Floristic Compositions and its Affinities to Phytogeographical Regions in Wadi Khulab of Jazan, Saudi Arabia

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ABSTRACT

Wadi Khluab is considered one of the most important wadis in Jizan, south-western Saudi Arabia. Thus the current work provides an analysis of the floristic composition, life form and chorology of plant life of the wadi, a total of 119 species related to 93 genera represented 44 vascular plant families were documented. Six families (Aizoaceae, Euphorbiaceae, Papilionaceae, Poaceae, Amaranthaceae and Asclepiadaceae) provided nearly half of the total number of species reported. Therophytes and chamaephytes are the most frequent life forms which may indicating a typical desert spectrum vegetation. The floristic composition of the different geomorphologic landscape units offered differences in species richness in the different sectors of the wadi, and the phytocoria. Monoregional and biregional areas contained 45 species (41%), while biregional species were 39 species (36%) respectively, while only two species (2%) were recorded in the pleuriregion. It is thus concluded that the region should be considered a hot-spot in the Kingdom in terms of floral diversity.

Key words: Floristic composition, Life forms, Chorology, Wadi Khluab

1. INTRODUCTION

Saudi Arabia is a huge arid desert with an area of about 2,250,000 km² that covers the majority of the Arabian Peninsula (Abdel Khalik et al., 2013). It is approximately located between latitude 15°45' and 34°35'N and longitude 34°40' and 55°45'E. Flora of Saudi Arabia is considered to be the richest in the Arabian Peninsula. Jazan province is situated in the south-western part of Saudi Arabia, their foothills are characterized by rocky slopes, cliffs and crevices with granite, sandy soil whereas the hilly areas are generally formed of rocky cliffs, rocky ridges, granite boulders, granite outcrops, granite sandstones and crevices (Marei, et al., 2014). Al-Sherif (1984) divided the Jazan region geomorphologically into three main landscapes: Mountains (El-Sarwat Mountains), Plains (Tihamah coastal plains) and islands including those between Jazan city and Farsan Islands. Distribution of the life form is closely related to topography and landform (Fakhireh et al., 2012). In several wadis, the composition of life forms expresses a typical desert flora, with the majority of species are therophytes and chamaephytes, The vegetation of wadis is not constant it varies from year to year, depending upon the moisture level (Siddiqui and Al-Harbi, 1995). Plant life growth and distribution in the wadis are controlled by many factors such as geographical position, physiographic features, and human impact (Shaltout and El-Sheikh, 2003; Kurschner and Neef, 2011; Alataret et al., 2012; Korkmaz and Ozcelik, 2013). Several studies on the floristic diversity and vegetation analysis in Tihamah plains of Saudi Arabia were performed (Al-Hubaishi and Hohenstein 1984; El-Demerdash et al., 1994; Al-Farhan et al., 2005; Masrahi, 2012; Marei, et al., 2014). Aim of the work was thus to survey and identification of the wild plants growing in
WadiKhulab and to study the vegetation types in the Wadi in terms of floristic composition, life-form and chorotype.

**Study area**

WadiKhulab is located in the southwestern part of Saudi Arabia, between the Al-Khobh in the east and the Ahad Al Masarih in the west. It lies between 16°46'0"N latitude and 43°16'0"E longitude (Figure 1). The study area, approximately 40-50 Km² long lies 70 meters above sea level. It is considered to be favorable for plant growth due to stagnant water after rainfall. According to Walter et al. (1975), the study area lies within the subtropical dry zone, and has very hot summers and mild winters. The average annual temperature is 31.3°C; January and February are the coldest months with the lowest average temperature (26°C), while the hottest months is August with the highest average temperature (40°C). The maximum precipitation (15.0 mm) falls during August, while the minimum of about 5.0 mm falls during June (Fig. 2, Table 1).

**2. MATERIALS AND METHODS**

The study area (Fig. 1) was conducted from April 2016 to February 2017, a species were recorded according to the classification of Cornquist (1981). Life forms were determined following Raunkiaer (1934). Phytogeographical analysis was carried out according to Wickens (1978) and Zohary (1973). The collected plant specimens were identified and named according to Migahid (1996), Chaudhary (2001), Al-Farhan et al. (2005) and Masrahi (2012), and deposited in Jazan University Herbarium, KSA (JAZUH).

![Fig. 1: A. Location map of Saudi Arabia showing the Southwestern border region. B. Location map of Jazan in which the study area (Map downloaded from http://google-aps.pro/satellite/Samitah.Saudi_Arabia)](image-url)
### 3. RESULTS and DISCUSSION

#### 3.1. Floristic Composition

A total of 119 taxa belonging to 93 genera and 44 families of phanerogams, were recorded in the 28 different surveyed sectors of Wadi Khluab. Their generic representations are quite variable. In terms of species richness, the Poaceae (Gramineae) was the most abundant family comprising 20% of the total taxa (Figure 3 and Table 2), with 24 species related to 19 genera (Table 2) due to water availability, including annual precipitation and soil properties. These floristic findings were in accordance with those of Parker (1991) and Soulé et al. (2016). The families of Aizoaceae, Euphorbiaceae and Papilionaceae are represented by six taxa, although the variation in the number of their genera (Table 4). As well, the two families of Amaranthaceae and Asclepiadaceae are similar in representing five species of four genera. family has four species representing 3 genera.Cyperaceae, Malvaceae, Convolvulaceae, and Caesalpinioideae families contained four species each representing 1, 3, 4 and 4 genera respectively. Furthermore, three species exhibited in five families (Aracaceae, Cucurbitaceae, Solanaceae, Tiliaceae and Zygophyllaceae). Likewise, the restricted families of Acanthaceae, Nyctaginaceae, Lamiaceae, Aracaceae, Heliotropiaceae and Primulaceae having only two species related to two genera. Also, the remainder families (26
families) were represented by a single species (Figure 3). These results were similar to Marei, et al., 2014 studies on Tihama hill slopes of Jazan region.

Table 2. Plant species recorded with their families, life forms and chorotypes.

| Family            | Taxa                                         | Life form* | Life Span | Chorotype |
|-------------------|----------------------------------------------|------------|-----------|-----------|
| Acanthaceae       | Anisotestriculus (Forssk.) Nees              | Ph         | Per       | SA + TR   |
|                   | Blepharisciliaris (L.) B.L. Burtt. Ch        | Ch         | Ann       | SA +SZ    |
| Amaranthaceae     | Amaranthushybridus L.                        | Th         | Ann       | PAL       |
|                   | Amaranthusgraecizans L.                      | Th         | Ann       | PAL       |
|                   | Aervajavanica (Burn. F.) Juss               | Ch         | Per       | SA + SZ   |
|                   | Achyranthesasaspica L.                      | Ch         | Ann       | Me + IT   |
|                   | Digeramuricata (L.) Mast.                    | Th         | Ann       | TR        |
| Anacardiaceae     | Mangiferaindica                              | Ph         | Per       | Cult      |
| Lamiaceae         | Ocimumbasilicum L.                          | Ch         | Per       | SZ        |
|                   | Ocimumforsskallii Benth                     | Ch         | Per       | SZ        |
| Aracaceae         | Hyphaenethebaica (L.) Mart                   | Ph         | Per       | SA +SZ    |
|                   | Phoenix dactylifera L.                      | Ph         | Per       | SA + SZ   |
| Astraceae         | Launaeamucronata (Forssk.) Muschl.          | Th         | Ann       | SA        |
|                   | Plucheadioscoridis (L.) DC.                  | Ch         | Per       | SA + SZ   |
|                   | Pulicariaundulata (L.) C.A. May             | He         | Per       | SA +SZ    |
| Asphodelaceae     | Asphodelustenufolius Cav                    | Cr         | Ann       | SA + SZ   |
| Asclepiadaceae    | Calotropisprocera (Ait.) R. Br.             | Ph         | Per       | SA + SZ   |
|                   | Ceropegiavariegata Decne                    | Ch         | Per       | SA + SZ   |
|                   | Pentatropisnivalis (Gmel.) Field & Wood     | Ch         | Per       | SA +SZ    |
|                   | Leptadeniapyrotechnica (Forssk.) Decne      | Ph         | Per       | SA + SZ   |
|                   | Leptadeniaarborea (Forssk.) Schweinf        | Ch         | Per       | SA + SZ   |
| Aizoaceae         | Glinuslotoides L.                           | Th         | Ann       | PAL       |
|                   | Mollugonudicaulis Lam.                      | Th         | Ann       | TR        |
|                   | Trianthemashei A.G. Miller                  | Th         | Ann       | SA        |
|                   | Trianthema portulacastrum L.                | Th         | Ann       | SA        |
|                   | Sesuvium sesuviodus (Fenzl) Verdc           | Ch         | Ann       | TR        |
|                   | Zaleyapentandra (L.) Jeffrey                | Th         | Ann       | SZ        |
| Chenopodiaceae    | Suaedamonoica Forssk. ex J. Gmel            | Ch         | Per       | SA + SZ   |
| Cappariaceae      | Dipterygium laugulum Decne                  | Ch         | Per       | SZ        |
| Cactaceae         | Opuntiadiellenii (Ker-Gawl.) Haw.           | Ch         | Per       | PAN       |
| Celastraceae      | Catha edulis (Vahl) Forssk                   | Ch         | Ann       | Cult      |
| Cleomaceae        | Cleome gynandra L.                          | Ch         | Ann       | SA + SZ   |
| Cyperaceae        | Cyperus conglomeratus Rotb.                 | Th         | Per       | SA        |
|                   | Cyperusalopecuroides Rotb. Descr            | Cr         | Per       | PAN       |
|                   | Cyperuslaevigatus L.                        | Cr         | Per       | PAN       |
|                   | Cyperusalternifolius L.                     | Cr         | Per       | SA        |
| Convolvulaceae    | Convolvulus prostratus Forssk.              | Th         | Per       | SA +SZ    |
|                   | Ipomoea sinensis (Desr.) Choisy in Mem      | Th         | Ann       | SA + SZ   |
|                   | Ipomoea hochstetteri House                  | Th         | Ann       | SA + SZ   |
|                   | Sedderavigata Hochst. & Steud. ex Hochst.   | Ch         | Per       | SZ        |
| Caesalpinaceae    | Chamaeristanicigricans (Vahl) Greene        | Ph         | Ann       | SA + SZ   |
|                   | Prosopis juliflora (Sw.) DC.                | Ph         | Per       | SA        |
|                   | Sennaitalica Mill                           | Ch         | Per       | SA + SZ   |
| Family          | Genus                        | Author          | Distribution |
|-----------------|------------------------------|-----------------|--------------|
| Cucurbitaceae   | Senna alexandrina           | Mill.           | Ch           |
|                 | Cucumis prophetarum         | L. He           | Ann          |
|                 | Cucumis melo                | L. He           | Ann          |
|                 | Zehneria anomala            | C. Jeffrey      | Ch           |
| Euphorbiaceae   | Acalypha fruticosa          | Forssk.         | Th           |
|                 | Acalypha indica             | L. Th           | Ann          |
|                 | Croton bonplandianus        | L. Th           | Ann          |
|                 | Euphorbia granulata         | Forssk.         | Th           |
|                 | Euphorbia hirta             | L. Th           | Ann          |
|                 | Ricinus communis            | L. Ph           | Per          |
| Heliotropiaceae | Heliotropium pterocarpum    | (DC.) Steud.    | Ch           |
|                 | Heliotropium longiflorum    | Steud. & Hochst.| Ch           |
| Malvaceae       | Abutilon pannosum           | (G. Forst.) Schlech. | Ch |
|                 | Abutilon hirtum             | (Lamk.) Sw      | Ch           |
|                 | Malvavarpflora              | L. Th           | Ann          |
|                 | Senraicana Cav.             | Ch              | Per          |
| Mimosaceae      | Acacia ehrenbergiana        | Hayne           | Ph           |
|                 | Acacia tortilis             | (Forssk.) Hayne | Ph           |
| Menispermae     | Coccusus pendulatus         | (J.R. & G. Forst.) Diels | Ph |
| Moraceae        | Ficus populifolia           | Vahl            | Ph           |
| Nyctaginaceae   | Boerhaviadiffusa            | L. Ch           | Ann          |
|                 | Boerhaviarepens            | L. Ch           | Ann          |
| Papilionaceae   | Alysicarpus rugosus         | (Willd.) DC.    | Ch           |
|                 | Indigofera oblongifolia     | L. Th           | Per          |
|                 | Indigoferaspinosa           | Forssk.         | Ch           |
|                 | Indigofera argentea         | Burm.           | Ch           |
| Menispermae     | Tephrosia purpurea          | (L.) Pers.      | Ch           |
|                 | Tephrosia anubica           | (Boiss.) Bak    | Ch           |
| Polygonaceae    | Polygala eriopera           | DC. Ch          | Ann          |
| Poaceae         | Aristidamutabilis           | Trin. & Rupr.   | Th           |
|                 | Cenchrus pennisetiformis    | Hochst. & Steud.| Th |
|                 | Cenchrus ciliaris           | L. Th           | Per          |
|                 | Chloris barbata            | Sw. Th          | Per          |
|                 | Dactyloctenium aegyptium    | (L.) Wild.      | Th           |
|                 | Dactyloctenium scindicum    | Boiss. Th       | Ann          |
|                 | Digitaria ciliaris          | (Retz.) Koel    | Th           |
|                 | Digitariavelutina           | (Forssk.) Beauv.| Th           |
|                 | Desmostachyapsinata         | (L.) Stapf      | Th           |
|                 | Dinebraretroflexa           | (Vahl) Panz     | Th           |
|                 | Eragrostis ciliaris         | (L.) R. Br.     | Th           |
|                 | Eragrostis minor            | Host Th         | Per          |
|                 | Eriochloa fatensis          | (Hochst. & Steud.) He | Per |
| Clayton         | Echinochloa colonolana      | (L.) Link       | Th           |
|                 | Ochchloa compressa          | (Forssk.) Hilu  | Th           |
|                 | Paspalidium desertorum     | (A. Rich.) Stapf.| Th |
|                 | Panicum turgidum           | Forssk. Cr      | Per          |
|                 | Sporobolus helvolus         | (Trin.) Dur. & Schinz | Th |
|                 | Saccharum spontaneum        | L. Th           | Per          |
|                 | Schoenefeldia gracilis     | Kunth Th        | Per          |
3.2. Life Form

Table 3 shows the life form spectra of the recorded species, the highest life form recorded was for the therophytes constituted by 50 species representing 42% of the total species followed by the chamaephytes with 40 species representing 34%. Likewise, 18 species of the phanerophytes estimated represented 15%. Furthermore, six species estimated as cryptophytes (Asphodelustenuifolius, Cyperusalopecuroides, Cyperuslaevigatus, Cyperusalterifolius, PanicumturgidumundTetrapogontenellus) compromised 5%. Also, four taxa of Pulicaria undulate, Cucumisprophetarum, Cucumismelo and Pennisetumsetaceumseen ashemicryptophyte. Also, hydrophytes in this area represented by Typhadomengensis. The five cultivated plants represented by 5 % (Fig. 4). A comparison of families in terms of the largest number of species recorded in this investigation and in similar studies in different regions of Saudi Arabia, such as: Hosni & Hegazi (1996) in the Asir Mountains, Mosallam (2007) in Taif, Al-Turki & Al-Olayan (2003) in Hail region and Alatar et al. (2012) in Al-Jufair Wadi. Therophyteshave the highest contribution followed by chamaephytes indicating the adjustment of the flora to water balance. The predominance of phanerophytes expresses that the flora is tertiary dominated with woody plants (shrub and trees). It also displayed the level of woody flora management by the farmers using of woody species as green fertilizers and assisting natural regeneration. These results coincide with the findings of Al-Turki and Al-Olayan (2003) and Soulé et al. (2016). As well, Danin and Orchan (1990); Abd El
Ghani (1997) and Fahmy and Hassan (2005) reported the domination of therophytes and chaemophytes as vegetation spectra in desert and semi-desert vegetation in other parts of the Middle East. Moreover, the dominance of therophytes, chaemophytes and phanerophytes over other life forms are seen to be a response to the hot dry climate, topographic variation and human and animal interference (Abd El-Ghani and Abd El-Khalik, 2006 and Al-Shammari et al., 2013). Three medicinal plants used by some local people, including *Acacia tortilis*, *Malvaparviflora* and *Solanum glabratum*. Also, many poisonous plants such as *Anagallis arvensis*, *Calotropis procera*, *Datura innoxia*, *Datura stramonium*, *Leptadenia pyrotechnica*, *Solanum nigrum*, *Tribulus terrestris* and *Zygophyllum simplex* were recorded.

![Fig. 3. Floristic composition of the different families in Wadi Khulab.](image)

**Table 3. Systematic composition of the studied flora families in the study area.**

| Family            | Genera | %  | Species | %  | Tree | Habit | Herb |
|-------------------|--------|----|---------|----|------|-------|------|
| Acanthaceae       | 2      | 2  | 2       | 2  |      |       | +    |
| Amaranthaceae     | 4      | 4  | 5       | 4  | +    |       |      |
| Anacardiaceae     | 1      | 1  | 1       | 1  | +    |       |      |
| Aracaceae         | 2      | 2  | 2       | 2  | +    |       |      |
| Astraceae         | 3      | 3  | 3       | 2  |      |       |      |
| Asphodelaceae     | 1      | 1  | 1       | 1  | +    |       |      |
| Asclepideae       | 4      | 4  | 5       | 4  |      |       |      |
| Aizoaceae         | 5      | 5  | 6       | 5  |      |       |      |
| Chenopodiaceae    | 1      | 1  | 1       | 1  |      |       |      |
| Capparidaceae     | 1      | 1  | 1       | 1  |      |       |      |
| Cactaceae         | 1      | 1  | 1       | 1  |      |       |      |
| Clasteraceae      | 1      | 1  | 1       | 1  | +    |       | Sub-shrub |
| Cleomaceae        | 1      | 1  | 1       | 1  |      |       |      |
| Cyperaceae        | 1      | 1  | 4       | 3  |      |       |      |
| Convolvulaceae    | 4      | 4  | 4       | 3  | +    |       |      |
| Caesalpiniaceae   | 4      | 4  | 4       | 3  | Sub-shrub | + |      |
Table 4. Aggregation summary showing the distribution of collected plant species into their growth types and life forms.

| Families           | Genera | Species | Type      | Spp. No. | %   | Life Form* | Species No. | Percentages |
|--------------------|--------|---------|-----------|----------|-----|------------|-------------|-------------|
| 44                 | 93     | 119     | Annual    | 55       | 46  | Ph         | 18          | 15          |
| --                 | --     | --      | Perennial | 64       | 54  | Ch         | 40          | 34          |
| --                 | --     | --      | --        | --       | --  | Cr         | 6           | 5           |
| --                 | --     | --      | --        | --       | --  | Th         | 50          | 42          |
| --                 | --     | --      | --        | --       | --  | Hy         | 1           | 1           |
| --                 | --     | --      | --        | --       | --  | He         | 4           | 3           |
| --                 | --     | --      | Total     | 119      | 100 | Total      | 119         | 100         |

*Ph = phanerophyte, Ch = chamaephyte, Th = therophyte, Cr = cryptopyte and Hy = hydrophyte
Figure 4. Life-form relative spectrum of WadiKhulab vegetation. Ph = phanerophyte, Ch = chamaephyte, Th = therophyte, Cr = cryptopyte and Hy= hydrophyte

Table 5: Phytochoric distribution of studied plant Species

| Phytochorial Type | Species Number | Percentage (%) |
|-------------------|----------------|----------------|
| **Monoregional**  |                |                |
| SA                | 20             | 18.00          |
| TR                | 7              | 6.00           |
| SZ                | 18             | 17.00          |
| Total             | 45             | 41.00          |
| **Biregional**    |                |                |
| SA + SZ           | 29             | 27.00          |
| SA + TR           | 6              | 5.00           |
| ME + IT           | 2              | 2.00           |
| SZ + TR           | 2              | 2.00           |
| Total             | 39             | 36.00          |
| **Pleuriregional**|                |                |
| ME + IT + SA      | 2              | 2.00           |
| Total             | 2              | 2.00           |
| PAN               | 8              | 7.00           |
| PAL               | 6              | 5.00           |
| COSM              | 4              | 4.00           |
| Cult              | 5              | 5.00           |
| **Total**         | **23**         | 25.00          |
Figure 5. Floristic category spectrum of Khulab. TR = Tropical, SA = Saharo-Arabian, SZ = Sudano-Zambezian, ME = Mediterranean, IT = Irano-Turanian, PAN = Pantropical, PAL = Paleotropical, COSM = Cosmopolitan and Cult = Cultivated.

3.3. Chorology

From the phytogeographical point of view, the recorded species in the different sectors of the studied valley may be classified as monoregional, biregional or pluriregional (Table 5). Monoregional area has in total 45 species representing 41%, in which 20, 18 and 7 species are within the Saharo-Arabian, Sudano-Zambezian and tropical regions, respectively. The highest percentage in this area was recorded in Saharo-Arabian (18%). Biregional area included 39 species with 36% in which 29 species were shared by Saharo-Arabian and Sudano-Zambezian regions (27%), six species were shared by Saharo-Arabian and tropical regions, and two species of Achyranthes aspera and Malva parviflora were recorded in the Mediterranean and Irano-Turanian regions and the two species of Anisotestriculus and Boerhavia diffusa were estimated in the Sudano-Zambezian and tropical regions. Pleuriregional (Mediterranean, Irano-Turanian and Saharo-Arabian) area has only 2 species (Tetrapogon villosus and Setaria viridis) representing 2%. Likewise, eight species (8%) were reported within the panatropical area and six species (6%) were recorded in paleotropical area. Cosmopolitan plants comprised 4% of the population are four species, Euphorbia hirta, Portulaca oleracea, Anagallis arvensis and Tribulus terrestris (Figure 5). These results agree with chorological characteristic in other parts of Saudi Arabia (ALSherif, et al., 2013 on Khulais region, Abdel Khalik, et al., 2013 on Wadi Al-Noman and Osman et al., 2014 on WadiArar). The results indicate that Saharo-Arabian elements predominate the studied area (66 species, 55.5%), and were represented as mono-regional (18 species, 15.12%), bi-regional under the influence of Sudano-Zambezian and tropical regions (35 species, 29.41%) and Pleuriregionals under the influence of Mediterranean, Irano-Turanian and Saharo-Arabian regions (2 species, 2.00%), followed by Sudano-Zambezian region (49 species, 41.17%), were represented in mono-regional with 18 species and bio-regional with 31 species.
CONCLUSION
Wadi Khulab, located in the south-western of Saudi Arabia, is floristically diverse in biodiversity. The present survey recorded 119 taxa and represented over one quarter of the checklist recorded before in Jazan area by Masrahi (2012) who identified and described about 524 species which belong to these floristic structures. The total number of identified genera was 93 indicating a high generic index of 78% (93/119). This high diversity in the wadi was due to the abundance of rainfall sources and soil fertility which considered as a biotic factors. The floristic composition of the wadi is rich in species, genera and botanical families due to rainfall water balance. Poaceae is the best represented botanical family followed by five families (Aizoaceae, Euphorbiaceae, Papilionaceae, Amaranthaceae and Asclepiadaceae) constituted the main bulk of the wild plants in the study area. Besides that, the life forms are diverse but the therophyte and chamaephytes are the dominant. The growth types in this study were perennial types were 64 species while the annual types were 55 species. Their predominance makes the phytoclimate of the waditherochoamephytic type. In addition, the areas of Saharo-Arabian and Saharo-Arabian and Sudano-Zambezian are the most dominant chorotypes represented more than third of total plants. There are some plant species were left unrecorded hence need long-term comprehensive study to document.

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