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ECOLOGICAL STUDIES ON RAWDHAT SYSTEM IN SAUDI ARABIA I-RAWDHAT KHORIM

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Abstract

A broad vegetation analysis has been carried out in one of the prominent Rawdhats (Rawdhat Khorim) in the Central region of Saudi Arabia. The vegetation of the study site which is protected from off road traffic is unusually rich compared to the surrounding areas, with the influence from the sand dunes on one side and calcareous desert on the other side. The study showed that the silt basin is dominated by ephemerals and their distribution and density varies each year, depending on the amount of rain fall. The perennial vegetation, represented by few stands, constitutes less than 10% of the total vegetation cover. An inventory of 112 species, consisting of 4 life forms (trees, shrubs, perennial herbs and annual herbs) alongwith the ecological and meteorological data have been provided. Qudrat studies have also been coonducted on 8 transect lines to verify the average abundance, frequency and density of each species.

Introduction

Saudi Arabia spread over an area of nearly 2,300,000 Km^2 (about 4/5th of the Arabian Peninsula) has 50,000 Km^2 of arable land, 1,200,000 Km^2 rangeland and 16,000 Km^2 of forest cover. Although, large regions of the Arabian peninsula have not been botanically described in detail, several workers have attempted to analyse and describe its vegetation and flora (Blatter,1919; Vesey-Fitzgerald, 1955, 1957a, 1957b; Zohary, 1957, 1973; Batanouny, 1979, 1981; Halwagy *et al.*, 1982; Chaudhary, 1983; Chaudhary & Cope, 1983; Collentte, 1985; Baierle *et al.*, 1985; Schulz & Whitney, 1985; Chaudhary, 1989; Mandaville 1990; Migahid, 1990. Some of the factors involved in the formation and distribution of the vegetation in Saudi Arabia are:

a) Climate:Saudi Arabia is classified in the arid province of the world where the climate is generally hot and dry. The Kingdom is affected by two climatic types viz., Monsoon (in the southern part) and Mediterranean (in the northern part) (Abd El Rahman & Balegh, 1974).

b) Temperature plays a very important role and normally influences every function of the plants. In Saudi Arabia the extreme high temperatures (over 48°C in the shade) usually occur during summer and low temperatures (below 0°C in some areas) in winter.

c) Precipitation:Rainfall in arid land varies from year to year and from one region to another in different aspects (time of precipitation, intensity, distribution and amount). In Saudi Arabia it is expected in all months of the year but the amounts and seasons vary greatly in different regions. According to MEPA records in 1987, minimum rain was recorded in Jeddah (only 9 ml) and the maximum amount (254 ml.) was

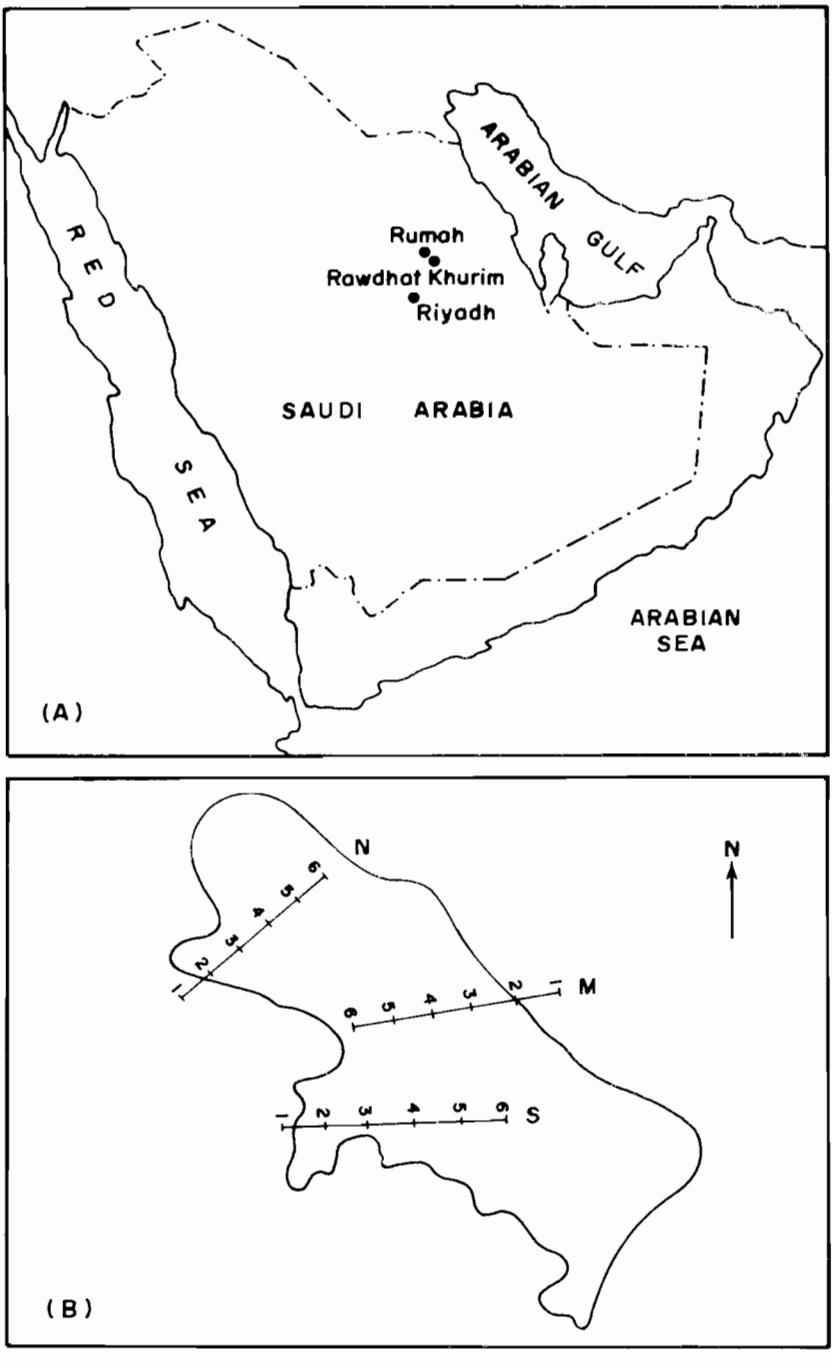

Fig.1. Map of Saudi Arabia (A) and Rawdhat Khorim (B) where N,M and S represent northern transect, middle transect and southern transect respectively.

precipitated on Abha area. In most regions of Saudi Arabia the topography is such that uneven distribution of rain is inevitable.

d) Relative Humidity is low in inland and mountainous regions and higher in coastal areas. In Jeddah, relative humidity ranges between 55-60% throughout the year with 40% RH in the eastern coastal regions during summer and about 70% in winter. In the central regions it varies from one season to the other and is much lower in summer ranging between 15-20% only.

e) Winds have a multitude of direct and indirect influence on the plants and their environments. Maximal velocities are recorded during March to May in most regions of Saudi Arabia with about 84 km/hr recorded in Al-Gassim area (Abdel Rahman & Balegh, 1974). The number of stormy days also varies. Besides, solar radiation and edaphic factors also influence the plants and their environment.

Since the Rawdhat ecosystem in Saudi Arabia is poorly described, studies were therefore carried out to analyze the vegetation of Rawdhat Khorim in terms of species composition, diversity, abundance and density, with reference to soil characters and human impact on the range management.

STUDY SITE

Rawdhat signifies a valley of flowrs. During the spring season, a rich variety of annual species come up in such places and the lush meadow may encircle a temporary rain-water pool. These areas are favourite pastures for the domestic animals of the Bedouins.

Rawdhat Khorim is one of the Rawdhats with extensive pans of fine silt against the sand dunes over which the run-off water flows along courses from the rocky ground and split out. It lies between 25°30'26° North and 47°O, 47°30' East about 120 km from Riyadh (Fig.1A). It is bounded by the Dahna (or Nafud) on one side and calcareous rocky area on the other sides. The Dahna sand belt is one of the major topographic features of the Arabian Peninsula. It's sands, consisting of orange-red, iron oxide-coated grains, are visibly distinct from those of the coastal lowlands. The Nafud posses its own characteristic plant communities consisting of *Artemisia monosperma, Calligonum comosum* etc.

The calcareous rocky area is a vast stretch of a mosaic of barren and vegetated patches which follow the runnel patterns and have a sandy covering on rocky soil, supporting a *Rhanterium* community. This rocky gravelly area serves as a catchment area with the water flowing towards the Nafud side.

The source of water in the Rawdhat is the direct rainfall and/or supplied by the flooded water coming through Wadis as a result of the rainfall collection from surrounding areas forming water pools and water bodies inside the Rawdhat.

Meteorological data obtained from Rumah (1 km, North-West of the Rawdhat) is presented in (Fig.2).

Materials and Methods

Three trips were made during winter and summer in 1993 for the collection of soil

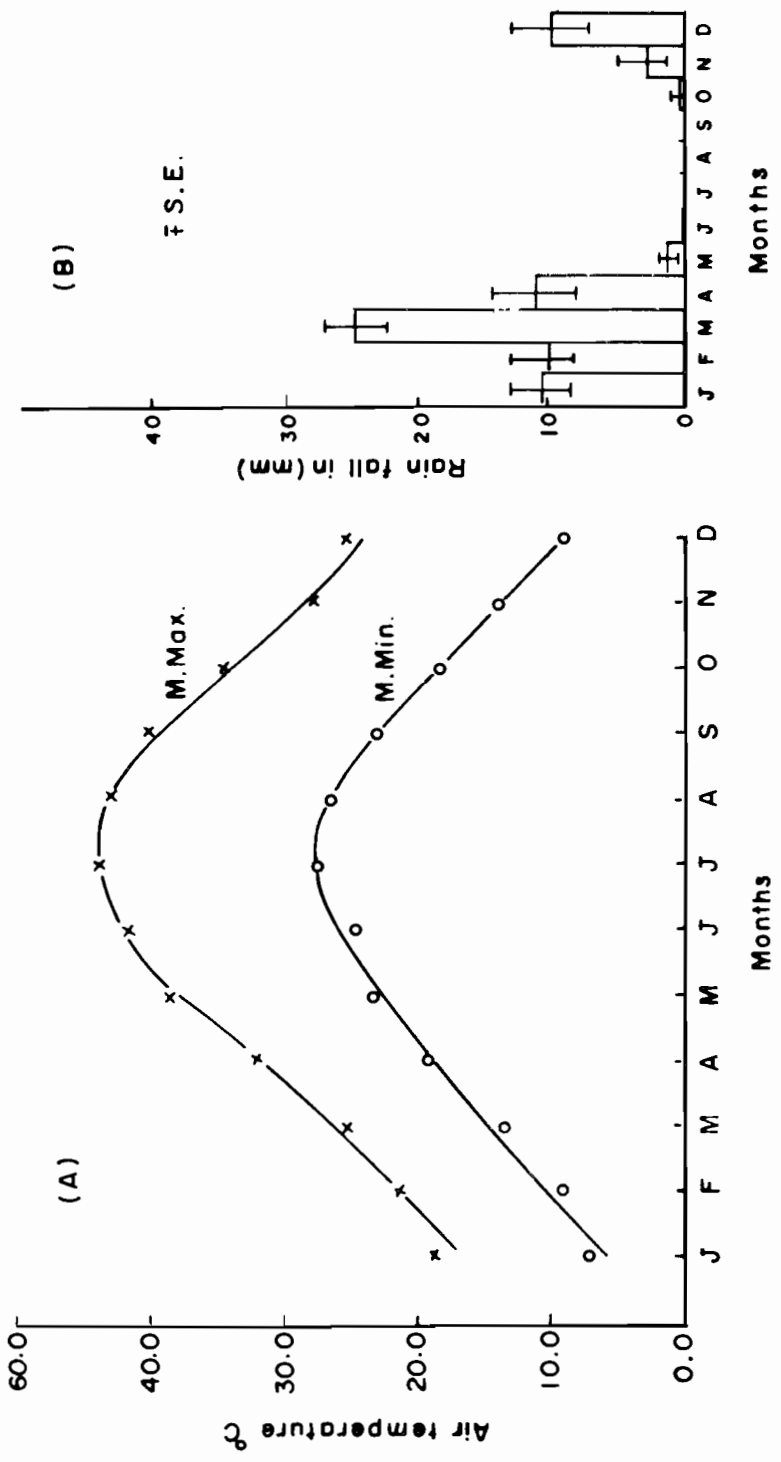

Fig. 2. Meteorological data obtained from Rumah (1 km. from Al-Rawdhat A. Mean daily temperature x = maximum and o = minimum. B. Monthly rain-fall (±S.E) data average of the records (1983-1992).

samples and during spring in 1995 for the collection and identification of plants. Three transact lines (N,M and S) (Fig.1B) were laid across the Rawdhat, with each divided into six point for collecting three replicates of soil samples. The soil samples were brought to the laboratory shortly after collection, spread over sheets of paper, air dried, thoroughly mixed, passed through 2 mm sieve to remove the gravel and debris, and packed in plastic bags for physical and chemical analysis. Soil texture analysis was carried out by the Bouyoucos hydrometer method, whereby the percentage of sand, silt and clay were calculated. Total organic matter was determined according to Allen *et al.*, (1974). Soil salinity (EC) was evaluated by a direct indicating conductivity bridge (umhos/cm) and soil reaction using a glass electrode pH meter.

In late spring of 1995, eight transact lines were laid acrosss the Rawdhat to represent its vegetation. Each of these line transects were subdivided into 50 meter unit intervals. In each 50 meters species composition, frequency, abundance and density were determined. The results obtained from all these lines were statistically analyzed using the SPSS package. The average abundance, frequency and density for each species were calculated.

Results and Discussion

Climatic Characteristics: From an ecological view point the climatic elements especially temperature and rainfall are decisive factors in determining the flora of an area and in the development of most soils. Fig.2 presents the meteorological data obtained from Rumah (1 km. North-West of Rawdhat). Monthly mean air temperature recorded for the period of 1983-1992 (Fig.2A) shows seasonal variation in temperature being with June, July, and August as hottest months while December, January and February as the coolest. Average record of rainfall is very low (27 mm or less and occurs during October - May (Fig.2B). According to the climatic classification of Balir (1942), the area is arid but due to the fact that the Rawdhat is a depression it receives during the rainy season drainage water (and water-borne soil) from neighbouring hills and high ground and from other far distant catchment areas; thus its water resources may be greater than the actual local rainfall. Local run-off of mountain rain-water in the Negev desert may increase the rain-water received by low level sites by 100 to 200 mm per annum (Evenari *et al.*, 1971).

Soil characteristics: According to the general soil map of the Kindom of Saudi Arabia (Anon., 1986) the soil of the Rawdhat belongs to the following types:

1) Calciorthid: loamy deep saline soils, 0 to 3%.
2) Rock outcrop-Torriorthents and calciorthids: rock and loamy-skeletal shallow soils, 0 to 15%.
3) Torripsamments: sandy deep soil, 0 to 5%.

Soil texture has great effect on the water content, soil fertility, soil aeration, soil temperature and water holding capacity of the soil as well as on penetrability of the root system. Sand fraction represents the main part of soil samples analysed (Table 1). Sand fraction ranges between 64-99%, with 0-34% salt and 0-4% clay.

Conductivity ranges between 0.077 and 0.950 mmhos/cm. This is mainly due to the accumulation of salts in the surface layer consequent upon evaporation of the water.

Table 1. Soil analysis of Rawdhat Khorim in Summer (S1-S18) and Winter (W1-W18) where N,M and S represent transects from North, Middle and South of the Rawdah respectively.

Transect Sample	pH	Conductivity mmhos/cm	Organic Matter (%)	Soil Texture Class	Soil Texture (%) Sand	Silt	Clay
MS1	8.92±0.05	0.128±0.006	0.377±0.061	Sand	99	1	0
MW1	9.55±0.11	0.0996±0.016	0.290±0.029	Sand	94	6	0
MS2	8.88±0.03	0.112±0.002	0.435±0.052	Sand	98	2	0
MW2	9.55±0.08	0.007±0.019	0.419±0.044	Sand	94	4	2
MS3	8.34±0.15	0.683±0.007	4.004±0.776	Loamy Sand	84	14	2
MW3	8.97±0.23	0.108±0.015	2.320±0.204	Loamy Sand	82	16	2
MS4	8.45±0.04	0.480±0.209	4.826±1.135	Loamy Sand	82	16	2
MW4	8.52±0.05	0.687±0.103	6.686±0.722	Loamy Sand	76	20	4
MS5	9.44±0.01	0.800±0.104	4.312±0.723	Loamy Sand	84	14	2
MW5	8.51±0.06	0.767±0.108	5.128±0.505	Loamy Sand	84	12	4
MS6	9.44±0.07	0.437±0.059	9.951±1.587	Loamy Sand	76	22	2
MW6	8.49±0.06	0.950±0.068	12.663±0.692	Loamy Sand	82	14	4
NS7	8.86±0.01	0.200±0.041	0.925±0.126	Sand	94	4	2
NW7	8.70±0.03	0.487±0.052	3.787±0.207	Sand	90	8	2
NS8	9.19±0.07	0.178±0.020	4.294±0.420	Sandy Loam	68	28	4
NW8	8.63±0.09	0.470±0.098	5.030±0.668	Loamy Sand	80	16	4
NS9	9.11±0.17	0.218±0.038	5.801±0.426	Sandy Loam	64	34	2
NW9	8.70±0.04	0.477±0.041	7.279±0.290	Loamy Sand	76	20	4
NS10	9.13±0.03	0.165±0.020	2.566±0.327	Sand	88	6	6
NW10	8.46±0.01	0.733±0.042	12.401±1.218	Loamy Sand	72	24	4
NS11	9.58±0.01	0.565±0.065	6.822±1.218	Loamy Sand	74	24	2
NW11	8.35±0.11	0.877±0.078	13.054±0.969	Loamy Sand	70	26	4
NS12	9.48±0.04	0.453±0.068	4.856±0.641	Loamy Sand	82	16	2
NW12	8.60±0.02	0.510±0.035	10.185±0.154	Loamy Sand	80	18	2
SS13	8.75±0.05	0.230±0.066	0.471±0.114	Sand	94	2	4
SW13	8.19±0.07	0.550±0.020	5.001±0.114	Sand	90	8	2
SS14	8.72±0.06	0.313±0.080	0.468±0.154	Loamy Sand	80	16	4
SW14	8.65±0.04	0.667±0.063	12.690±0.628	Loamy Sand	82	14	4
SS15	8.63±0.047	0.177±0.019	5.054±0.511	Sand	90	6	4
SW15	8.62±0.02	0.560±0.081	9.945±0.986	Loamy Sand	82	14	4
SS16	9.22±0.288	0.252±0.04	2.718±1.12	Sand	90	6	4
SW16	9.35±0.05	0.192±0.003	5.144±0.619	Loamy Sand	84	12	4
SS17	9.57±0.03	0.340±0.015	4.713±0.479	Sandy Loam	68	28	4
SW17	9.00±0.03	0.302±0.024	5.048±0.344	Loamy Sand	78	18	4
SS18	9.67±0.12	0.320±0.056	8.476±0.577	Loamy Sand	80	18	2
SW18	9.17±0.07	0.128±0.007	1.419±0.137	Sand	98	0	2

Fig.3. One of the local residents cutting down an *Acacia* tree inside the Rawdhat.

Fig.4. Grazing one of the most damaging factors affecting the vegetation of the Rawdhat.

Percentage of organic carbon in soil of the Rawdhat is relatively low and ranges between 0.290-13.054%. This is in accordance with the conclusion of Weaver & Clements (1938) who stated that arid soils contain less quantities of humus.

Daubenmire (1974) reported that in warm dry climates, soils are usually circumneutral to strong basic because there is insufficient rainfall to leach away the bases as soon as they are released in weathering and few acidic materials are produced due to decay. In the Rawdhat the pH values range between 8.19-9.67.

Human actvities in the Rawdhat: The effect of man on the desert vegetation may be direct on the vegetation cover itself or indirect through their influence on the other components of the ecosystem whether positive or negative.

Positive activites: Semi-protection by building posts around the Rawdhat barriers and temporary full-protection by guarding it after the rain, specially in spring when a lush carpet of vegetation appears. This protection gives the species a chance to develop their seed bank.

Negative activities: The impact of man on vegetational cover in the deserts resulting in its degradation has been recorded (Kassass, 1970; McGinnies, 1970; LeHouerou, 1974; Batanouny, 1979; Al-Farraj, 1989). The Rawdhat is a favourite pasture for the bedouin and their livestock and it is a suitable place, beside the Wadi-banks and mountains, for cutting or uprooting of ligneous species for firewood. Although it is prohibited to cut trees from the Rawdhat, but during our visits were have seen one of the locals pulling *Acacia* tree with his truck after cutting it with his axe (Fig.3).

Nomadic life is based on grazing and the most attractve area in the desert is the Rawdhat due to rich vegetation. There are several locations around Rawdhat Khorim where the bedouins keep their sheeps, goats and camel's (Fig.4). In addition to grazing the locals collect the grass and take it to their residence.

In Saudi Arabia, camping and picnicking have significantly increased over the last few decades due to the higher per capita income leading to higher levels of car ownership's and a new trend of living in multistory buildings. Such recreations away from the urban areas resulted in the deterioration of the once intact and ecologically balanced desert habitats. One could easily find such activites in the Rawdhat around the year since it is not far away from the capital (Riyadh and easy to reach via asphalted road.

Vegetation: Three types of desert vegetation are recognized depending on the water regime of habitat viz., (a) accidental type (Kassas, 1966, 1970) in the so-called rainless parts of the arid zone where rainfall is not an annually recurring incident; (b) restricted type (Walter, 1963) in arid areas where rainfall, though low and variable is an annually recurring phenomenon and vegetation is confined to rather restricted areas (depressions, runnels and wadis) with relatively adequate water supply due to accumulation of run-off water and water borne sediments; and (c) the diffuse type in less arid areas where the vegetation is more or less evenly distributed. In the Rawdhat all these three types of vegetation were found. The species found in the Rawdhat can be divided into four layers: Trees, shrubs, under shrubs and herbaceous and woody plants (Table 2).

A total number of 112 species were recorded in the Rawdhat while the total number of species in all transects was 77. The highest total number of individuals of all species was 6834 recorded in transect 2 which reflects the high species diversity in that

Table 2. Average frequency, abundance and density of total number of species collected from the 8 lines.

Species	Average abundance (P/Q)	Average frequency (%)	Average density (P/Q)
Acacia gerrardii	1.0	15.0	0.2
Andrachene telephoides	2.5	15.0	0.5
Anthemis deserti	1.3	20.0	2.5
Anthemis psudocotula	15.0	42.9	8.4
Arnebia linerifolia	6.4	25.0	2.1
Artemisia judaica	1.0	10.0	0.1
Asphoedelus tenuifolius	2.0	18.0	0.5
Astenatherum forsskalli	2.0	10.0	0.2
Astragalus asteraias	7.1	28.0	2.6
Astragalus corrugatus	12.1	60.0	7.7
Astragalus hauarensis	2.0	10.0	0.2
Astragalus spinosus	1.0	10.0	0.1
Bassia indica	7.5	10.0	0.8
Bromus madritensis	1.5	10.0	1.5
Calendula arvensis	36.2	70.0	31.0
Capparis spinosa	1.0	10.0	0.1
Cassia italica	2.0	20.0	0.2
Caylusea hexagyna	4.0	14.0	0.4
Chenopodium murale	13.2	15.0	1.5
Convolvulus pilosellifolius	15.5	13.3	17.7
Cutandia memphitica	36.7	20.0	9.2
Cynodon dactylon	12.5	30.0	4.3
Echium horridum	3.7	30.0	1.1
Emex spinosus	11.9	58.6	5.4
Eragrostis barrelieri	10.0	10.0	1.0
Eremobium aegyptium	3.0	10.0	0.3
Erodium deserti	2.2	13.3	0.27
Erodium laciniatum	2.7	10.0	0.3
Erucaria hispanica	1.1	14.0	0.2
Faronia bruguieri	1.0	10.0	0.1
Filago desertorum	43.7	61.3	30.1
Gastrocotyle hispida	3.0	10.0	0.3
Haplophyllum tuberculatum	4.3	20.0	1.8
Heliotropium bacciferum	1.0	20.0	0.2
Heliotropium digynum	14.0	20.0	2.8
Koelpinia linearis	6.9	66.7	2.0
Lappula spinocarpos	1.3	10.0	0.1
Lasiurus scindicus	1.0	10.0	0.1
Launaeae capitata	8.5	20.0	1.7
Launaeae nudicaulis	8.5	20.0	1.7
Leontodon laciniatus	2.0	20.0	0.2
Lapidium aucheri	27.4	30.0	4.9
Lycium shawii	1.0	20.0	0.2

Table 2 (Cont'd.)

Species	Average abundance (P/Q)	Average frequency (%)	Average density (P/Q)
Malva parviflora	9.3	35.0	4.2
Martricaria aurea	136.8	15.7	36.9
Medicago laciniata	14.9	26.0	4.1
Molkiopsis ciliata	2.5	20.0	0.5
Paronychia arabica	7.2	22.5	2.2
Phalaris minor	50.9	38.0	22.2
Picris babylonica	17.2	36.7	4.1
Plantago amplexicaulis	29.8	41.7	14.7
Plantago boissieri	53.5	40.0	26.7
Plantago ciliata	86.3	10.0	8.6
Plantago ovata	8.1	20.0	1.8
Poa annua	24.5	36.6	7.6
Polycarpae repans	5.9	20.0	1.7
Polygonum aviculare	1.0	10.0	0.1
Pulicaria crispa	6.1	36.8	3.0
Pulicaria incisa	2.0	10.0	0.2
Reichardia tingitana	1.0	10.0	0.1
Rhazya stricta	1.2	14.0	0.2
Robbieria diandra	10.3	25.0	3.8
Rostraria pumila	6.0	20.0	1.2
Rumex vesicarius	3.4	20.0	0.9
Schismus barbatus	6.0	20.0	1.2
Scorzonera intricata	1.0	10.0	0.1
Senecio glaucum	2.5	20.0	0.5
Silene arabica	2.5	20.0	0.5
Sisymbrium irio	17.3	10.0	1.7
Spergula fallax	69.0	33.7	40.7
Spergularia diandra	1.0	10.0	0.1
Stipa capensis	42.0	71.7	34.0
Stipagrostis plumosa	1.2	15.0	0.6
Trigonella anguina	40.0	51.3	25.5
Trigonella hamosa	43.4	77.5	34.5
Tripleurospermum auriculatum	19.0	41.4	24.6
Zilla spinosa	1.1	16.7	0.2

area, whereas, the lowest total number of individuals was 1335 recorded in transect 6 (Fig.5).

Matricaria aurea was the most abundant species (136.8 plant per quadrat) followed by *Plantago ciliata* (86.3 P/Q), *Plantago boissieri* (53.5 P/Q) and *Phalaris minor* (50.9 P/Q). Least abundant species recorded were: *Acacia gerrardii*, *Artemisia judaica*, *Astragalus spinosus*, *Capparis spinosa*, *Fagonia bruguieri*, *Heliotropium bacciferum*, *Lasiurus scindicus*, *Lycium shawii*, *Polygonum aviculare*, *Reichardia tingitana*,

Fig.5. *Razya stricta* as one of the Sand binders grown in the Rawdhat.

Fig.6. The *flourishment* and richness of the plants in the Rawdhat as a result of the semi-protection state.

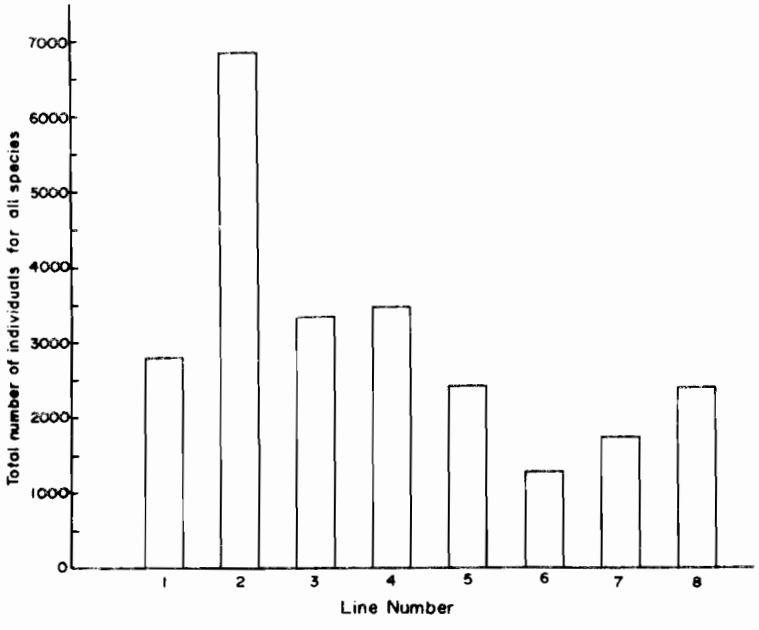

Fig.7. Histogram showing the total number of individuals for the species.

Scorzonera intricata and *Spergularia diandra* with an average abundance of 1.0 plant per quadrat each (Table 2). The most frequent species recorded were *Trigonella hamosa* (77.5%), *Stipa capensis* (71.7%), *Filago desertorum* (61.3%) and *Astragalus corrugatus* (60.0%), while the least frequent species were *Artemisia judaica, Astenatherum forskalli, Astragalus hauarensis, Astragalus spinosus, Bassia indica, Bromus madritensis, Capparis spinosa, Eragrostis barrelieri, Eremobium aegyptium, Erodium laciniatum, Fagonia bruguieri, Gastrocotyle hispida, Lappula spinocarpos, Lasiurus scindicus, Plantago ciliata, Polygonum aviculare, Pulicaria incisa, Reichardia tingitana, Scorzonera intricata, Sisymbrium irio* and *Spergularia diandra* with an average frequency of 10.0% each (Table 2).

Density was recorded to be highest in *Spergula fallax* (40.7 plant per quadrat), *Martricaria aurea* (36.9 P/Q), *Trigonella hamosa* (34.5 P/Q) and *Stipa capensis* (34.0 P/Q), whereas, the least dense species were *Artemisia judaica, Astragalus spinosus, Capparis spinosa, Fagonia bruguieri, Lasiurus scindicus, Polygonum aviculare, Reichardia tingitana, Scorzonera intricata* and *Spergularia diandra* with the average density of 0.1 P/Q each.

Comparing the recorded species as found in the present study with those of the previous reports, a number of 112 plants are present in that region against 17 species recorded by Vesey-Fitzgerald (1957b) from the Rawdhat. The increase in the number of species in recent years is presumably related to recent enforcement of guarding and protection of the Rawdhat (Anon., 1980). Al-Eisawi & Hatough (1987) have emphasized the importance of natural reserves and wildlife protection in Jordan.

Since deep, heavy soil and plenty of moisture allow the establishment of trees, shrubs and under shrubs, the low-lying nature of the Rawdhat results in the accumulation of seeds of annuals and the abundance of moisture during rainy seasons favours a luxuriant growth of the annuals. It is interesting of to note that peripheral area close to the Nafud are exposed to drifting sand and some components of the vegetation e.g., *Dipterygium glaucum, Hammada elegans, Panicum turgidum* and *Rhazya stricta* are adapted to tolerate sand burial and are effective sandbinders (Fig.6). Undoubtedly, the vegetation of the Rawdhat has benefitted from the semi-protection state, which is reflected in the richness of the vegetation (Fig.7). The species diversity and the vegetation density might vary seasonally or yearly due to the amount of rainfall or water floods feeding the Rawdhat (Fig.2). The diversity during spring was higher than in other seasons due to the growth of ephemeral species.

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