Egyptian J. Desert Res., 55, No.1, 39-52 (2005)

PLANT DIVERSITY OF WADI EL-GHAYL, ASEER MOUNTAINS, SAUDI ARABIA

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Vegetation analysis was undertaken in Wadi El-Ghayl, 25 km south of Al Harajah Town, South West Saudi Arabia, with an altitude ranges between 2100-2185 m.a.s.l. The flora of the Wadi comprises a total of 35 species of vascular plants belonging to 17 families. Chamaephytes, phanerophytes and hemi-cryptophtes are the dominant life forms. Four vegetation groups were recognized based on application of TWINSPAN and DCA analysis; Group (A) is characterized by *Acacia asak*, *Aizoon canariense* and *Ochradenus baccatus*. *Aerva lanata*, *Fagonia bruguieri* and *Ziziphus spina-christi* are dominant species. Group (A) is an indicator to the slopes of the rocky granitic plateau (2185 m.a.s.l), where plants grow between fissures of the rock. Group (B) is characterized by *Acacia tortilis*, *A..woodii*, *Citrullus colocynthis*, *Solanum incanum*, *Pulicaria crispa* and *Ficus sycomorus*. This group is located in the main wadi bed and the lower stream of the wadi (2100 m.a.s.l). Agriculture practiced on the eastern depression of the wadi bed depending on the ground water. Group (C) is indicated by *Euphorbia balsamiflora* and *Klenia odorata*, *Aerva lanata* and *Commicarpus helnae*. This habitat is cretaceous debris of stony plateau, and the area with a high altitude of 2185 m.a.s.l. Group (D) is indicated by *Acacia woodii*, *Acacia sp*, *Calotropis procera* and *Commicrpus helenae*. The habitat is stony plateau on 2185 m.a.s.l.

Keywords: Saudi Arabia, Aseer Mountains, plant diversity, Wadi El-Ghayl .

The major part of Saudi Arabia is hot and dry desert, and accordingly the xerophytic vegetation makes up the prominent feature of the plant life (Zahran, 1982). Geomorphologically, Saudi Arabia consists of 7 regions, namely: Arabian Gulf Coastal Region, Al Summan Plateau, Eolian Sand Areas, Cuesta Region, Central Plateau Region, Mountaines of Western Arabian and Red Sea coastal Plain. Wadi El-Ghayl is 27 km to the south of

Al Harajah city (17° 55´13 N - 43° 22´10 E), crosses the southern most part of Aseer Mountains, west of Saudi Arabia.

During the last decades, the flora and vegetation of Saudi Arabia have attracted many scholars, namely: Mandaville (1965), Batanouny (1979), Batanouny and Baeshin (1978 and 1983), Zahran (1983), Boulos (1985), Cope (1985), Collenette (1985), Fayed and Zayed (1989), Abd-el-Ghani (1993), Hosni and Hegazy (1996) Migahid (1996) and Al-Turki (1997). However, there are still many gaps in our knowledge concerning plant diversity and habitat features of the country. El Karemy and Zayed (1999) noted that studies on plant cover of western Saudi Arabia are scanty or descriptive.

The present study aims to monitor plant life in Wadi El-Ghayl in the southern part of Aseer Mountains, west of Saudi Arabia. It explores the distribution pattern of plant communities in relation to environmental variables. This information provides a baseline survey necessary for the conservation of natural resources and sustainable use of wild plants in Aseer Mountains, Saudi Arabia.

STUDY AREA

Sarawat and Aseer highlands (> 2000 m) constitute a major part of the south- western Saudi Arabia where a temperate climate prevails. Wadi El-Ghayl (27 km to the south of Al Harajah city) lies between 17° 46' 28 N - 43° 29' 48 E and 17° 45' 34 N - 43° 30' 17 E with an altitude ranges between 2100-2185 m .a. s. l. (Fig. 1). Sandy plains characterize the wadi. The area bordering the wadi is composed of tertiary sedimentary rocks to the north while eastern sections are surrounded by basement complex rocks outcrop. Soil is coarse textured and covered by gravel and rock fragments. Agriculture being practiced in eastern depressions of the wadi.

Climate

The area lies within the subtropical dry zone of the deserts (Walter, 1984). According to Anonymous (1984) the records of Najran and Beishah climatic stations show that the highest average amount of rainfall is in spring (March-April), ranging between 14-30 mm/year. Summer (May-August), autumn (September-November) and winter (December-February) are characterized by low rainfall averages (0-9 mm/year). Air temperatures are high in summer. Mean monthly temperature ranges from 33□C in December to 42□C in May. Generally, the average relative humidity in the study area is moderate (70%).

MATERIALS AND METHODS

Five sites (I-V) were selected in the wadi representing different types of habitats. In each site, 10 stands were randomly distributed, however habitat uniformity and homogeneity were considered. The vegetation was

studied sociologically according to the line-intercept method (Canfield, 1941), in which line transects (10 m long) were placed along the wadi. In each stand 10 line transects, covering a total area of 100 m long were taken. The cover value for each taxon have been obtained as follows: total of intercept length for a species / total of transect length x 100.

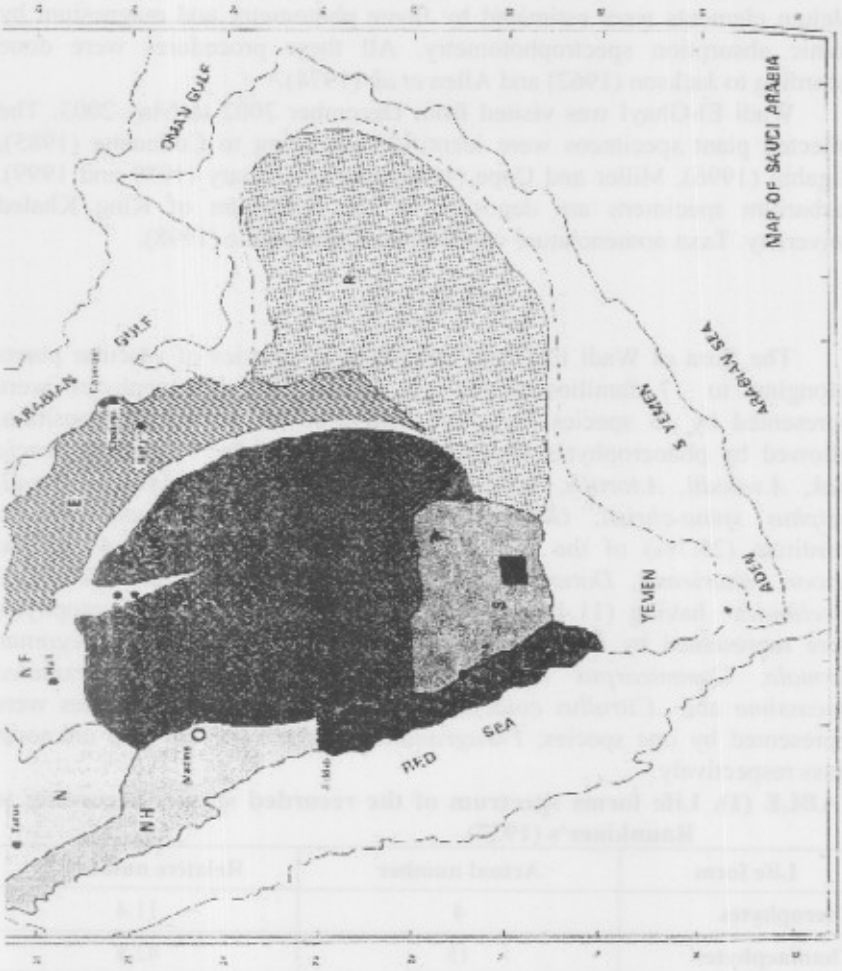

Fig. (1). Location map of the wadi Ghayl in the south west of Saudi Arabia.

Two-way indicator species analysis (TWINSPAN) and Detrended Correspondance Analysis (DCA) were applied to the cover of 35 species in stands according to Hill (1979 a and b). Three soil samples were collected from each stand at 0-50 cm depth. pH value of soil samples were

determined by pH meter. Total dissolved salts (T.D.S) were measured using conductivity meter. Sulphates were determined turbidimetrically as barium sulphate and the transmittance was measured with reference to blank by spectrophotometer at 500 nm from standard curve of sulphate(Harrison and Berry, 1986). Chlorides were determined by titration against standard silver nitrate, carbonates and bicarbonates by acid titration. Sodium, potassium and calcium elements were estimated by flame photometry and magnesium by atomic absorption spectrophotometry. All these procedures were done according to Jackson (1962) and Allen *et al.* (1974).

Wadi El-Ghayl was visited from December 2002 to May 2003. The collected plant specimens were identified according to Collenette (1985), Migahid (1996), Miller and Cope (1996) and Chaudhary (1989 and 1999). Herbarium specimens are deposited at the herbarium of King Khaled University. Taxa nomenclature was following Collenette (1998).

RESULTS

The flora of Wadi El-Ghayl comprises 35 species of vascular plants belonging to 17 families. Table (1) shows that chamaephytes were represented by 15 species constitute 42.8% of the floristic composition, followed by phanerophytes which were represented by 9 species; *Acacia asak*, *A.woodii*, *A.tortilis*, *Acacia sp.*, *Ficus sycomorus*, *Lycium shwaii*, *Ziziphus spina-christi*, *Ochradenus baccatus* and *Calotropis procera* constitute (25.7%) of the total species. Therophytes include 4 species; *Aizoon canariensis*, *Datura stramonium*, *Echiochilon sp.* and *Verbesina encelioides* having (11.4%) of the recorded species. Hemi-cryptophytes were represented by five species (14.3% of the total species); *Peganum harmala*, *Commicarpus helenae*, *Gypsophilla capillaries*, *Forsskalea tencassima* and *Citrullus colocynthis* while parasite and geophytes were represented by one species; *Phragranthera austeroarabica* and unknown grass respectively.

TABLE (1). Life forms spectrum of the recorded species according to Raunkiaer's (1937).

Life form	Actual number	Relative number %
Therophytes	4	11.4
Chamaephytes	15	42.8
Hemi-cryptophytes	5	14.3
Phanerophytes	9	25.7
Geophytes	1	2.9
Parasites	1	2.9
Total	35	100

The application of TWINSPAN on the cover estimates of the 35 species recorded in 50 stands produces four groups (Fig. 2 and Table 2). These groups are well separated along the DCA ordination plane axes (Fig. 3). The four vegetation groups are named after their characteristic species as follows:

Group A (rocky substratum, 2100 m.a.s.l) comprises 10 stands (31,32,33,34, 35,36,38,39 and 40) and 16 species. It is characterized by, *Acacia asak* (C.SD 18± 8.67), *Aizoon canarienses* (C.SD 6± 4.58), unknown grass (C.SD 12.33± 12.50) and *Ochradenus baccatus* (C.SD 3.33±5.77). *Aerva lanata, Fagonia bruguieri* and *Ziziphus spina-christi* and *Lycium shwaii* are dominant species. Most species are growing between fissures of the rocks. Trees of *Acacia asak* dominate northeastern rocky slopes of wadi El-Ghayl. This type of the habitat is a gully penetrating the rocky complex, which surround the wadi from its northern borders. This community has a limited distribution and does not contribute to the vegetation of the area, being confined to rocky fissures where the soil is formed of silt with high water retaining capacity. The plant cover is low, being only 10% on average, with recognizable stratification of vegetation. *Fagonia bruguieri* has a limited range of distribution confined to the stony plateau in the eastern parts of the wadi. *Fagonia bruguieri* dominates this community. Its distribution is confined to the stony plateau covered with sandy soil. The texture of the sand varies in alternate layers but it is usually coarse wind borne material with occasional thin layers of soft water borne silt. *Fagonia bruguieri* and *Aizoon canariensis* form the main frame of the plant cover. Scattered individuals of *Aerva lanata* and *Lavandula coronopifolia* were recorded as associated species.

Group B includes 32 stands (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14,15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 37 and 49) and 22 species. It is characterized by *Acacia tortilis* (C.SD 20.60±25.68), *Acacia woodii* (C.SD 28.33±25.40), *Citrullus colocynthis* (C.SD 1.20±2.51), *Solanum incanum*.(C.SD 1.18± 2.57), *Phragranthera austroarabica* (C.SD 2.6±5.33), *Peganum harmala* (C.SD 0.53±1.07), *Pulicaria crispa*, (C.SD 1.53±3.20) and *Ficus sycomorus* (C.SD 3.6±13.9). Group B is characterizes the main wadi bed habitat and the lower stream of the wadi. It is dominated by *Acacia woodi* and *Acacia tortilis*. Scrubs of *Acacia tortilis* subsp *tortilis* are widespread in northern and southern parts of the wadi. This community abounds in the main wadi bed having shallow coarse textured soil. Stones and gravel cover considerable part of the ground surface. The total plant cover ranges between 5-25%. The most common species are: *Citrullus colocynthis*, *Peganum harmala* and *Pulicaria crispa*. The herbs layer is relatively sparse, but it is usually enriched by ephemeral growth in the rainy season. The agriculture is being practiced in the eastern

side of the wadi depending on ground water extracted by motor pumps. Among the main cultivated plants are pomegranate (*Punica granatum*), henna (*Lawsonia inermis*) and tomato (*Lycopersicum esculentum*).

Group C includes 7 stands (41,43,44,45, 46,48 and 50) and 9 species. It is characterized by *Euphorbia balsamifea* (C.SD 22.67±10.78) and *Acacia woodii* (C.SD 7.67±4.01), *Kleinia odorata* (C.SD 2±2.83) and *Solanum incum* (C.SD 0.33±0.58). It represents the cretaceous debrious of the stony plateau, with a high altitude between 2110 & 2185 m.a.s.l. *Aerva lanata* and *Commicarpus helenae* were recorded in the terraces of the wadi .

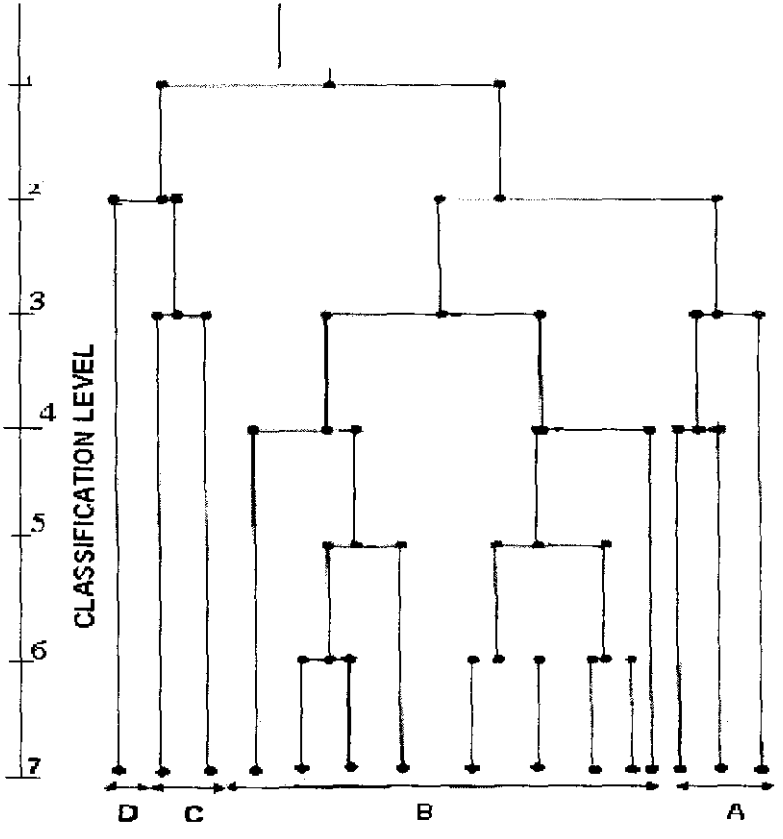

Fig. (2). Dendrogram of 50 stands based on cover value of 35 species in the study area. Four vegetation groups are produced by TWINSPAN (A,B,C and D).

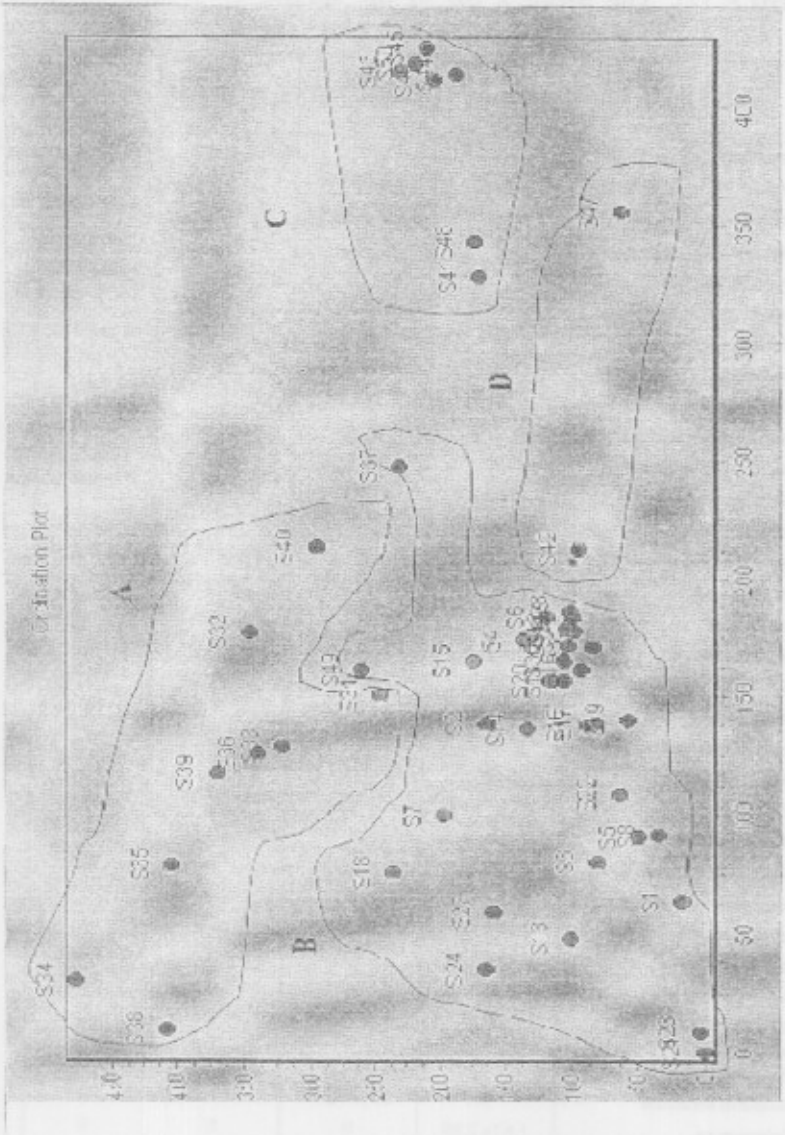

Fig. (3). DCA ordination diagram of 50 stands with vegetation groups obtained from TWINSPAN classification.

TABLE (2). The Mean ± SD of the species cover and the presence percentage in the different vegetation groups.

List of species	A St. 31-40 C SD	B St.1-30,37,49 C SD	C St.41-46,48,50 C SD	D St. 42, 47 C SD	Presence %
Acacia asak.	18± 8.67	0	0	0	25
Acacia tortilis	0	20.60±25.68	0	0	25
Acacia woodii	6.33± 12.02	28.33 ± 25.40	7.67±4.01	40±56.56	100
Acacia sp.	0	0	0	6±1.41	25
Aerva lanata.	9.33± 15.64	0.88± 3.64	0.75±0.96	0	75
Aizoon canariensis	6 ± 4.58	0	0	0	25
Calotropis procera	0	0	2±4	4.5±2.12	50
Carallumsp.	0	0.47± 1.30	0	0	25
Citrullus colocynthis	0	1.2±2.51	0	0	25
Commicarpus helenae	1± 1.73	0.77±1.44	1± 1	1.5±0.71	100
Datura stramonium	0	0.47±1.36	0	0	25
Echiochilon sp.	0.17± 0.4 0	0	0	0	25
Unknown grass	12.33± 12.50	0	0	0	25
Euphorbia balsamifera	0	0	22.67±10.78	0	25
Fagonia brugieri	14.5± 10.4	2.41± 3.59	0.25± 0.50	0	75
Fagonia sp.	0	0.8±3.10	0	0	25
Ficus sycomorus	0	3.60± 13.94	0	0	25
Forsskalea tenaccissima	0	0.4± 1.06	0	0	25
Grewia tenax	0.83± 2.04	0	0	0	25
Gypsophila capillaries	0	0.12±0.33	0	0	25
Indigofera arabica	0	0.53±1.4 6	0	0	25
Kickxia sp	0.17± 0.41	0	0	0	25
Kleinia odorata	0	0	0 2±2.83	0	25
Lavandula citriodora	4± 6. 93	0.71±1.21	0	0	50
Lavandula coronopifolia	1.67± 2.89	0	2±4	0	50
Lycium shawii	4.17± 3.97	8.93±10.68	0	0	50
Ochradenus baccatus	3.33± 5.77	0	0	0	25
Peganum harmala	0	0.53±1.07	0	0	25
Phragranthera austeroarabica	0	2.60±5.33	0	0	25
Pulicaria crispa	0	1.53±3.20	0	0	25
Solanum incanum	0	1.18 ± 2.57	0 0.33±0.58	0	50
Solanum sp.	1.67± 2.89	0	0	0	25
Verbesina enceiloides	0	0.13± 0.52	0	0	25
Withania somnifera	0	0.35±1.46	0	0	25
Ziziphus spina-christi	2.83± 6.94	0.29±1.21	0	0	50
Total no. of species	16	22	9	4	

St. = Stand
C= mean cover
SD = Standard Deviation

Group D has two stands (42 & 47) and 4 species; Acacia *woodii* (C.SD 40±56.56), *Acacia sp.* (C.SD 6±1.41), *Calotropis procera* (C.SD4.5±2.12) and *Commicarpus helenae* (C.SD 1.5±0.71). The habitat represents the stony plateau of the study area.

Soil characteristics show a little variation between the different vegetation groups (Table 3). pH value ranges between 7.15 and 7.23. The highest value of T.D.S (105.6 mg/l) is recorded in vegetation group B. Groups C and D contribute the highest value of calcium carbonates (3.4%). The highest value of sodium (0.8 mg eq/l) is recorded in group A.

As indicated in table (2), presence category V (81-100%) includes two species; *Commicarpus helenae* and *Acacia woodii*. Two species; *Aerva lanata* and *Euphorbia balsamifera* with presence value (75 %) represent presence category IV (61-80%). Most of the recorded species (25 species) are recorded in the presence category II (21-40%).

TABLE (3). Soil variables in the different stands representing the vegetation groups obtained by TWINSPAN classification in Wadi El-Ghayl.

Soil variables	Group	Group B	Group C	Group D
PH	7.15	7.22	7.23	7.23
T.D.S mg/ l	102.4	103.6	76.8	76.8
CO_3^{--} mg eq/ l	0	0	0	0
HCO_3^- mg eq/ l	0.4	0.5	0.4	0.4
Cl^- mg eq/ l	0.9	0.8	0.7	0.7
SO_4^{--} mg eq/ l	0.3	0.3	0.2	0.2
Ca CO_3 %	2.1	2.0	3.4	3.4
Na+ mg eq/ l	0.8	0.7	0.5	0.5
K+ mg eq/ l	0.1	0.1	0.1	0.1
Ca++ mg eq/ l	0.6	0.5	0.4	0.4
Mg++ mg eq/ l	0.2	0.4	0.3	0.3

mg eq/l = milligram eqivalent per liter.
T.D.S = Total dissolved salts

DISCUSSION

Spatial distribution of plant species and communities over a small geographic area in desert ecosystems is related to heterogeneous topography and landform pattern. Heterogeneity of the local topography, edaphic factors, microclimatic conditions and degree of slope leads to variation of the distribution behavior of the plant associations (Kassas, 1952; Harniss and

West, 1973). When the edaphic conditions are more favorable to plant growth the vegetation becomes denser and numerous associates are encountered (Kassas, 1966; El Karemy and Zayed, 1999), the recognized community types showed different ecological, geographical and sociological distribution: *Acacia tortilis* occurs on deep sandy soil, especially in the main wadi bed, *Acacia asak* grows in rocky gullies, *Fagonia brugieri* abounds stony plateau. These species have repeatedly been recorded as abundant in phytosociological surveys in various habitats in Saudi Arabia and other adjacent Arab Gulf countries (Batanouny, 1987; Abdel Ghani, 1996, 1997 and 1998; El Karemy and Zayed, 1999).

Plant growth in the study area shows remarkable seasonal and annual fluctuations. The notable aspects of these fluctuations are primarily due to the growth of annuals and ephemerals that are drought evaders. They usually appear in late winter and early spring in profuse number of individuals. The present study shows that trees, shrubs and perennial herbs comprise more than 50% of the total species recorded in each habitat. This is could be attributed to the favorable moisture balance and the higher content of silt and clay in the soil. The degree of human interference seems also to play a prominent role in forming the characters of vegetation. Human factors contribute to the disruption of the natural equilibrium among the components of the ecosystem thus causing its deterioration (Abd-el Ghani, 1997). Among the changes in the vegetation induced by human disturbances which lead to the retrogressive changes (Kassas, 1970).In the study area, the following can be mentioned:

(1) Continued destruction of grass-cover due to uncontrolled grazing increases soil erosion and soil impoverishment, changes the soil's mechanical composition and water relations.

(2) Severe cutting of trees and shrubs of *Acacia tortilis* either for fuel (charcoal production) or by over-grazing favours invasion of the habitat supporting this vegetation type by *Calotropis procera*. This may cause this plant, on the long-run to be endangered. The modification of species composition of the natural vegetation in the study area by continued human interference is inevitable and affects its diversity and potentiallity.

(3) Construction activities, especially digging and widening the roads, result in the removal of vegetation from vast areas and enhance erosion. This could be attributed to the prevalence of the open desert. High evaporation rate reduces the natural accumulation of surface water. The dominance of these life forms over the others should be a response to the semi arid conditions combined with human and animal interference in the area under study.

Three habitats were recognized, *viz.* main wadi bed, rocky slopes and stony plateau. A permanent framework of trees and shrubs characterizes

each of these habitats, which supports special types of vegetation with characteristic floristic composition and plant cover. These habitats are relatively simple in structure hosting the growth of species capable of surviving in such harsh environment. This is clear by preponderance of highly adapted species, i.e. drought tolerant species like *Acacia tortilis*, *Acacia asak* and *Fagonia bruguieri*. Abd-el-Ghani (2000) noted that there is a relative advantage of trees and shrubs over herbs in dry areas where water is a limiting factor, as in the study area. The upper dry layer of the soil surface acts as a protective layer, moisture is stored in subsurface layers, and the underlying sandstone provides added water storage capacity, especially in shaded areas below trees and shrubs. The presence of a sub-surface layer that is permanently wet is a well-known phenomenon in the desert (Kassas and Batanouny, 1984).

When the edaphic conditions are more favorable to plant growth that the vegetation becomes denser and numerous associates are encountered (Kassas, 1966; El Karemy and Zayed, 1999), the recognized community types showed different ecological, geographical and sociological distribution: *Acacia tortilis* occurs on deep sandy soil, especially in the main wadi bed, *Acacia asak* grows in rocky gullies, *Fagonia brugieri* abounds stony plateau. These species have repeatedly been recorded as abundant in phytosociological surveys in various habitats in Saudi Arabia and other adjacent Arab Gulf countries (Batanouny, 1987; Abdel Ghani, 1996, 1997 and 1998; El Karemy and Zayed, 1999).

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Received: 08/11/2004
Accepted: 05/05/2005

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أحمد جمال الدين فهمى – لطفى محسن حسن
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يقع وادى الجهيل على بعد ٢٥ كيلو مترا من مدينة الهرا جنوب غرب المملكة العربية السعودية بارتفاع يصل إلى ٢١٨٥ مترا وهو أحد النظم البيئية ويحتوى غطاءه النباتي على ٣٥ نوعا نباتيا تنتمى إلى ١٧ فصيلة.

وجد ان مجموعة النباتات فوق السطحية هى أكثر الطرز الحياتية سيادة مع مجموعة النباتات الظاهرة. باستخدام نظم التحليل الاحصائى الهرمى والتسلسلى وجد أن هناك ٤ مجموعات نباتية مميزة: المجموعة الأولى وتتميز بنبات السنط والهايرفا ونبات الناجوبيا والنبق وهى تنتمى إلى بيئة الصخور المميزة لمنطقة الدراسة بارتفاع ٢١٨٥ متر حيث تنمو هذه النباتات بين شقوق الصخور. المجموعة الثانية وتتميز بأحد أنواع السنط والحنظل والبيلوكاريا وأيضا نبات التين وهى مميزة لبطن الوادى على ارتفاع ٢١٠٠ متر حيث توجد الزراعات التى تعتمد على المياه الجوفية. المجموعة الثالثة وتتميز بنبات الكيموكاربس والأريزونا وهى عبارة عن مناطق صخرية حفرية على ارتفاع ٢١٨٥ متر. المجموعة الرابعة وتشمل أحد أنواع السنط والعشار. أوضحت الدراسة تباين التنوع النباتى فى هذه المنطقة بجنوب غرب المملكة العربية السعودية ومدى تأثرها بالظروف المناخية مما يسهل عملية صون هذه النباتات لهذه المنطقة الجغرافية المميزة.