrantha Desf.	*Annual*	0	2	Not Recorded
	Iflago spicata (Forssk.) Sch. Bip.	*Annual*	0	10	Not Recorded
	Launaea angustifolia (Desf.) Kuntze	*Annual*	0	8	Not Recorded
	Launaea nudicaulis (L.) Hook. f.	*Per. Herb*	0	2,8	Not Recorded
	* *Nauplius graveolens* (Forssk.) Wiklund	*Shrub*	10	0	Very Rare
	Phagnalon barbeyanum Asch. & Schweinf.	*Subshrub*	0	2	Not Recorded
	Picris sp.	*Annual*	0	2	Not Recorded
	* *Pulicaria undulata* (L.) C.A.Mey	*Per. Herb*	1,2,3,6,8	2,8	Vulnerable
	* *Senecio glaucus* L. subsp. *coronopifolius*	*Annual*	7	8	Weed
	* *Seriphidium herba-album* (Asso) Soj?k	*Subshrub*	3,4,5	2	Vulnerable
	* *Sonchus oleraceous* L.	*Annual*	7	8	Weed
	Urospermum picroides (L.) F. W. Schmidt	*Annual*	0	2,8	Not Recorded
	Volutaria lipii (L.) Cass. ex Maire	*Annual*	0	2,8	Not Recorded
Convolvulaceae	*Convolvulus althaeoides* L.	*Per. Herb*	0	8	Not Recorded
	Convolvulus lanatus Vahl.	*Subshrub*	3,6,10	10	Associated
	* *Convolvulus oleafolius* Desr.	*Subshrub*	0	3	Not Recorded
	Convolvulus pilosellifolius Desr.	*Per. Herb*	3,6	0	Associated
	Cuscuta planiflora Ten.	*Annual*	0	2	Not Recorded
Crassulaceae	*Rosularia lineata* (Boiss.) A. Berger	*Per. Herb*	0	2,3	Not Recorded
Cruciferae	* *Anastatica hierochuntica* L.	*Annual*	7,8	8	Endangered
	Conringia orientalis (L.) Dumort.	*Annual*	7	0	Very Rare
	* *Diplotaxis acris* (Forssk.) Boiss.	*Annual*	0	9	Not Recorded
	* *Diplotaxis harra* (Forssk.) Boiss.	*Per. Herb*	3	3	Rare
	Eremobium aegyptiacum (Spreng.) Asch. &	*Annual*	0	10	Not Recorded
	Erucaria microcarpa Boiss.	*Annual*	0	2	Not Recorded
	Erucaria pinnata (Viv.) Tackh. & Boulos	*Annual*	0	8	Not Recorded
	* *Farsetia aegyptia* Turra	*Subshrub*	2,3,4,5,10	10	Associated
	Lobularia arabica (Boiss.) Muschl.	*Annual*	0	8	Not Recorded
	Malcolmia pygmaea (DC.) Boiss.	*Annual*	0	8	Not Recorded
	Matthiola longipetala (Vent.) DC. subsp.	*Annual*	3	3	Rare
	Moricandia nitens (Viv.) Durand & Barratte	*Subshrub*	3,8	8	Rare
	Rorippa integrifolia Boulos **(Endemic)**	*Annual*	0	3	Not Recorded
	Savignya parviflora (Delile) Webb	*Annual*	0	10	Not Recorded
	Sisymbrium erysimoides Desf.	*Annual*	0	2	Not Recorded
	* *Zilla spinosa* (L.) Prantl subsp. *Spinosa*	*Shrub*	1,2,3,4,5,6,7,8,9	0	Dominant
Cucurbitaceae	* *Citrullus colocynthis* (L.) Schrad.	*Per. Herb*	2,3	2	Endangered
	* *Cucumis prophetarum* L.	*Per. Herb*	0	2,8	Not Recorded
Cupressaceae	* *Juniperus phoenicea* L.	*Shrub or*	3	3	Endangered
Dipsacaceae	*Pterocephalus plumosus* (L.) Coult.	*Annual*	2,6	2	Very Rare
	Scabiosa eremophila Boiss.	*Annual*	0	8	Not Recorded
Ephedraceae	* *Ephedra alata* Decne	*Shrub*	3	8	Very Rare
Euphorbiaceae	*Andrachne telephioides* L.	*Per. Herb*	3	2	Rare
	Euphorbia erinacea Boiss. & Kotschy	*Subshrub*	0	2,3	Not Recorded
	* *Euphorbia peplus* L.	*Annual*	7	2,8	Weed
	* *Euphorbia retusa* Forssk.	*Per. Herb*	7,8	8	Associated
Frankeniaceae	*Frankenia pulverulenta* L.	*Annual*	0	2	Not Recorded
Fumaricaceae	*Hypecoum littorale* Wulfen	*Annual*	0	8,9	Not Recorded
Geraniaceae	*Erodium ciconium* (L.) L'Hér.	*Annual*	0	2	Not Recorded
	Erodium crassifolium L'Hér.	*Per. Herb*	0	2	Not Recorded
	Erodium laciniatum (Cav.) Willd.	*Annual*	2,7,8	2,8	Rare
	Erodium oxyrhynchum M. Bieb. subsp.	*Per. Herb*	0	2	Not Recorded
	Monsonia nivea (Decne.) Webb	*Per. Herb*	0	10	Not Recorded
Globulariaceae	* *Globularia arabica* Jaub. & Spach.	*Shrub*	2,3	2	Associated
Gramineae	* *Avena barbata* Pott ex Link	*Annual*	2,7	2	Rare
	Brachypodium distachyum (L.) P. Beauv.	*Annual*	0	2	Not Recorded
	Bromus fasciculatus C. Presl.	*Annual*	0	2,3	Not Recorded
	Centropodia forsskaolii (Vahl) Cope	*Per. Herb*	0	8	Not Recorded
	* *Cynodon dactylon* (L.) Pers.	*Per. Herb*	7,8	8	Weed

Family	Species	Growth form	Distribution		Conservation Status
			Current 2005	Boulos 1960	
	Hordeum murinum L. subsp. *leporinum*	*Annual*	0	2,8	Not Recorded
	Hyparrhenia hirta (L.) Stapf	*Per. Herb*	2,7,8	2,8	Very Rare
	Lamarckia aurea (L.) Moench	*Annual*	0	2	Not Recorded
	Lasiurus scindicus Henrard	*Per. Herb*	0	9	Not Recorded
	Oryzopsis miliacea (L.) Asch. & Schweinf.	*Per. Herb*	0	3	Not Recorded
	* *Panicum turgidum* Forssk.	*Per. Herb*	2,5,7,8,9,10	8	Dominant
	Pennisetum divisum (Forssk. ex J.F. Gmel.)	*Per. Herb*	0	2,9	Not Recorded
	Phalaris minor Retz.	*Annual*	0	2	Not Recorded
	* *Phragmites australis* (Cav.) Trin. Ex Steud.	*Per. Herb*	7	0	Weed
	Poa annua L.	*Annual*	2,7,8,10	0	Associated
	Schismus barbatus (L.) Thell.	*Annual*	2,3,7,8	8	Associated
	Stipa capensis Thunb.	*Annual*	0	2	Not Recorded
	Stipagrostis ciliata (Desf.) De Winter	*Per. Herb*	0	8	Not Recorded
	Stipagrostis obtusa (Delile) Nees	*Per. Herb*	0	8	Not Recorded
	* *Stipagrostis scoparia* (Trin. & Rupr.)	*Per. Herb*	1,3,7,9,10	0	Dom. Loc.
	Tetrapogon villosus Desf.	*Per. Herb*	0	2,9,10	Not Recorded
	Tricholaena teneriffae (L.f.) Link	*Per. Herb*	0	8	Not Recorded
Hycinthaceae	*Bellevalia zoharyi* Feinbrun	*Per. Herb*	0	2	Not Recorded
	Dipcadi erythraeum Webb & Berthel	*Per. Herb*	0	8	Not Recorded
	Muscari neglectum Guss.	*Per. Herb*	0	8	Not Recorded
	* *Ureginea maritima* (L.) Baker	*Per. Herb*	0	2	Not Recorded
	* *Ureginea undulata* (Desf.) Steinh.	*Per. Herb*	3	8	Endangered
Iridaceae	*Moreae sisyrinchium* (L.) Ker Gawl.	*Per. Herb*	0	3,8	Not Recorded
Juncaceae	* *Juncus rigidus* Desf.	*Per. Herb*	2	2	Rare
Labiatae	* *Ballota undulata* (Fresen.) Benth.	*Per. Herb*	2,3,4	2,3	Vulnerable
	* *Lavandula pubescens* Decne.	*Per. Herb*	2,3,4,5,6	2	Vulnerable
	Micromeria sinaica Benth.	*Subshrub*	0	2,8	Not Recorded
	* *Salvia aegyptiaca* L.	*Subshrub*	6	8	Rare
	* *Salvia lanigera* Poir.	*Per. Herb*	0	2	Not Recorded
	* *Stachys aegyptiaca* Pers.	*Subshrub*	1,2,3,4,5,8	2	Associated
	* *Teucrium leucocladum* Boiss.	*Subshrub*	3,6	0	Endangered
	* *Teucrium polium* L.	*Subshrub*	3,6	8	Endangered
	* *Thymus bovei* Benth.	*Shrub*	0	2	Not Recorded
Leguminosae	* *Acacia pachyceras*O. Schwartz var.	*Tree*	1,4	0	Endangered
	* *Acacia tortilis* (Forssk.) Hayne	*Tree*	1,2,3,4,5,7,8,9	0	Vulnerable
	Argyrolobium uniflorum (Decne.) Jaub. &	*Subshrub*	0	8	Not Recorded
	Astragalus annularis Forssk.	*Annual*	0	8	Not Recorded
	Astragalus kahiricus DC.	*Per. Herb*	0	8,9	Not Recorded
	Astragalus sieberi DC.	*Subshrub*	2,6	2	Rare
	Astragalus sinaicus Boiss.	*Annual*	0	2	Not Recorded
	Astragalus spinosus (Forssk.) Muschl.	*Subshrub*	2,4,5,6,7,8	8	Associated
	Astragalus tribuloides Delile *v. minutus*	*Annual*	0	2	Not Recorded
	* *Colutea istria* Mill.	*Shrub*	2,4,5	2,8	Very Rare
	Hippocrepis unisiliquosa L.	*Annual*	0	2	Not Recorded
	Lotus glinoides Delile	*Annual*	0	9	Not Recorded
	Lotus halophilus Boiss. & Spruner	*Annual*	0	8	Not Recorded
	Medicago laciniata (L.) Mill.	*Annual*	0	2	Not Recorded
	* *Melilotus indicus* (L.) All.	*Annual*	7	0	Weed
	Ononis reclinata L.	*Annual*	0	2	Not Recorded
	Ononis serrata Forssk.	*Annual*	0	10	Not Recorded
	* *Retama raetam (*Forssk.) Webb & Berthel	*Shrub*	2,3,6,7,8,9,10	10	Dominant
	* *Trigonella stellata* Forssk.	*Annual*	7	2	Weed
Liliaceae	*Gagea reticulata* (Pall.) Schult. & Schult. f.	*Per. Herb*	0	2	Not Recorded
Malvaceae	* *Malva parviflora* L.	*Annual*	2,7	2	Rare
Menispermaceae	*Cocculus pendulus* (J.R. & G. Forst.) Diels	*Shrub*	0	9	Not Recorded
Molluginaceae	*Telephium sphaerospermum* Boiss.	*Annual*	0	2	Not Recorded
Neuradaceae	*Neurada procumbens* L.	*Annual*	10	8	Associated
Nitrariaceae	* *Nitraria retusa* (Forssk.) Asch.	*Shrub*	2,3,4,5	0	Associated
Orobanchaceae	* *Orobanche cernua* Loefl.	*Per. Herb*	0	2	Not Recorded
	Orobanche nana (Reut) Noë ex Beck	*Per. Herb*	0	2,8	Not Recorded
Palmae	* *Phoenix dactylifera* L.	*Tree*	7,8	0	Rare
Papaveraceae	*Papaver hybridum* L.	*Annual*	0	2	Not Recorded
	Roemeria hybrida (L.) DC.	*Annual*	0	2	Not Recorded
Peganaceae	* *Peganum harmala* L.	*Per. Herb*	1,2,3,5,7,8	2	Associated

Family	Species	Growth form	Distribution		Conservation Status
			Current 2005	Boulos 1960	
Plantaginaceae	* *Plantago coronopus* L.	*Annual*	0	2,8	Not Recorded
	Plantago cylindrica Forssk.	*Annual*	0	9	Not Recorded
	* *Plantago ovata* Forssk.	*Annual*	0	2,8	Not Recorded
	Plantago phaeostoma Boiss. & Heldr.	*Annual*	0	2	Not Recorded
Plumbaginaceae	*Limonium pruinosum* (L.) Chaz. subsp.	*Per. Herb*	2,4	2	Very Rare
Polygonaceae	*Calligonum polygonoides* L.	*Shrub*	1,8,9	9	Associated
	Emex spinosa (L.) Campd.	*Annual*	7	0	Rare
	Rumex cyprius Murb.	*Annual*	7,8	2,8	Very Rare
Primulaceae	* *Anagallis arvensis* L.	*Annual*	7	0	Weed
Ranunculaceae	*Adonis cupaniana* Guss. (Not listed in	*Annual*	0	10	Not Recorded
Resedaceae	*Caylusea hexagyna* (Forssk.) M. L. Green	*Annual*	2,6,7	2	Rare
	* *Ochradenus baccatus* Delile	*Shrub*	2,3,5,6	2	Associated
	Oligomeris linifolia (Vahl ex Hornem.) J.F.	*Annual*	0	8	Not Recorded
	Reseda arabica Boiss.	*Annual*	2,3	0	Associated
	Reseda decursiva Forssk.	*Annual*	0	2	Not Recorded
	* *Reseda lutea* L.	*Annual*	0	2	Not Recorded
	Reseda pruinosa Delile	*Annual*	0	8	Not Recorded
	Reseda urnigera Webb	*Annual*	0	2	Not Recorded
Rubiaceae	*Callipeltis cucullaris* (L.) Steven	*Annual*	0	2	Not Recorded
	Crucianella membranacea Boiss.	*Annual*	7	0	Very Rare
Rutaceae	* *Haplophyllum tuberculatum* (Forssk.) Juss.	*Per. Herb*	1,7,8	9	Vulnerable
Scrophulariaceae	*Kickxia floribunda* (Boiss.) T?ckh. & Boulos	*Per. Herb*	2,8	2,8	Very Rare
	Linaria tenuis (Viv.) Spreng.	*Annual*	0	8	Not Recorded
	Scrophularia xanthoglossa Boiss.	*Per. Herb*	0	2	Not Recorded
Solanaceae	* *Hyoscyamus muticus* L.	*Per. Herb*	6,8,10	0	Associated
	Lycium europaeum L.	*Shrub*	0	2	Not Recorded
	* *Lycium shawii* Roem. & Schult.	*Shrub*	2,3,4,5,8	0	Dom. Loc.
	* *Solanum nigrum* L.	*Annual*	7	0	Weed
Tamaricaceae	* *Reaumuria hirtella* Jaub. & Spach	*Subshrub*	2,3,4,5,6,8	2,8	Associated
	* *Tamarix aphylla* (L.) H. Karst.	*Tree*	7	0	Rare
	* *Tamarix nilotica* (Ehrenb.) Bunge	*Shrub or*	1,2,5,6,7	0	Dominant
Thymelaceae	* *Thymelaea hirsuta* (L.) Endl.	*Shrub*	1,2,3,4,5,7,8,9	3	Dominant
Umbellifera	* *Deverra tortuosa* (Desf.) DC.	*Subshrub*	3,6	3	Very Rare
	* *Eryngium glomeratum* Lam.	*Per. Herb*	0	2	Not Recorded
	* *Ferula sinaica* Boiss.	*Per. Herb*	2,6	0	Very Rare
	Zozimia absinthifolia (Vent.) Link	*Per. Herb*	0	8	Not Recorded
Urticaceae	*Parietaria alsinifolia* Delile	*Annual*	0	2	Not Recorded
Zygophyllaceae	* *Fagonia arabica* L.	*Subshrub*	1,4,7	0	Associated
	Fagonia glutinosa Delile	*Per. Herb*	1,9	0	Very Rare
	* *Fagonia mollis* Delile	*Subshrub*	1,2,3,4,5,6,7,8	8	Dom. Loc.
	Fagonia scabra Forssk.	*Per. Herb*	2,3,6,7	2	Rare
	* *Tribulus terrestris* L.	*Annual*	7	0	Very Rare
	Zygophyllum album L.f.	*Subshrub*	1,3,7	0	Rare
	Zygophyllum dumosum Boiss.	*shrub*	1,2,3,4,5,6,8,9	2	Dominant

تقييم تباين الأنواع النباتية فى جبل المغارة بشمال سيناء - مصر

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الملخص العربـــى

هدفت الدراسة الحالية إلى تقييم الأنواع النباتية فى الوديان والبيئات المختلفة فى جبل المغارة وكذلك رصد التغيرات الحديثة فى فلورا جبل المغارة وبخاصة ما يتعلق بالنباتات الطبية والمهددة بالإضافى إلى التعرف على التأثيرات الإنسانية والمناخية التى أدت لذلك. لتحقيق هذه الأهداف تم دراسة التركيب الفلورى والغطاء النباتى فى عشرة اودية تمثل ست أنواع مختلفة من المواطن البيئية. تم قياس التنوع النباتى وإجراء التحاليل الإحصائية والمتعددة المتغيرات لبيانات الكساء الخضرى وتحليلات التربة السطحية
أمكن التعرف على 110 نباتاً ينتمون إلى 42 عائلة وتصل نسبة النباتات الطبية إلى 64 % . يعتبر وادى العروسية من أكثر الوديان تنوعاً وكذلك بيئة الأخوار التى تتميز عن سائر المواطن البيئية فى وفرة الأنواع النباتية والطبية. تم التعرف على سبعة من المجتمعات النباتية السائدة فى جبل المغارة وهى: العجرم *Anabasis articulata* ، والعرعر *Juniperus phoenicea* ، والسلة *Zilla spinosa* subsp. *spinosa* ، والرطريط *Zygophyllum dumosum* ، والرتم *Retama raetam* ، والعادر *Artemisia monosperma* ، والسيال *Acacia pachyceras var. najdensis* . يعتبر مجتمع العرعر من أكثر المجتمعات تنوعاً ، كذلك أظهرت النتائج تأثير خصائص التربة وبخاصة محتوى الرمل ومحتوى الكربونات فى التربة الجيرية على توزيع النباتات وتنوعها .

بمراجعة دراسة بولس (1960) لجبل المغارة وجد أنه تعرف على 193 نباتاً ينتمون إلى 54 عائلة . وجد أن من بين هذه الأنواع يوجد 121 نباتا لم يتم التعرف عليه فى الدراسة الحالية كذلك يوجد من بين الأنواع ال 110 التى تم التعرف غليها فى الدراسة الحالية يوجد منهم 38 نوعا غير موجودين فى قائمة بولس (1960) وقد يرجع ذلك لأنه زار خمسة وديان فقط من جبل المغارة. يمكن تفسير غياب 121 نباتاً من الدراسة الحالية إلى شدة الجفاف التى تتميز بها المنطقة وإلى التأثيرات الإنسانية غير الرشيدة والتى أدت إلى تدهور البيئات الطبيعية وفقدان الأنواع . ومن هذه التأثيرات المحاجر والملوثات التى نتجت عن منجم فحم المغارة ، والتقطيع الجائر للنباتات سواء كان لاستخدامات الوقود أو للإستخدامات الطبية والتجارية .

خلصت الدراسة إلى أهمية جبل المغارة لما يحتويه من تنوع نباتى متميز بالعديد من النباتات الطبية . تشتمل فلورة جبل المغارة على 231 نباتاً تم التعرف عليهم فى الفترة من 1960 وحتى 2005 . خلال هذه الفترة الزمنية حدثت تغيرات واضحة فى التنوع النباتى أدت إلى فقدان نسبة كبيرة من هذا التنوع بالإضافة على تدهور العديد من النباتات وبخاصة الطبية والخشبية. أمكن تقسيم نباتات جبل المغارة بناءً على تواجدات هذه الأنواع والتأثيرات الإنسانية المؤثرة عليها إلى 5% نباتات سائدة ، و12% نباتات مصاحبة ، 4% حشائش ، 26% نباتات مهددة ، و 53% نباتات غير مسجلة يحتمل أن تحتوى على العديد من النباتات المفقودة.

أوصت الدراسة بضرورة صون التنوع النباتى فى جبل المغارة وذلك من خلال وضع الخطط التنفيذية تعتمد على الدراسات البيئية للتنوع النباتى ويشارك فيها السكان المحليين إضافة إلى الهيئات الحكومية ومتخذى القرار لتفعيل الأليات لحماية وصون التنوع النباتى وبخاصة النباتات الطبية والمهددة.