SPECIES DIVERSITY AND FLORISTIC COMPOSITION OF RAWDHAT ABALWOROOD VEGETATION IN AL-ASYAH, AL-QASSIM REGION, SAUDI ARABIA

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(Received 2nd May 2023; accepted 21st Jul 2023)

Abstract. Rawdhat Abalworood in Al-Qassim region of Saudi Arabia is one of the most important rawdhats of this area. The present study provides insight of vegetation types, life forms, as well as floristic categories and species distribution, highlighting the ecological factors that influence species distribution. A total of 44 species representing 19 families of vascular plants were recorded. The dominating groups were Asteraceae and Brassicaceae, and the dominant life forms were therophytes and chamaephytes, displaying a typical desert life-form range. Two of the eighteen studied sites had the maximum species richness value of 15 species per plot. Five of the 18 sites studied had the lowest species richness assessing of 10 species per plot. The most frequent life form classes observed in Rawdhat Abalworood, Al-Asyah, Al-Qassim region were Therophytes (Th) and Chamaephytes (Ch), with 65.91% and 15.91%, respectively. Chorological analysis exhibited Saharo-Sindian (SA-SI) and Irano-Turanian-Saharo-Sindian (IR-TR+SA-SI) represented by 20.45% and 18.18, respectively. Chronologically, surveyed plant species were recognized into three categories; mono regional, bi regional, and pluri regional. The three chorological categories were represented by 31.81%, 50.0%, and 18.18%; respectively. Species diversity in terms of Margalef's diversity index (*Figure 6A*) ranged between 1.6 to 2.6 with an average of 2.1 to 0.3, Shannon-Weiner diversity index (*Figure 6D*) showed close diversity levels as Margalef's and ranged between 1.6 to 2.4 with an average of 2.1. Using CCA multivariate analysis effect of 6 environmental factors is distinguished upon vegetation. The CCA ordination revealed that the separation of Vegetation group III along the axis was influenced by Silt, WHC, OM, OC, and Clay, whereas VG II was substantially related to sand%.
Keywords: *Abalworood, Al Qassim region, Saudi, floristic, vegetation*

Introduction

The Kingdom of Saudi Arabia is a country with a large dry desert region of approximately 2250,000 km^2, accounting for nearly 80% of the total area of the Arabian Peninsula. However, most of Saudi Arabia region is deserts except the south-western region highlands with a mild climate and sufficient precipitation that's suitable and supports plant life (Masrahi, 2012).

Saudi Arabia's Qassim province is located between 24 40' and 27 50' N and 41 50' E. The region is practically central in Saudi Arabia's famous for dry to extremely arid conditions (AlNafie, 2008). It is enclosed to the north by Ha'il, to the west by Al-Madina, and to the east and south by Riyadh (*Fig. 1* Map) (AlTurki, 1997; Ghazali, 2013). This region is a subjected complex of Precambrian igneous and metamorphic rocks, and it is part of an extensive belt of phanerozoic formations that connect the northern and eastern border of the Arabian shield and consist of escarpments consisting of Paleozoic to

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DOI: http://dx.doi.org/10.15666/aeer/2105_47034719

Mesozoic sandstone and lime stone (Al-Turki, 1997). The sand seas in the north and eastern parts are Nafud as Sirr, Nafud Al-Thuwayrar and Nafud Al-Mazhur. Asyah is a town in Al-Qassim region, it has a total of about 200 Km^2, an interesting vegetation area in Asyah, Al Qassim region is Rawdhat Abalworood where the study was undertaken.

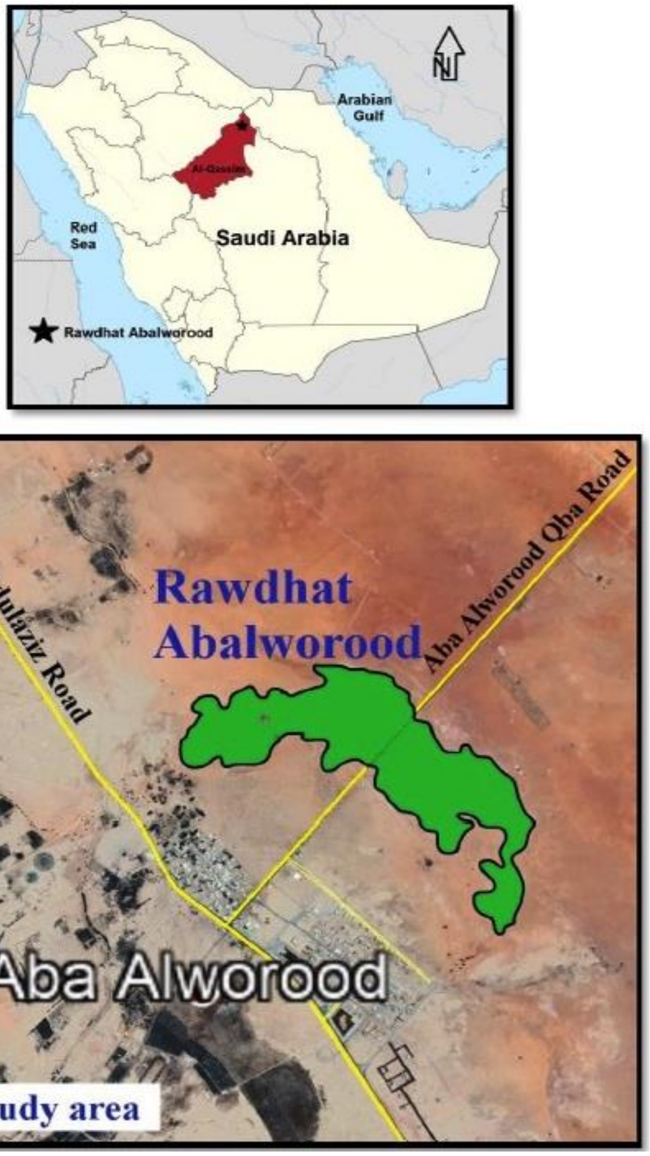

Figure 1. *Map of Saudi Arabia with geomorphological characters. Study area include Rawdhat Abalworood in Al-Asyah, Al-Qassim region. Green area indicates area of field survey*

Vegetation is the main compositions defining the nature of ecosystems (Orshan, 1986). The low vegetation coverage is considered as one of the main indicators of arid lands is the lower vegetation coverage (Brovkin et al., 2002). The vegetation unit structure and form is recognized by evaluating the floristic composition associated in assemblies reflecting the environmental circumstances (Saxena et al., 1982). The form of plant life is the growth type that characterizes the adaptation to particular environmental and ecological conditions, including temperature, precipitation, etc. (de Mera et al., 1999). These represent the adaptation to climate and hence, the entire vegetation in a specific

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
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area as an expression of the essential climate (Batalha and Martins, 2002; Al Shaye et al., 2020). The most widely used life form classification system is the Raunkiaer system (Raunkiaer, 1934; de Mera et al., 1999). The Raunkiaer system classifies plant's life forms based on the degree of protection and position of the buds or other reproductive organs e.g. rhizomes, tubers and seeds relative to the protection against unfavorable conditions (Raunkiaer, 1934). Accordingly, life forms is classified into five groups; Therophytes, cryptophytes, hemicryptophytes, chamaephytes, and phanerophytes. The biological spectrum is represented by percent of each life form composed in a particular vegetation constructing a normal spectrum and representing a null type against life form spectra. The normal spectrum respects the global distribution of all plant life forms (Raunkiaer, 1934). Fundamental climate patterns are characterized by a relatively or absolutely dominant life-form either one or few life-forms. In a specific area, any aberration in the biological spectrum versus the normal one identify the phyto-climate of that area (Raunkiaer, 1934).

Previously, some ecological and floristic studies were undertaken and published concerning the vegetation of Wadis (Zohary and Orshan, 1956; Alatar et al., 2012; Osman et al., 2014; Abdel Khalik et al., 2017; Osman and Abdein, 2019). A preliminary checklist of Al-Qassim region's flora and weeds flora were also published (Al-Turki, 1997; Ghazali, 2013).

Keeping in view the above facts and figure, the current study was undertaken with the objective, to explore the species diversity, floristic composition, and life forms of Rawdhat Abalworood vegetation in Al-Asyah, Al-Qassim Region, Saudi Arabia to define the dominant plant families, biological spectrum, and biological diversity of plant communities in the study sites.

Materials and Methods

Field surveys were performed in Rawdhat Abalworood vegetation in Al-Asyah, Al-Qassim area, during November 2019-April 2022, involved the collection of plant samples to study the floristic composition. According to recent flora literature, plant specimens were carefully identified (Chaudhary, 1999, 2001; Collenette, 1999). The life form groups were recognized based on Raunkiaer categories (Raunkiaer, 1934).

Study area

The study was conducted in Rawdhat Abalworood in Al-Qassim region of Saudi Arabia, which is about 100 km from the city of Buraidah and is located in the northeastern part of Al-Qassim region (27º01'52"N 44º05'20"E). Similar to most regions of Saudi Arabia, Rawdhat Abalworood has low annual precipitation rates, which are always less than 200 mm/year. The temperature varies greatly between the summer and winter seasons. The temperature ranges from 43°C in the summer to less than 7°C during the winter.

Sample sites

The plant species were studied using 10×10 m stand following the standard procedures. Each plant species' coverage and relative density have been quantified (Canfield, 1941; Shukla and Chandel, 2005) in the eighteen surveyed sites along Rawdhat Abalworood vegetation. The relative coverage, density, and importance value (IV= 200)

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
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were estimated for each species per site. Nomenclature and phytogeographic range evaluation were done according to Zohary (1962), Tackholm (1974), and Boulos (2005, 2002, 2000, 1999).

Soil analysis and estimation

Soil samples were taken in triplicate at depths ranging from 0 to 15 cm, then spread out and allowed to air-dry. Following a prior study (Piper, 2011), soil water holding capacity (WHC), texture, organic carbon, and sulphate were evaluated. Titration against 1N NaOH was used to calculate calcium carbonate (%) (Jackson, 1973). According to Jackson, (1973), the pH and Electrical conductivity (EC) were measured in a 1:5 soil-water extract. Na^+ and K^+ were estimated using a flame photometer; however, Ca^{2+} and Mg^{2+} were determined using an atomic absorption spectrometer (Allen et al., 1974). Carbonates and bicarbonates were estimated by titration against 0.1 N HCl (Pierce et al., 1958).

Data analyses

Data were handled and organized using Microsoft Excel 2016. Data were checked for normality using Shapiro-Wilk normality tests at a 0.05 probability level. In order to evaluate differences in vegetation and soil physio-chemical parameters among the examined sites, a one-way analysis of variance (ANOVA) was implemented at a significance level of 0.05, while the Kruskal-Wallis test was employed for nonparametric data. The study utilized Spearman's rank correlation coefficient (r) to assess the correlation between the physicochemical soil parameters and other vegetation parameters. A 2-tailed significance test was then conducted at a significance level of 0.05. The statistical analyses were performed utilizing the SPSS software version 23.0 for Mac OS (Armonk, NY: IBM Corp, 2015) (Sweet and Grace-Martin, 2012; MacInnes, 2017).

To evaluate the interrelationship between soil & environmental factors and vegetation at the Rawdhat Abalworood area, ordination by Canonical Correspondence Analysis (CCA) (ter Braak, 1986) by using PC-ORD version 5 (MJM Software, Gleneden Beach, OR, USA) was performed (Grandin, 2006).

The total number of species at each study a site is referred to as the species richness (SR). Using the formula, H= –Pi ln Pi, the Shannon-Wiener diversity index was obtained. The Margalef's diversity index (Margalef, 1958; Gamito, 2010) (*d*) was calculated in a spreadsheet with the formula S-1/ln N; where S is the number of recorded species, and N is the total number of individuals. Selected species diversity and richness indices were calculated using the software PAST version 3.16 (Hammer et al., 2001; Gamito, 2010; Morris et al., 2014).

Results

Floristic

A total of eighteen location sites were surveyed in Rawdhat Abalworood, Al-Asyah, and Al-Qassim region, and an overall of 44 plant species were recorded (*Table 1*). Recorded plant species belong to 19 plant families and 39 genera (*Table 1*). The most common families with the highest number of species were Asteraceae, Brassicaceae, Fabaceae, and Plantaginaceae, each represented by 9, 8, 5, and 5 species (*Figure 2*); respectively. Among the reported plant species, 63.6% were annuals, and 36.4% were

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perennials (*Figure 3A*). Nine recorded species from the family Asteraceae and eight from Brassicaceae comprise about 20% and 17.8% of the total number of recorded species, respectively (*Figure 2*). Moreover, five species for Fabaceae and Plantaginaceae e about 11.1% of the recorded species. Families Boraginaceae, Chenopodiaceae, and Malvaceae were represented by two species with 4.44% of the total recorded species (*Figure 2*). Other families were represented by only one species, each with 2.22% of the total.

Table 1. *Floristic composition of the recorded species in RawdhatAbalworood, Al-Asyah, Al-Qassim Region, Saudi Arabia*

No.	Species	Family	Life span	Life form	Chorotype
1	Acacia gerrardiiBenth.	Fabaceae	Per	Ph	S-Z
2	Aizoon canarienseL.	Aizoaceae	Ann	Th	SA-SI+S-Z
3	Althaea ludwigiiL.	Malvaceae	Ann	Th	IR-TR+SA-SI+S-Z
4	Anagallis arvensis L.	Primulaceae	Ann	Th	COSM
5	AnisosciadiumisosciadiumBornm.	Apiaceae	Ann	Th	IR-TR+ SA-SI
6	Anthemis deserti(Boiss.) Eig.	Asteraceae	Ann	Th	ME+SA-SI
7	Asphodelus tenuifoliusCav.	Asphodelaceae	Ann	Th	ME+SA-SI
8	Astragalus asterias Hohen	Fabaceae	Ann	Th	ME+IT-TR+SA-SI
9	Astragalus dactylocarpusBoiss.	Fabaceae	Per	He	SA-SI
10	Brassica tournefortiiGouan	Brassicaceae	Ann	Th	ME+IR-TR+SA-SI
11	Calendula tripterocarpaRupr.	Asteraceae	Ann	Th	IR-TR+SA-SI
12	Convolvulus fatmensisG.Kunze	Convolvulaceae	Ann	Th	SA-SI
13	Cynodondactylon(L.) Pers.	Poaceae	Per	G	COSM
14	DipcadiErythraeumWebb & Berth.	Asparagaceae	Per	G	SA-SI
15	Diplotaxis acris (Forssk.) Boiss.	Brassicaseae	Per	Th	ME+IR-TR
16	Diplotaxisharra(Forssk.) Boiss.	Brassicaseae	Per	Ch	ME+SA-SI
17	Emex spinosa (L.) Campd.	Polygonaceae	Ann	Th	ME+SA-SI
18	FilagodesertorumPomel	Asteraceae	Ann	Th	IR-TR+SA-SI
19	Frankenia pulverulentaL.	Frankeniaceae	Ann	Th	ME+IR-TR+ER-SR
20	Gastrocotylehispida(Forssk.) Bunge	Boraginaceae	Ann	Th	SA-SI+IR-TR
21	Haloxylonsalicornicum(Moq.) Bunge ex Boiss.	Chenopodiaceae	Per	Ch	SA-SI
22	HeliotropiumcrispumDesf.	Boraginaceae	Per	Ch	IR-TR+SA-SI
23	Hyoscyamus muticusL.	Solanaceae	Per	Ch	SA-SI
24	Lepidium aucheriBoiss.	Brassicaceae	Ann	Th	ME
25	Malva parviflora L.	Malvaceae	Ann	Th	ME+IR-TR
26	Matricariaaurea(Loefl.) Sch.Bip.	Asteraceae	Ann	Th	SA-SI
27	Melilotus officinalis (L.) Desr.	Fabaceae	Per	H	ME+IR-TR+ER-SR
28	Neurada procumbens L.	Neuradaceae	Ann	Th	SA-SI+S-Z
29	Peganum harmala L.	Zygophyllaceae	Per	H	ME+IR–TR+SA–SI
30	Picris cyanocarpaBoiss.	Asteraceae	Ann	Th	SA-SI
31	Plantago albicans L.	Plantaginaceae	Ann	Th	ME+SA-SI
32	Plantago boissieriHusskn. &Bornm.	Plantaginaceae	Ann	Th	ME+SA-SI
33	Plantago major L.	Plantaginaceae	Per	H	COSM
34	Plantago ovata Forssk.	Plantaginaceae	Ann	Th	IR-TR+SA-SI
35	Plantago psammophilaAgnew &Chalibi-Ka, bi.	Plantaginaceae	Ann	Th	IR-TR+SA-SI
36	Pulicariaundulata(Forssk.) C.A.Mey.	Asteraceae	Per	Ch	SA-SI+S-Z
37	Savignya parviflora (Delile)Web.	Brassicaceae	Ann	Th	IR-TR+SA-SI
38	Schimperenniala arabica Hochst. &Steud. Ex Endl	Brassicaceae	Ann	Th	SA-SI
39	ScorzoneraschweinfurthiiBoiss.	Asteraceae	Per	He	IR-TR+ME
40	Sinapis arvensis L.	Brassicaceae	Ann	Th	ME+IR-TR+ER-SR
41	Suaeda vera Forssk. ex J.F. Gmel	Chenopodiaceae	Per	Ch	ME+ ER-SR+SA-SI
42	Trigonella hamosaL.	Fabaceae	Ann	Th	ME+SA-SI
43	Tripleurospermumauriculatum(Boiss.) Rech.f.	Asteraceae	Ann	Th	ME+IR-TR
44	Zilla spinosa (L.) Prantl.	Brassicaceae	Per	Ch	SA-SI

P%, presence of values; Per, perennials; Bi, Biannual; Ann, annuals; Ph, Phanerophytes; H, Hemicryptophyte; Ch, Chemaephytes; Th, Theophytes; G, Geophytes; He, Helophytes; COSM, Cosmopolitan; SA-SI, Saharo-Sindian; S-Z, Sudano-Zambezian; IR-TR, Irano-Turanian; ER-SR, Euro-Siberian; ME, Mediterranean

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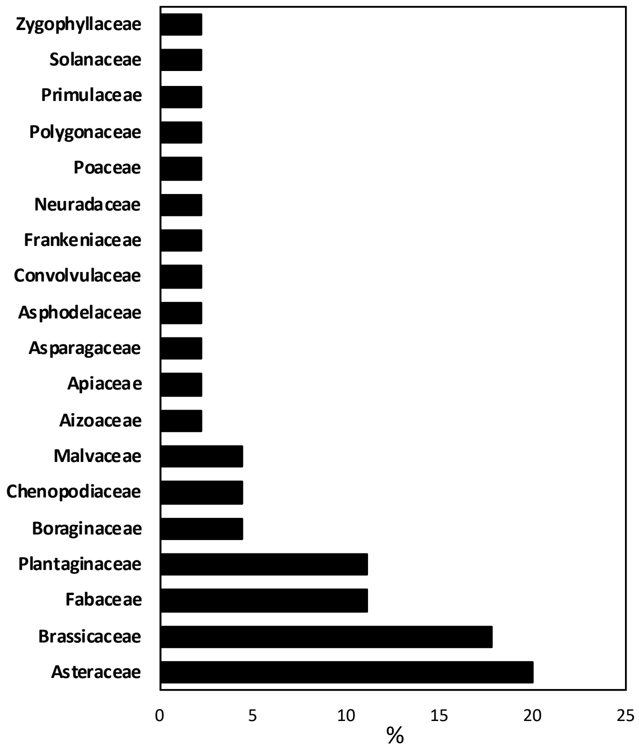

Figure 2. *Percentage of recorded plant families in the study area*

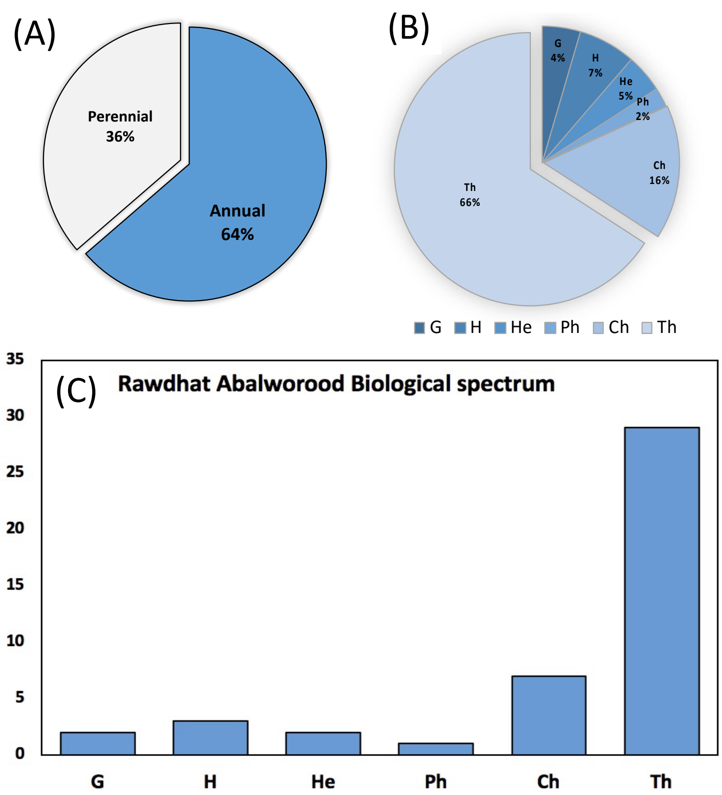

Figure 3. *(A) Life history percentage (B) Life form percentage and (C)Biological spectrum of Rawdhat Abalworood Vegetation in Al-Asyah, Al-Qassim Region, Saudi Arabia*

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The most frequent life form classes observed in Rawdhat Abalworood, Al-Asyah, and Al-Qassim region were Therophytes (Th) and Chamaephytes (Ch), with 65.91% and 15.91%; respectively. Hemicryptophytes (H) were represented by 6.82%; however, geophytes (G) and Helophytes (He) comprised about 4.55% of the total. Phanerophytes showed the lowest represented life form of about 2.27% (*Figure 3B,C*). The area of Rawdat Abalworood showed significantly different life form classes, as revealed by Kruskal-Wallis (p<0.05).

The life span, life forms, and Chorotype of recorded species were presented in *Table 1*. The most frequent floristic category chorotype in the Abalworood area was Saharo-Sindian (SA-SI) and Irano-Turanian-Saharo-Sindian (IR-TR+SA-SI) represented by 20.45% and 18.18; respectively (*Figure 4A,B*). However, the Mediterranean and Saharo-sindian showed a percentage of 15.91% of the total. Both Mediterranean Irano-Turanian Saharo-Sindian and Mediterranean Irano-Turanian were represented by 9.09% (*Figure 4B*). Chronologically, surveyed plant species were categorized into mono regional, bi regional, and pluri regional. The three chronological categories were represented by an overall of 14, 22, and 8 species forming a percentage of 31.81%, 50.0%, and 18.18% (*Figure 4A*); respectively. Furthermore, Saharo-Sindian had the highest mono regional representation (20.45%) with 9 species. However, the Irano-Turanian-Saharo-Sindian region had the highest bi regional representation with 8 species (18.18%). whereas the Mediterranean-Irano-Turanian-Saharo-Sindian region had the highest Pluri regional phytochorion, with the 4 species (9.09%).

The physical and chemical analyses were performed for the 18 studied sites and are represented in *Table 2*. The sand % in Abalworood sites ranged between 5048 to 87.70% with an average (±SD) of 74.9±10.9%. While the silt compartment of the soil ranged between a minimum of 2.79% to a maximum of 20.58% with an average of 8.6±5.2, and clay showed an average of 16.5±6.1% of the soil (*Table 2*). The maximum water holding capacity, porosity %, organic matter %, and organic carbon % showed an average of 24.4±4.6, 26.1±1.5, 6.2±4.5, and 3.6±2.6 %; respectively (*Table 2*). Various chemical analyses, including electric conductivity (EC), pH, Cl^-, HCO^{3-}, SO_4^{2-}, Na^+, Mg^{2+}, K^+, and Ca^{2+} showed an average (±SD) of 0.17±0.1, 0.80±0.1, 17.1±9.9, 21.9±10.5, 10.0±3.7, 4.1±3.4, 3.1±1.7, 7.3±2.3, 8.5±6.3 %; respectively. The eighteen studied sites in Abalworood area showed a significant (p<0.05) difference in both physical and chemical analyses (*Table 2*) revealed by one-way analysis of variance at 0.05 level.

The correlation between various soil parameters and species recorded was presented in *Table 3* revealed by Spearman’s rank correlation followed by a two-tailed significance test. High, moderate significant correlation is recognized e.g., EC and *Acacia gerrardii* Benth. Where a negative strong (r=-0.72; sign.<0.001**) highly significant correlation exist; however, sand is positively strongly correlated with *Acacia gerrardii* (r=0.52; sign(2tailed<0.001***) (*Table 3*).

The species richness and diversity of studies sites were calculated in all studies sites and presented in *Figure 5A-E*. The species richness ranged between 10 to 15 species with an average of 11.8±1.7 with the highest species richness recorded at sites 1 and 18, represented by 15 species (*Figure 5E*). Species diversity in terms of Margalef’s diversity index (*Figure 6A*) ranged between 1.6 to 2.6 with an average of 2.1±0.3, Shannon-Weiner diversity index (*Figure 5D*) showed close diversity levels as Margalef’s and ranged between 1.6 to 2.4 with an average of 2.1. The differences in species diversity in studied sites were not significant (p>0.05). Other diversity indices were calculated and presented, including Evenness and Simpson’s (*Figure 5B-C*). The correlation between species

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richness and various species diversity indices versus edaphic factor is presented in *Table 4*.

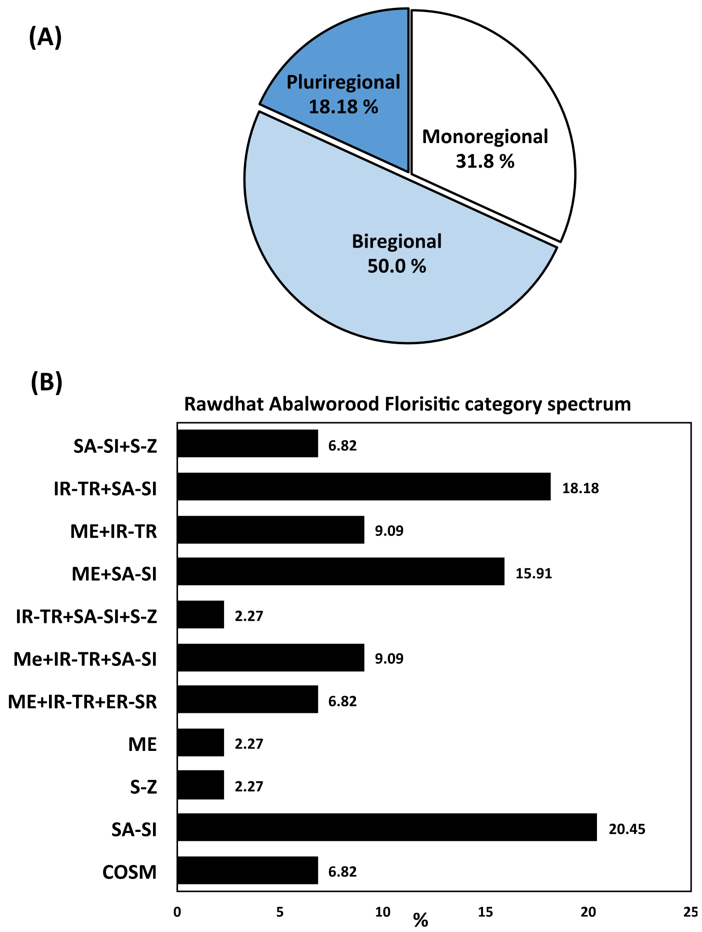

Figure 4. *(A,B) Floristic category spectrum of Rawdhat Abalworood. COSM, Cosmpolitan; SA-SI, Saharo-Sindian; S-Z, Sudano-Zambezian; IR-TR, Irano-Turanian; ER-SR, Euro-Siberian; ME, Mediterranean*

The CCA biplot (*Figures 6, 7, and 8*) reveals the influence of various environmental consequences (physio-chemical) on the distribution of plant species and studied sites at the Abalworood area, Al-Qassim region. The Eigen values of the used axes were 0.717 and 0.465 that are significantly correlated. Important environmental parameters, either physical or chemical characterized by longer arrows. Depending on the length of the vector (ter Braak, 1986), it was concluded that the forms of vegetation abundance in the Abalworood area were influenced positively by changes in 7 factors out of 16 environmental factors tested. Species at the boundaries of the main axes were generally not correlated with any of the tested parameters. In *Figure 6*, it can be noted that the effect of organic carbon and organic matter increases the number of species and is increased. Cluster analysis based on Euclidean distances was also generated to assess the linkage between studied sites, as presented in *Figure 8*. Using CCA multivariate analysis effect of 6 environmental factors is distinguished upon vegetation. The CCA ordination revealed that Silt, WHC, OM, OC, and Clay influenced the separation of Vegetation Group III along the axis, while VG II was substantially linked with sand%.

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Table 2. *Edaphic parameters including Physio-chemical analyses of eighteen studied sites. Differences between sites were assessed by one-way ANOVA*

Site	Edaphic parameters															
	Soil texture			WHC %	Porosity %	OM %	OC %	EC	pH	Cl^-	HCO_3^-	SO_4^{2-}	Na^+	Mg^{2+}	K^+	Ca^{2+}
	Sand %	Silt %	Clay %													
1	81.84	8.43	9.73	25.9	25.7	4.3	2.5	0.23	7.99	16.0	22.0	9.0	1.7	2.5	7.5	10.8
2	75.84	8.36	15.80	25.6	25.0	5.9	3.5	0.16	8.10	14.0	19.0	7.0	4.5	1.8	7.0	7.6
3	69.84	12.58	17.58	27.1	24.6	12.3	7.1	0.21	7.97	18.0	24.0	12.0	2.0	3.3	8.4	11.1
4	61.84	16.58	21.58	32.7	28.6	12.3	7.2	0.17	8.06	15.0	22.0	10.0	7.4	2.2	6.8	7.5
5	77.48	6.72	15.80	25.2	26.1	6.0	3.5	0.13	8.07	10.0	14.0	7.0	1.5	2.2	6.4	6.1
6	71.48	6.72	21.80	27.3	27.9	6.0	3.5	0.15	8.01	12.0	15.0	8.0	1.7	2.0	7.0	7.3
7	65.84	11.82	22.34	25.7	26.8	8.3	4.8	0.16	8.04	13.0	16.0	9.0	3.0	2.3	6.5	7.4
8	81.84	4.22	13.94	22.7	25.7	3.8	2.2	0.11	8.05	10.0	12.0	6.0	2.3	1.7	4.2	5.1
9	85.62	4.36	10.02	19.1	25.4	2.0	1.1	0.13	7.94	14.0	20.0	7.0	0.8	4.1	7.7	6.4
10	55.19	16.72	28.09	28.7	26.1	13.5	7.8	0.59	7.72	55.0	60.0	22.0	9.0	7.9	14.4	32.7
11	50.48	20.58	28.94	33.0	28.6	16.2	9.4	0.21	7.99	20.0	28.0	12.0	12.9	2.5	7.3	8.9
12	72.98	9.86	17.16	23.9	27.2	6.0	3.5	0.15	8.03	18.0	20.0	8.0	9.1	2.3	6.6	6.2
13	85.84	4.72	9.44	19.6	26.5	1.9	1.1	0.11	8.04	16.0	22.0	10.0	4.5	5.2	7.3	5.1
14	87.55	2.86	9.58	14.6	22.7	1.3	0.8	0.14	7.97	20.0	26.0	15.0	4.8	6.0	11.1	4.9
15	87.70	2.79	9.51	20.0	24.2	1.2	0.7	0.10	7.98	12.0	18.0	10.0	5.1	3.0	5.7	5.1
16	81.98	3.58	14.44	23.4	27.2	2.6	1.5	0.12	7.95	14.0	12.0	8.0	1.0	2.0	4.8	5.9
17	80.20	6.36	13.44	21.3	25.4	2.9	1.7	0.12	7.98	16.0	23.0	11.0	1.3	2.6	7.0	7.0
18	74.42	8.14	17.44	23.1	26.1	5.3	3.1	0.13	7.99	15.0	21.0	9.0	1.7	2.1	5.5	7.4
Min	50.48	2.79	9.44	14.6	22.7	1.2	0.7	0.10	7.72	10.00	12.00	6.00	0.8	1.7	4.2	4.9
Max	87.70	20.58	28.94	33.0	28.6	16.2	9.4	0.59	8.10	55.00	60.00	22.00	12.9	7.9	14.4	32.7
Mean	74.9	8.6	16.5	24.4	26.1	6.2	3.6	0.17	8.0	17.1	21.9	10.0	4.1	3.1	7.3	8.5
SD	10.9	5.2	6.1	4.6	1.5	4.5	2.6	0.11	0.1	9.9	10.5	3.7	3.4	1.7	2.3	6.3
ANOVA	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*

* significant at p<0.05

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DOI: http://dx.doi.org/10.15666/aeer/2105_47034719

Table 3. *Simple linear correlation between Edaphic factors and species richness and diversity indices at the studied sites*

Species	site	Edaphic factor															
		sand	silt	clay	WHC	porosity	OM	OC	EC	pH	Cl	HCO3	SO4	Na	Mg	K	Ca
Acacia gerrardii Benth.	0.52***	0.52***	-0.56***	-0.50***	-.465**	-.097	-.555**	-.555**	-.718**	-.012	-.339*	-.366**	-.208	-.479**	-.252	-.597**	-.452**
Aizoon canariense L.	.184	.319*	-.187	-.312*	-.438**	-.247	-.333*	-.333*	.024	-.308*	.276*	.174	-.094	-.111	.276*	.242	-.153
Althaea ludwigii L.	-.270*	-.110	-.068	.198	.214	.250	.174	.174	-.045	.296*	-.476**	-.408**	-.337*	-.302*	-.278*	-.091	-.094
Anagallis arvensis L.	-.164	-.593**	.564**	.571**	.532**	.560**	.564**	.564**	.393**	.265	.094	.174	.242	.424**	-.116	-.027	.307*
Anisosciadium isosciadium Bornm.	-.008	.146	-.185	-.054	-.006	.003	-.146	-.146	-.084	.040	-.171	-.369**	-.337*	-.189	-.474**	-.285*	-.017
Anthemis deserti (Boiss.)Eig.	-.164	-.593**	.564**	.571**	.532**	.560**	.564**	.564**	.393**	.265	.094	.174	.242	.424**	-.116	-.027	.307*
Artemisia sieberi L.	-.334*	-.270*	.141	.310*	.342*	.025	.302*	.302*	.230	-.107	-.055	-.021	.068	-.174	-.053	.263	.259
Asphodelus tenuifolius Cav.	.266	.413**	-.264	-.500**	-.401**	-.254	-.408**	-.408**	-.264	.094	.069	.099	.055	-.213	.206	-.073	-.256
Astragalus asterias Hohen	.338*	.543**	-.543**	-.475**	-.482**	-.548**	-.542**	-.542**	-.292*	-.277*	.059	.121	.353**	.270*	.382**	.093	-.514**
Astragalus dactylocarpus Boiss.	.257	.398**	-.398**	-.351**	-.257	-.352**	-.397**	-.397**	-.399**	-.141	-.282*	-.164	.118	.210	.164	-.257	-.304*
Brassica tournefortii Gouan	-.536**	.039	.099	-.124	.020	-.029	.029	.029	.140	.435**	-.216	-.240	-.622**	-.039	-.288*	-.072	.062
Calendula tripterocarpa Rupr.	.162	.667**	-.595**	-.665**	-.694**	-.385**	-.640**	-.640**	-.443**	-.027	-.127	-.146	-.400**	-.446**	.094	.030	-.526**
Convolvulus fatmensis G.Kunze	.189	-.123	.055	.083	-.081	-.031	.019	.019	-.084	.021	-.055	.017	.147	-.217	.042	-.094	.030
Cynodon dactylon (L.) Pers.	-.446**	-.408**	.311*	.383**	.491**	.183	.440**	.440**	.335*	.049	-.013	.081	.155	-.008	-.103	.211	.342*
Dipcadi Erythraeum Webb & Berth.	.051	-.089	.135	.089	.135	-.006	.119	.119	.139	-.451**	.373**	.254	.380**	-.018	.344*	.295*	.227
Diplotaxis acris (Forssk.)Boiss.	.351**	.070	-.117	-.164	-.210	-.188	-.164	-.164	-.235	-.141	.118	.211	.212	-.304*	.117	.023	-.023
Diplotaxis harra (Forssk.) Boiss.	.023	-.351**	.351**	.351**	.304*	.023	.351**	.351**	.399**	-.399**	.400**	.399**	.401**	.304*	.397**	.397**	.397**
Emex spinosa (L.)Campd.	-.011	.068	-.018	-.046	-.011	.064	-.042	-.042	-.102	-.069	-.057	-.089	-.196	.288*	.077	.020	.011
Filago desertorum Pomel	.331*	-.042	.045	-.059	-.163	.051	-.023	-.023	-.125	-.007	.262	.109	.019	.060	.062	-.074	-.106
Frankenia pulverulenta L.	.023	-.351**	.351**	.351**	.304*	.023	.351**	.351**	.399**	-.399**	.400**	.399**	.401**	.304*	.397**	.397**	.397**
Gastrocotyle hispida (Forssk.) Bunge	.164	.304*	-.164	-.398**	-.304*	.117	-.304*	-.304*	-.329*	.188	.118	.117	.118	.070	.304*	.117	-.257
Haloxylon salicornicum (Moq.) Bunge ex Boiss.	-.309*	-.454**	.551**	.360**	.333*	.294*	.488**	.488**	.424**	.084	.319*	.383**	.235	.393**	.302*	.340*	.288*
Heliotropium crispum Desf.	-.403**	.002	.012	0.000	.066	-.159	.070	.070	.007	.544**	-.370**	-.315*	-.446**	-.117	-.331*	-.178	.019
Hyoscyamus muticus L.	-.134	-.069	-.053	.119	-.045	.041	.055	.055	-.156	.327*	-.435**	-.433**	-.324*	-.002	-.353**	-.418**	-.221
Lepidium aucheri Boiss.	-.260	-.795**	.718**	.801**	.808**	.542**	.774**	.774**	.702**	-.185	.304*	.243	.290*	.234	-.048	.288*	.701**
Malva parviflora L.	.260	.170	-.121	-.161	.009	-.162	-.193	-.193	.027	-.312*	.163	.110	.210	.131	-.024	-.115	.055
Matricaria aurea (Loefl.)Sch.Bip.	-.176	-.583**	.551**	.564**	.513**	.546**	.551**	.551**	.383**	.279*	.058	.135	.221	.399**	-.122	-.049	.294*
Melilotus officinalis (L.) Desr.	-.339*	-.414**	.410**	.438**	.356**	.199	.447**	.447**	.458**	-.141	.161	.045	-.034	.185	-.022	.168	.268
Neurada procumbens L.	.342*	.546**	-.546**	-.478**	-.471**	-.545**	-.546**	-.546**	-.323*	-.269*	.010	.083	.334*	.274*	.367**	.043	-.506**
Peganum harmala L.	.316*	.291*	-.391**	-.159	-.407**	-.048	-.333*	-.333*	-.419**	-.243	-.322*	-.380**	-.490**	-.492**	-.300*	-.375**	-.254
Picris cyanocarpa Boiss.	.410**	.435**	-.507**	-.295*	-.231	-.062	-.435**	-.435**	-.455**	-.331*	-.284*	-.401**	-.046	-.125	-.121	-.446**	-.370**
Plantago albicans L.	.210	.351**	-.351**	-.304*	-.397**	-.399**	-.351**	-.351**	-.023	-.235	.329*	.305*	.354**	.164	.351**	.351**	-.397**
Plantago boissieri Husskn. & Bornm.	.542**	.006	-.074	-.045	-.242	-.128	-.142	-.142	-.261	-.124	.090	.178	.147	-.314*	-.055	-.191	.062
Plantago major L.	.265	.081	-.002	-.180	-.125	-.164	-.164	-.164	-.040	-.123	.144	.221	.117	-.392**	-.011	-.056	.221
Plantago ovata Forssk.	-.210	.023	-.047	0.000	.023	.023	.070	.070	-.117	.352**	-.377**	-.305*	-.307*	-.257	-.117	-.210	-.164
Plantago psammophila Agnew & Chalibi-Ka,bi.	.304*	.210	-.304*	-.070	-.070	.235	-.210	-.210	-.235	-.305*	-.118	-.375**	-.165	-.351**	-.304*	-.351**	-.210
Pulicaria undulata (Forssk.) C.A.Mey.	-.284*	-.431**	.316*	.466**	.469**	.033	.459**	.459**	.421**	-.312*	.170	.199	.279*	.011	.170	.450**	.446**
Savignya parviflora (Delile)Web.	.683**	.383**	-.412**	-.380**	-.537**	-.420**	-.477**	-.477**	-.423**	-.248	.150	.162	.294*	.127	.239	-.150	-.393**
Schimperenniala arabica Hochst. & Steud. Ex Endl	-.397**	.140	.117	-.257	.164	-.094	-.070	-.070	.352**	-.023	.118	.117	-.024	-.210	.070	.210	.304*
Scorzonera schweinfurthii Boiss.	.210	.351**	-.351**	-.304*	-.397**	-.399**	-.351**	-.351**	-.023	-.235	.329*	.305*	.354**	.164	.351**	.351**	-.397**
Sinapis arvensis L.	-.070	.140	-.257	-.117	-.164	-.094	-.117	-.117	-.329*	.258	-.377**	-.375**	-.401**	-.023	-.397**	-.397**	-.351**
Suaeda vera Forssk. ex J.F. Gmel	-.506**	-.065	.278*	-.051	.274*	-.299*	.149	.149	.458**	-.196	.262	.279*	.201	-.198	.210	.378**	.478**
Trigonella hamosa L.	-.288*	-.361**	.312*	.304*	.344*	.391**	.389**	.389**	.153	.627**	-.049	.049	.005	.362**	-.187	.007	.094
Tripleurospermum auriculatum (Boiss.) Rech.f.	.418**	.155	-.095	-.183	-.299*	.099	-.227	-.227	-.316*	.111	.081	.099	.063	-.042	.047	-.153	-.087
Zilla spinosa (L.)Prantl.	-.182	-.073	.215	-.015	.126	.128	.076	.076	.229	.270*	.199	.059	-.160	.210	-.067	.151	.255

NS, non-significant correlation at $p>0.05$; *, significant correlation at $p<0.05$; *** highly significant at $p<0.001$ revealed by two tailed significance test

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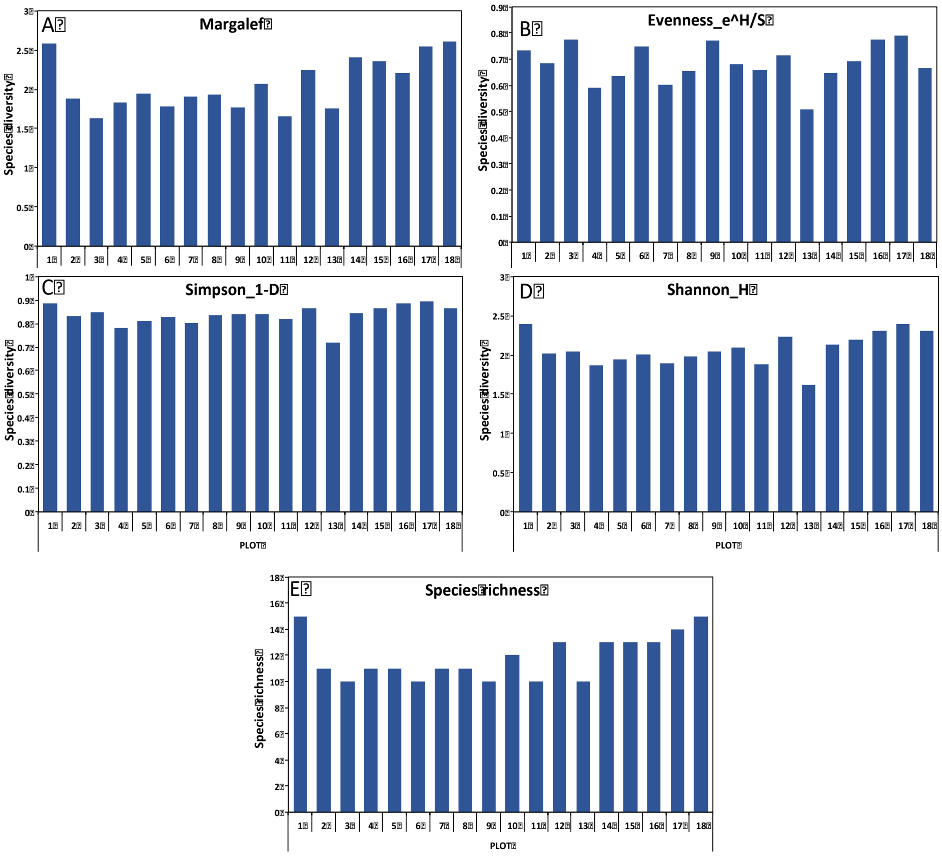

Figure 5. *Species diversity, richness, and evenness indices of the study area*

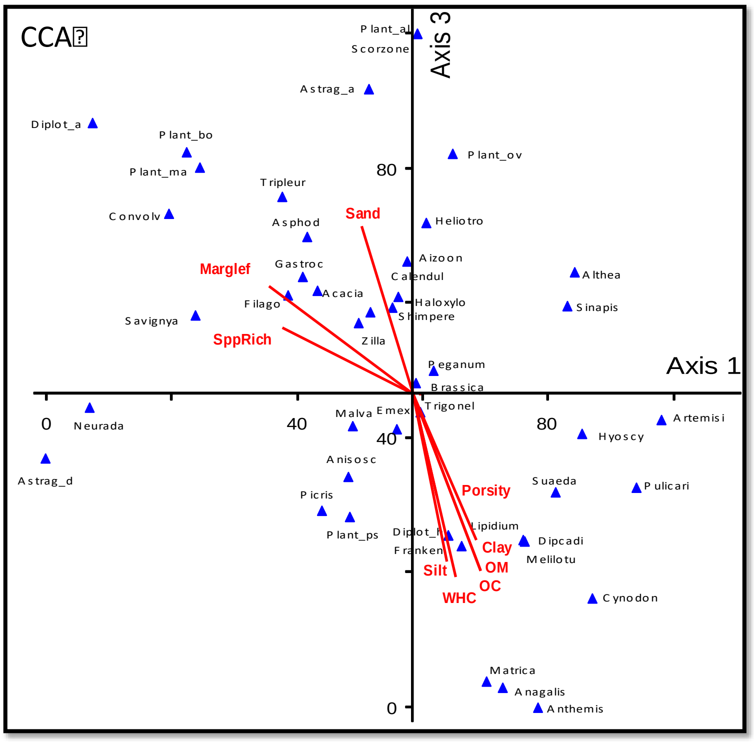

Figure 6. *CCA ordination for the physicochemical parameters and species*

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Table 4. *Simple linear correlation between Edaphic factors and species richness and diversity indices at the studied sites.*

Indices	site	Edaphic factor															
		Sand	**Silt**	**Clay**	**WHC**	**Porosity**	**OM**	**OC**	**EC**	**pH**	**Cl**	**HCO3**	**SO4**	**Na**	**Mg**	**K**	**Ca**
Species richness	0.41***	0.27ns	-0.21ns	-0.28*	-0.25ns	-0.24ns	-0.32*	-0.32*	-0.1193	-0.19ns	0.13ns	0.03ns	0.10ns	-0.08ns	0.04ns	-0.28*	-0.10ns
Dominance (D)	-0.42***	-0.35***	0.32*	0.33*	0.31*	.433**	0.39***	.392**	0.1639	0.60***	-0.18ns	-0.05ns	-0.10ns	0.33*	-0.09ns	0.07ns	-0.04ns
Margalef's diversity index	0.44***	0.34*	-0.32*	-0.34*	0.34*	-.276*	-0.39***	-.395**	-0.2105	-0.17ns	0.03ns	-0.05ns	0.03ns	-0.14ns	-0.03ns	-0.28*	-0.21ns
Simpson diversity index	0.42***	0.35***	-0.32*	-0.33*	-0.31*	-.433**	-0.39***	-.392**	-0.1639	-0.60***	0.18ns	0.05ns	0.10ns	-.326*	-0.09ns	-0.07ns	-0.04ns
Shannon-Weiner index	0.39***	0.316*	-0.28*	-0.30*	-0.29*	-.404**	-0.36***	-.360**	-0.0892	-0.56***	0.21ns	0.07ns	0.09ns	-0.33*	0.10ns	-0.02ns	0.003ns
Evenness	0.08 ns	0.10 ns	-0.13ns	-0.07ns	-0.04ns	-.278*	-0.12ns	-0.1166	0.0197	-0.57***	0.08ns	-0.01ns	-0.05ns	-0.47***	0.03ns	0.15ns	0.20ns
Fisher alpha diversity index	0.47***	0.34*	-0.33*	-0.33*	-0.3***	-.280*	-0.40***	-.399**	-0.2364	-0.18	0.03ns	-0.04ns	0.04ns	-0.14ns	-0.02ns	-0.29*	-0.23ns

NS, non-significant correlation at p>0.05, *, significant correlation at p<0.05; *** highly significant at p<0.001 revealed by two tailed significance test

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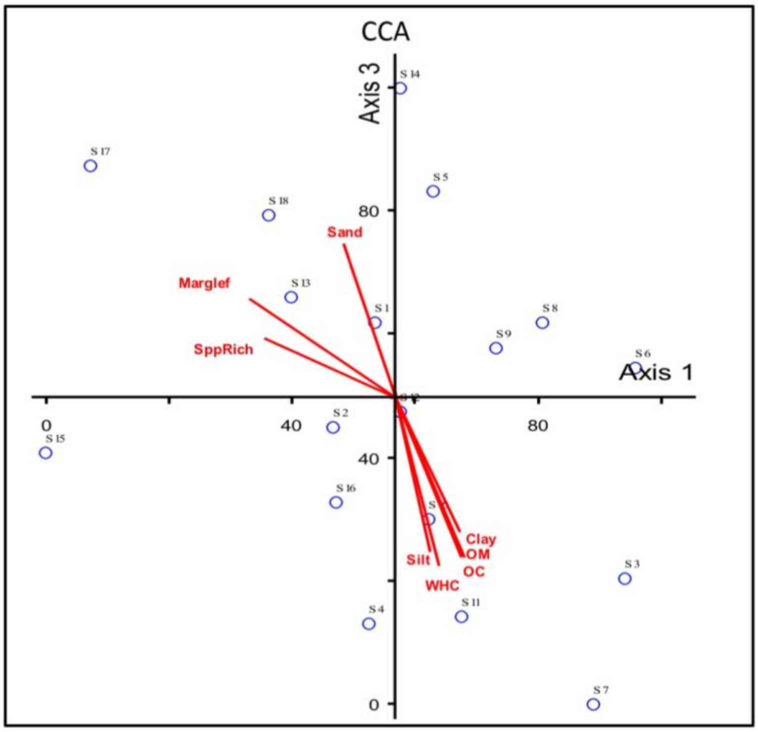

***Figure 7.** CCA ordination for the physicochemical parameters and species*

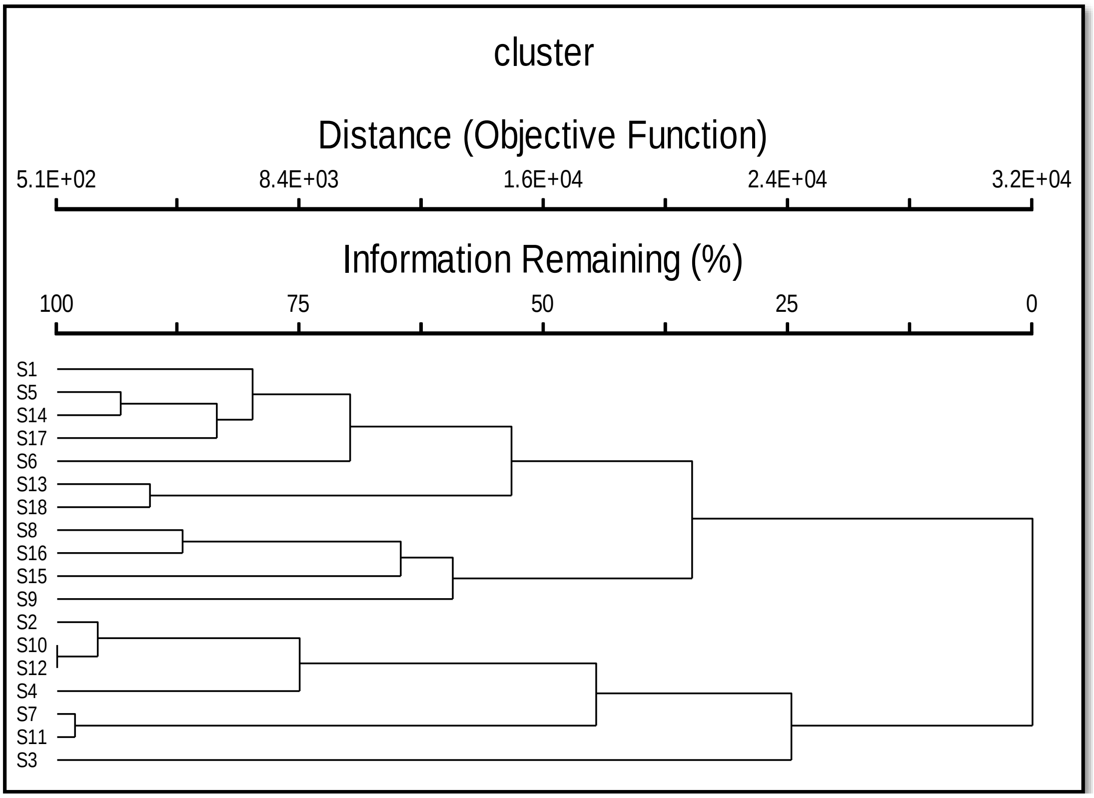

***Figure 8.** Dendrogram cluster analysis for the relationship between studied sites*

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DOI: http://dx.doi.org/10.15666/aeer/2105_47034719

Discussion

The current research survey emphasizes the explanation of flora in Rawdhat Abalworood, Al-Asyah, and Al-Qassim region. An overall of 44 plant species were recorded, attributed to 19 families and 39 genera. The most frequent plant families with the highest number of species were Asteraceae, Brassicaceae, Fabaceae, and Plantaginaceae. Those conclusions were in agreement with El-Ghanim et al. (2010), who stated that Brassicaceae and Asteraceae, who stated that Asteraceae and Brassicaceae were the most frequent families. Also, in conformity with Osman et al. (2014), Osman and Abdein (2019) stated that Asteraceae, Fabaceae or Brassicaceae were most represented families in other areas Saudi Arabia. In addition, those consequences were fundamentally in accordance with many investigations achieved in various habitats in Saudi Arabia (Farrag, 2012; Abdel Khalik et al., 2017; Osman and Abdein, 2019). Furthermore, El Ghazali et al. (2013) indicated that the most common families in their studies were Poaceae, Asteraceae, and Brassicaceae. The families Poaceae, Fabaceae, and Asteraceae constitute the majority of Saudi Arabia's Flora (Collenette, 1999; AlNafie, 2008). Only two species represented three plant families in the current study. Furthermore, in the current study, 12 families were represented by only one species. One of the most prominent features of the Saudi Arabian flora's plant composition is that many families were characterized by 1-2 plant species, and few families were of botanical importance, as in most subtropical and tropical deserts (Alsherif et al., 2013). This could be because just a few plants can withstand the harsh conditions found in these areas. Other plants, on the other hand, could not survive in these harsh conditions.

Regarding the life span, the majority of recorded plant species in the current research were recorded as annuals, with 28 species comprising about 63.64% of the total recorded species. These consequences were in agreement with Osman and Abdein (2019), Shaltout et al. (1996), and Al-Rowaily et al. (2012), who stated that annuals are the principal constituents of Saudi Arabia vegetation.

The distribution of plants' life form that grows in dry arid regions is extensively related to topographic and landform factors (Orshan, 1986; Shaltout et al., 2010). In our research, Therophytes was the most prevalent and dominant form of life (65.91%). This could be due to a variety of environmental factors, including dry hot climates, animal interference, and human impacts. These results were consistent with numerous investigations conducted in diverse Saudi Arabian arid habitats (El-Demerdash et al., 1995; Chaudhary, 2001, 1999; Collenette, 1999; Al-Turki, 2008; El-Ghanim et al., 2010; Farrag, 2012; Alatar et al., 2012; Alsherif et al., 2013; Osman et al., 2014; Abdel Khalik et al., 2017; Osman and Abdein, 2019). Therophytes were the dominant life form in an arid desert region because of the dry climate, and overgrazing (Cain, 1950). Moreover, the high percentage of Therophytes life forms was also credited to the impact of human activities (Barbero et al., 1990).

Phytogeographically, the surveyed plant species were recognized into three categories; mono regional, bi regional and Pluri regional. The three chronological categories were represented by an overall of 14, 22, and 8 species forming a percentage of 31.81%, 50.0%, and 18.18%, respectively. Furthermore, the Saharo-Sindian region exhibited the greatest number of mono regional species, totaling 9 and accounting for 20.45% of the total. However, it is noteworthy that the region with the highest bi regional diversity was the Irano-Turanian-Saharo-Sindian region, which was comprised of 8 species, accounting for 18.18% of the total. The Pluri regional phytochorion with the highest count was the Mediterranean-Irano-Turanian-Saharo-Sindian region, which comprised of 4 species,

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DOI: http://dx.doi.org/10.15666/aeer/2105_47034719

accounting for 9.09% of the total. The aforementioned results were consistent with the research conducted by Osman et al. (2014) and Osman and Abdein (2019). According to Abd El-Ghani and Amer (2003) as well as Danin and Plitman (1987), it has been observed that the Sudano-Zambezian and Saharo-Arabian phytochoria exhibit a decrease towards the northern regions and are replaced by the Irano-Turanian and Mediterranean phytochoria. The aforementioned phenomenon could be attributed to various factors, such as the utilization of Sudano-Zambezian and Saharo-Arabian flora as reliable indicators of arid environments.

Conclusion

The structure of the vegetation and the distribution of species at 18 sample plots in Rawdhat Abalworood, Al-Asyah, Al-Qassim Region, Saudi Arabia, emphasizing the ecological factors that influence the distribution of species. The study uncovered 44 plant species from 19 families. The dominating groups were Asteraceae and Brassicaceae, and the dominant life forms were therophytes and chamaephytes, demonstrating a typical desert life-form range. Therophytes and Chamaephytes were the most common life form classes noticed in Rawdhat Abalworood, Al-Asyah, and Al-Qassim. The plant species have been classified into three categories: mono regional (31.81%), bir egional (50.0%), and Pluri regional (18.18%). The Mediterranean-Irano-Turanian-Saharo-Sindian region had the largest Pluri regional phytochorion, with 4 species (9.09%). Two of the eighteen studied sites had the maximum species richness value of 15 species per plot. Five of the 18 sites studied had the lowest species richness assessing of 10 species per plot. Species diversity was measured using Margalef's diversity index, which varied from 1.6 to 2.6 with an average of 2.10.3. The Shannon-Weiner diversity index indicated similar diversity levels to Margalef's, ranging from 1.6 to 2.4 with an average of 2.1. The effect of six environmental factors on vegetation is identified using CCA multivariate analysis. The CCA ordination revealed that Silt, WHC, OM, OC, and Clay influenced the separation of Vegetation Group III along the axis, while VG II was substantially linked with sand%.

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http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
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