1. Introduction

Ephemeral streams are common features of landscapes around the world, and are the predominant fluvial environments in arid zones (Shaw and Cooper, 2008). In most arid land systems, vegetation cover rarely exceeds 75% and bare soil is always a significant feature (Huxman et al., 2004). Plant ecosystems in arid and semiarid climates, however, show high complexity, especially in areas where water availability allows plants to carry out vital processes (Quevedo and Francés, 2008). Yet, because dominant plant communities and habitat types change according to soils and precipitation (Zhang et al., 1999; Obando, 2005; Stromberg et al., 2007; Skirvin et al., 2008), assessing the plant diversity of ephemeral stream plant communities has proven challenging.

Jordan consists not only of desert, but also semi-desert and steppe (Shaw and Cooper, 2008). Ephemeral streams called wadies, where soil moisture is sufficient to support vegetation. Badia of northeast Jordan are particularly fragile. As a consequence, habitat degradation and species losses in this region have been severe, reducing biodiversity at rates that far exceed natural processes (Ministry of Agriculture, 1996).

Although 80% of the total area (90,000 km²) of Jordan is desert, the flora of Jordan is diverse. Previous studies have identified between 2543 and 2978 plant species belonging to between 120 and 142 families and 719 to 868 genera (Al-Eisawi, 2013). Continued floristic studies, especially of wadi plant communities, would help accurately assess plant diversity of Jordan’s Eastern Badia.

The goal of the present work is to study the floristic composition, life forms, and chorology of the Wadi Hassan watershed in the Azraq Basin (Eastern Badia). This study may help better understanding whether vegetation can be used in the future as a major tool for watershed management.

2. Materials and methods

2.1. The study area

Wadi Hassan is located in the eastern Badia of Jordan (31° 97’ N, 36° 89’ E), in the north western part of the Al-Azraq area. The Wadi...
is a part of one of the largest catchment areas in the northern Badia of Jordan (≈ 360 km²). The main catchment consists of three main wadies; the largest of them begin in the Syrian Jebal Al–Arab north of Jordan and is joined by the other two wadies near the Southern edge of the catchment. Wadi Hassan stretches from Jebal Al-Asfar in the east. All the wadies reach a mud flat locally known as Marab Hassan. Downstream, one wadi continues to the Azraq mud flat (Qa’a Al-Azraq) and has an elevation gradient 580 m–610 m. Soil is composed of basaltic volcanic rock, which has a texture that ranges between silty clay and course sand, and a pH between 7.5 and 8.3; soil salinity ranges from 0.5 to 7.4 mM/cm (Fig. 1).

The climate of the Northeastern Badia is arid with a mean annual rainfall increasing from 50 mm per year in the south to over 250 mm per year in the north near the Syrian border (Fig. 2). The rainy season lasts from October through April. On average, there are 23 rainy days; the average annual rainfall for the catchment is 194 mm and for Wadi Hassan is 50 mm (Figs. 2 and 3).

Fig. 1. (A) Map of Jordan showing the location of Wadi Hassan and pictures taken during the study period (2010/2011). (B) Wadi Hassan catchment and sub-catchment areas (31° N, 36° E; Al-Ayyash et al., 2012).
January is the coldest month of the year, during which the average monthly temperature can fall below 0 °C. The hottest months are July and August with an average temperature of 29 °C. The mean annual temperature is about 20 °C. These six families represent 60% of the total families recognized in the study area (Fig. 4). Of 34 families identified at Wadi Hassan, 26.5% (9 families) of the total number of families, are represented by one species per family. This common feature of desert flora indicates that only a few of the large number of species that belong to these plant families have adapted to the harsh desert environment.

Our survey of Wadi Hassan identified numerous plants of special interest. Notably, many of the plant species recorded from Wadi Hassan are medicinal herbs (e.g., *Achillea fragrantissima*, *Artemisia herba-alba*, *Paronychia argentea*, *Teucrium montbretii*, *Thymus bovei*, *Glaucium arabicum*, *Citrus vulgaris*, *Anagallis arvensis*, *Plantago ovata*) used in folk medicine. In addition, several toxic (poisonous) plant species were found in the study area, including *C. colycnthis*, *Urginea maritima*, and the African rue *Peganum harmal*. Some of the recorded species are endemic to Jordan such as *Eremostachys transjordana*, and some of these species (e.g., *Ducrosia flabellifolia*) are rare.

In Jordan Badia, most of the area appears to the casual observer to be without vegetation cover all. According to the flora survey conducted by the Azraq Project (*Al-Eisawi*, 1995), terrestrial plant communities comprise 133 species of vascular plants, belonging to 100 genera and 33 families. Seven species were recorded as new to the flora of Jordan and unique to the Azraq Wetland Reserve. However, the previous checklist for the flora of the Eastern Badia stands only at 322 plant species in 46 families (*Cope and Al-Eisawi*, 1998; *Dutton et al.*, 1998). Due to the scarcity of water and nutrients, most of the plant species identified by our checklist are restricted to small time periods and at select sites. These species may have been successful at maintaining high diversity because of strong root systems, which facilitate absorption of moisture as well as nutrients from different soil types (*Ahmad et al.*, 2009; *Hussain*, 2002).

The Wadi Hassan flora exhibit a great diversity of life forms typical of desert flora. Most plants recorded are annual plants (61%), some plants are hemicyclophtyes (18%) and caamaephyttes (15%), few are geophytes (5%) and phanerophyte shrub composed only 0.5% (Fig. 5). Furthermore, *Retama raetam* was one of the most common species recorded during the two-year collection period (2010/2011). *R. raetam* is the only phanerophyte shrub recorded in Wadi Hassan and the maximum vegetation height for the study area (245 cm) can be attributed to the presence of this plant.

Arid vegetation community structure, function, patterns of species colonization, and succession are highly determined by climatic factors. On an annual scale, precipitation pattern and intensity affect floristic composition and biomass; even rainfall events less than 5 mm can play a vital role in affecting species composition (*Westbrookea et al.*, 2005, *Fariz and Hatough-Bouran*, 1998). Recruitment of some long-lived species is probably confined to very rare occasions when soil water reservoirs are substantial enough to allow the growing taproot of seedlings to reach soil depths with reliable ground water (*Westbrookea et al.*, 2005). Furthermore, the mortality of perennials is affected by periods of limited water availability (*Milton and Dean*, 2000). Finally, the abundance of annuals is largely, determined by the amount of rainfall (*Ward et al.*, 2000). Our finding that 60% of plants in Wadi Hassan are annuals and 73.2% are ephemeral plants agrees with these previous studies. Moreover, the highest vegetation cover in Wadi Hassan occurs in the same area where soil moisture was the highest, except in the area where soil crust formed. The low percent of phanerophytes recorded in this study in consistent with the floristic composition of the Khulais region, West Saudi Arabia (*Alsherif et al.*, 2013) and are in agreement with previous observation that south and south-western Arabian Peninsula are very poor in tree (*White and Leonard*, 1991).

Short-term dynamics in arid/semi-arid systems have been relatively well studied. For example, annuals are thought to act as...
Table 1
Checklist of Wadi Hassan 206 species belong to 138 genera and 34 families, ordered alphabetically.

| Family              | Species                                      | Life form     | Summer Shedding | Chorotype |
|---------------------|----------------------------------------------|---------------|-----------------|-----------|
| Aizoaceae           | 1. Aizoohanicum L.                           | Annual        | Ephemeral       | SA        |
|                     | 2. Mesembryanthemum nodiflorum L.            | Annual        | Ephemeral       | ES, M, SA |
| Amaranthaceae       | 3. Amaranthus albus L.                       | Annual        | Ephemeral       | A         |
|                     | 4. A. blitoides S. Wats.                     | Annual        | Ephemeral       | A         |
|                     | 5. Halogenus alpoeauroides (Del.) Moq.       | Perenating    |                 |           |
| Boraginaceae        | 6. Anchusa aegyptiaca (L.) DC.               | Annual        | Ephemeral       | SA        |
|                     | 7. A. milleri Willd.                         | Annual        | Ephemeral       | IT, SA    |
|                     | 8. A. ovata Lehm                            | Annual        | Ephemeral       | IT        |
|                     | 9. Arehina hispissima (Lehm.) DC.           | Annual        | Ephemeral       | SA, SU    |
|                     | 10. A. linariafolia DC.                      | Annual        | Ephemeral       | IT, SA    |
|                     | 11. A. tinctoriaeus Forssk.                  | Annual        | Ephemeral       | SA        |
|                     | 12. Gastrocytide hispida (Forssk.) Bunge     | Geophyte      |                 |           |
|                     | 13. Heliotropium bacciferum Forssk.          | Chamaephyte   | Perenating      | SA, SU    |
|                     | 14. H. europarem L.                          | Annual        | Ephemeral       | M, I, T   |
|                     | 15. H. hirsutissimum Grauer                  | Annual        | Ephemeral       | M         |
|                     | 16. L. muricata                              | Annual        | Ephemeral       | SA        |
|                     | 17. L. spinocarpus (Forssk.) Aschers.        | Annual        | Ephemeral       | IT, SA    |
|                     | 18. Nonea ventricosa (Sm.) Griseb.           | Annual        | Ephemeral       | M, IT     |
|                     | 19. Paracaryum rugulorum (DC) Boiss.         | Hemicryptophyte| Ephemeral       | IT, SA    |
| Capparaceae         | 20. Capparis ovata Desf.                     | Chamaephyte   | Perenating      | M, IT, SA |
| Caryophyllaceae     | 21. Dianthus judaicus Boiss.                 | Hemicryptophyte| Perenating      | IT        |
|                     | 22. Gypsophila arabica Barkoudah.            | Chamaephyte   | Perenating      | IT        |
|                     | 23. Hernia hissuta L.                        | Annual        | Ephemeral       | ES, M, IT |
|                     | 24. Minuartia picta Borm                     | Annual        | Ephemeral       | IT        |
|                     | 25. Paronychia argentea (Lam.               | Hemicryptophyte| Perenating      | M         |
|                     | 26. Petranthus dichotomus Forssk.            | Annual        | Ephemeral       | SA        |
|                     | 27. Silene colorata Poir.                    | Annual        | Ephemeral       | M         |
|                     | 28. S. conoidea L.                           | Annual        | Ephemeral       | M, IT     |
|                     | 29. S. arctica Boiss                         | Annual        | Ephemeral       | SA        |
|                     | 30. Spargula fallax (Lowe) karuse            | Annual        | Ephemeral       | SA        |
|                     | 31. Spargularia diandra (Guss.) Heldr. Et Sart. | Annual   | Ephemeral       | M, IT, SA |
|                     | 32. Vaccaria pyramidata Medik.               | Annual        | Ephemeral       | M         |
| Chenopodiaceae      | 33. Anabasis setifera Moq.                   | Chamaephyte   | Perenating      | SA        |
|                     | 34. A. syriaca Iljin.                        | Chamaephyte   | Perenating      | IT        |
|                     | 35. Ariplex leucocladus Boiss.               | Chamaephyte   | Perenating      | IT, SA    |
|                     | 36. Bassia eriophora (Schrud.) Aschers       | Annual        | Ephemeral       | SA, SU    |
|                     | 37. B. muricata (L. Aschers.                 | Annual        | Ephemeral       | IT, SA    |
|                     | 38. Halothamnus acutifolis (Moq.) Botsch.    | Chamaephyte   | Perenating      | IT        |
|                     | 39. Hammadah egii Iljin                      | Chamaephyte   | Perenating      | IT        |
|                     | 40. Salsoola volksisii Schweinf. et Aschers. | Annual        | Ephemeral       | SA        |
|                     | 41. Seidlitzia florida (M. Bieb.) Boiss.     | Chamaephyte   | Ephemeral       | SA        |
|                     | 42. S. rosmarinus Beg. ex. Boiss.            | Chamaephyte   | Ephemeral       | SA        |
| Cistaceae           | 43. Helianthemum sessiflorum (Desf.) Pers.   | Chamaephyte   | Perenating      | SA        |
| Compositae          | 44. Auuonushnia factoroskovy Warb.& Eig.     | Annual        | Ephemeral       | SA        |
|                     | 45. Achillea fragrantissima (Forsk.) Sch Bip | Hemicryptophyte| Perenating      | IT, SA    |
|                     | 46. A. membranacea (Labill.) DC.             | Hemicryptophyte| Perenating      |           |
|                     | 47. Anthemis bornmullerii Stoj. & Acht.      | Annual        | Ephemeral       | M         |
|                     | 48. A. haussknechtii Boiss. & Reut.          | Annual        | Ephemeral       | IT        |
|                     | 49. Artemisia herba-alba Asso                | Chamaephyte   | Perenating      | IT        |
|                     | 50. Asteriscus pygmaeus (DC.) Coss. & Dur.   | Chamaephyte   | Perenating      | SA        |
|                     | 51. Attraclyis cancellata L.                 | Annual        | Ephemeral       | M         |
|                     | 52. A. prolifera Boiss.                      | Annual        | Ephemeral       | SA        |
|                     | 53. Calendula arvensis L.                    | Annual        | Ephemeral       | M, IT     |
|                     | 54. C. tripterycra Rufr.                     | Annual        | Ephemeral       | SA        |
|                     | 55. Cardius getulos Pomel                    | Annual        | Ephemeral       | SA        |
|                     | 56. Carthamus tenuis (Boiss & BL) Bormm      | Annual        | Ephemeral       | M         |
|                     | 57. Centaurea aegyptiaca L.                  | Chamaephyte   | Perenating      | SA        |
|                     | 58. C. ammonycusus Boiss.                    | Annual        | Ephemeral       | SA        |
|                     | 59. C. lanulata Eig                          | Hemicryptophyte| Ephemeral       | SA        |
|                     | 60. Crepis aspera L.                         | Annual        | Ephemeral       | M         |
|                     | 61. C. sancta (L.) Bormm.                    | Annual        | Ephemeral       | M, SA     |
|                     | 62. Echinos glaberrimus DC.                  | Hemicryptophyte| Perenating      | SA        |
|                     | 63. Filago contracta (Boiss.) Chirte & Holub | Annual        | Ephemeral       | IT        |
|                     | 64. F. desertorum Pomel                      | Annual        | Ephemeral       | IT, SA    |
|                     | 65. Gynmarnhena micronthe Desf.              | Annual        | Ephemeral       | SA        |
|                     | 66. Ilfgro spicata (Forssk.) Sch Bip.        | Annual        | Ephemeral       | SA        |
|                     | 67. Lactuca orientalis (Boiss.) Boiss.       | Hemicryptophyte| Perenating      | IT        |
|                     | 68. L. serriola L.                           | Annual        | Ephemeral       | ES, M, IT |
|                     | 69. Lasagopon muscoides (Desf.) DC.          | Annual        | Ephemeral       | SA        |
|                     | 70. Launaea mucronata (Forssk.) Muschler     | Annual        | Ephemeral       | SA        |
|                     | 71. L. nudicaulis (L) Hook. fil.             | Hemicryptophyte| Perenating      | SA        |
|                     | 72. Leontodon laciniatus (Bertol.) Widder    | Annual        | Ephemeral       | IT, SA    |

(continued on next page)
| Family       | Species                          | Life form       | Summer Shedding | Chorotype |
|-------------|----------------------------------|-----------------|-----------------|-----------|
|             | 73. Matricaria aurea (Loefl.) Sch. Bip. | Annual          | Ephemeral       | M, IT     |
|             | 74. Notobasis syriaca (L.) Cass.   | Annual          | Ephemeral       | M         |
|             | 75. Onopordum alexandrinum Boiss. | Hemicryptophyte | Ephemeral       | IT, SA    |
|             | 76. O. transjordanicum Eig.       | Hemicryptophyte | Ephemeral       | SA        |
|             | 77. Phagnalon rupestris (L.) DC.  | Chamaephyte     | Perenating      | M, IT     |
|             | 78. P. acuminatum (L.) Cass.      | Annual          | Ephemeral       | M, IT     |
|             | 79. Picris aspleniodies          | Annual          | Ephemeral       | SA        |
|             | 80. P. cyanocarpae Boiss.        | Annual          | Ephemeral       | SA        |
|             | 81. Reichardia tingitana (L.) Roth | Annual          | Ephemeral       | M, IT     |
|             | 82. Scorzonera papposa DC.       | Hemicryptophyte | Ephemeral       | IT        |
|             | 83. S. puella Pall.              | Hemicryptophyte | Ephemeral       | IT        |
|             | 84. S. schweinfurthii Boiss.     | Hemicryptophyte | Ephemeral       | SA        |
|             | 85. Sonchus oleraceus L. remend. Gouan | Annual          | Ephemeral       | ES, M, IT |
|             | 86. Zygia purnurea Fresen.       | Annual          | Ephemeral       | IT, SA    |
| Convolvulaceae | 87. Convolulus lanatus Vahl    | Chamaephyte     | Perenating      | SA        |
| Cruciferae  | 88. Abyssum marginatum Steud. ex Boiss. | Annual          | Ephemeral       | IT        |
|             | 89. A. meniacoides Bois.         | Annual          | Ephemeral       | IT        |
|             | 90. Biscutella didyma L.         | Annual          | Ephemeral       | M, IT     |
|             | 91. Diplotaus erucoides (L.) DC. | Annual          | Ephemeral       | M         |
|             | 92. D. harra (Forssk.) Bioss.    | Chamaephyte, Hemicryptophyte, Annual | Ephemeral | SA        |
|             | 93. Eruca sativa Mill.           | Annual          | Ephemeral       | M, IT     |
|             | 94. Eruca boweana Cass.          | Annual          | Ephemeral       | SA        |
|             | 95. E. pinnata                   | Annual          | Ephemeral       | SA        |
|             | 96. Lepidium aucherii Boiss.     | Annual          | Ephemeral       | IT        |
|             | 97. Lobularia arabica (Boiss.) Muschl. | Annual          | Ephemeral       | SA        |
|             | 98. L. malcolmia africana (L.) R. Br. | Annual          | Ephemeral       | IT, SA    |
|             | 99. M. conringioides            | Annual          | Ephemeral       | IT, SA    |
|             | 100. Matthiola aspera Boiss.     | Annual          | Ephemeral       | SA        |
|             | 101. M. paviflora (Schoubl.) R. Br. | Annual          | Ephemeral       | SA        |
|             | 102. Notoceras bicorne          | Annual          | Ephemeral       | SA        |
|             | 103. Schimpera arabisca Hochst. Et Steud. ex Boiss | Annual          | Ephemeral       | SA        |
|             | 104. Sinapis alba L.            | Annual          | Ephemeral       | ES, M, IT |
|             | 105. S. arvensis L.             | Annual          | Ephemeral       | M         |
|             | 106. Sisymbrium runcinatum Lag.  | Annual          | Ephemeral       | IT        |
|             | 107. S. septulatum DC. prolo. bilobum (C. Koch) O. E. Schulz | Annual          | Ephemeral       | IT        |
|             | 108. Zilla spinosa (L.) Prantl   | Perenating      | M               |
| Cucurbitaceae | 109. Citrullus colocynthis (L.) Schrad. | Annual          | Hemicryptophyte | Perenating | SA        |
| Dipsacaceae | 110. Scabiosa porphyaneura Blakelock | Annual          | Ephemeral       | IT, SA    |
| Euphorbiaceae | 111. Andrachne telephioides L.  | Hemicryptophyte | Perenating      | M, IT     |
|             | 112. Chrozophora oblongifolia (Det.) Ad. Juss. ex Spreng | Chamaephyte     | Perenating      | SU        |
|             | 113. C. obliqua (Vahl) Ad. Juss. | Perenating      | M               |
|             | 114. C. pilata (Vahl) Ad. Juss. ex Spreng | Annual          | Ephemeral       | SU        |
|             | 115. Euphorbia chamaepeplus Boiss. et Hohen | Annual          | Ephemeral       | IT, SA    |
| Geraniaceae | 116. E. terracina L.             | Euphorbia       | Perenating      | M         |
|             | 117. Erodium bryoniifolium Boiss. | Annual          | Ephemeral       | M, IT     |
|             | 118. E. deserti (Eig) Eig.      | Annual          | Ephemeral       | SA        |
|             | 119. E. fasciatus (Cav.) Willd.  | Annual          | Ephemeral       | M         |
| Gramineae   | 120. Bromus dantoniae Trin.      | Annual          | Ephemeral       | IT        |
|             | 121. B. scoparius L.            | Annual          | Ephemeral       | M, IT     |
|             | 122. Cithopis delileana (Schult. & Schult. fil.) Roshev | Annual          | Ephemeral       | M, IT     |
|             | 123. Cynodon dactylon (L.) Pers. | Perenating      | TR               |
|             | 124. Hordeum glaucum Steud.     | Annual          | Ephemeral       | M, IT     |
|             | 125. Poa bulbosa L.             | Euphorbia       | Perenating      | ES, M, IT |
|             | 126. Polygonon viridis (Gouan) Breistr. | Hemicryptophyte | Ephemeral       | M         |
|             | 127. Schismus urabricus Nees.   | Annual          | Ephemeral       | IT, SA    |
|             | 128. Stipa capensis Thunb.      | Annual          | Ephemeral       | IT, SA    |
|             | 129. S. parviflora Desf.       | Hemicryptophyte | Perenating      | IT        |
| Iridaceae   | 130. Iris isyrinchium L.        | Geophyte        | Ephemeral       | M, IT     |
| Lamiaceae   | 131. Ballota undulata (Sieb. ex Fresen) Benth. | Chamaephyte     | Perenating      | M         |
|             | 132. Eremostachys transjordanica Eig. | Hemicryptophyte | Ephemeral       | IT        |
|             | 133. Phlomis brachyodon Boiss.  | Perenating      | M               |
|             | 134. Salvia lanigera Poir.      | Chamaephyte     | Perenating      | M,SA      |
|             | 135. S. spinosa L.              | Hemicryptophyte | Ephemeral       | IT        |
|             | 136. Teucrium montbretii Benth. | Hemicryptophyte | Perenating      | M, IT     |
|             | 137. Thymus bovei Benth.        | Chamaephyte     | Perenating      | SA        |
| Leguminosae | 138. Astragalus alexandrinus Bois. | Hemicryptophyte | Perenating      | M, IT     |
|             | 139. A. anularis Forssk          | Annual          | Ephemeral       | SA        |
|             | 140. A. bombycinus Bios.        | Annual          | Ephemeral       | SA        |
|             | 141. A. corrugatus Bertol.       | Annual          | Ephemeral       | IT, SA    |
|             | 142. A. palaestinus Eig.        | Hemicryptophyte | Ephemeral       | M, IT     |
|             | 143. A. sieberi DC.             | Chamaephyte     | Perenating      | SA        |
|             | 144. A. sparsus Del.            | Hemicryptophyte | Ephemeral       | SA        |
|             | 145. A. spinosus (Forssk.) Muschl. | Chamaephyte     | Perenating      | IT        |
|             | 146. A. trachomiticus Post      | Annual          | Ephemeral       | –         |
|             | 147. A. triloboides Del.        | Annual          | Ephemeral       | IT, SA    |
The chorotypes are: A, American; IT, Irano-Turanian; ES, Euro-Siberian; M, Mediterranean; SA, Saharo-Arabian; SU, Sudania; TR, Tropical.

Ber (29%) followed by Irano-Turanian elements (15%) and Mediterranean elements (14%). In addition to plant species that belong to the Mediterranean and the Irano-Turanian elements presented in the target region, it has a large number of plant species which dominate in other uniregional region, such as Saharo-Arabian. American and Tropical elements showed the least species number (2 and 3 species, respectively).

The high species number of Saharo-Arabian elements can likely be explained by the adaptation of these plant species to the aridity and high temperatures of harsh environments similar to the Jordan flora. Saharo-Arabian region elements recorded the highest number (29%) followed by Irano-Turanian elements (15%) and Mediterranean elements (14%). In addition to plant species that belong to the Mediterranean and the Irano-Turanian elements presented in the target region, it has a large number of plant species which dominate in other uniregional region, such as Saharo-Arabian. American and Tropical elements showed the least species number (2 and 3 species, respectively).

The Table 1 (continued)

| Family | Species | Life form | Summer Shedding | Chorotype |
|--------|---------|-----------|-----------------|-----------|
| Anagallis arvensis | Annual | Ephemeral | M |
| Fagonia bruguieri | Annual | Ephemeral | SA |
| Zygophyllaceae | Fagonia bruguieri | Annual | Ephemeral | M |
| Hibiscus trionum | Annual | Ephemeral | TR |
| Malvaceae | Malva parviflora L. | Annual | Ephemeral | M, IT |
| Papaveraceae | Papaver syriacum | Annual | Ephemeral | M, IT |
| Plantaginaceae | Plantago lanceolata | Annual | Ephemeral | M, IT |
| Polygonaceae | Rumex cyprius | Annual | Ephemeral | M, IT |
| Primumaceae | Androsace maxima L. | Annual | Ephemeral | M, IT |
| Rafflesiae | Rhyncospermum schweinfurthii | Annual | Ephemeral | M, IT |
| Rauvolfiaceae | Rauvolfia serpentina | Annual | Ephemeral | M, IT |
| Rutaceae | Hypecoum pendulum | Annual | Ephemeral | M, IT |
| Solanaceae | Solanum sisymbriifolium | Annual | Ephemeral | M, IT |
| Umbelliferae | Anethum graveolens | Annual | Ephemeral | M, IT |
| Urticaceae | Urtica dioica | Annual | Ephemeral | M, IT |
| Zygophyllaceae | Zygophyllum armatum | Annual | Ephemeral | M, IT |

The chorotypes are: A, American; IT, Irano-Turanian; ES, Euro-Siberian; M, Mediterranean; SA, Saharo-Arabian; SU, Sudania; TR, Tropical.
Fig. 4. The plant family diversity in Wadi Hassan/Eastern Desert. The most diverse families are Compositae (20.5%), Cruciferae (10.2%), Leguminosae (8.3%), Boraginaceae (6.8%), followed by Caryophyllaceae and Gramineae (5.4% the same for both families). These six families represent 56.6% of the total families recognized in the study area.

Fig. 5. Life form of plant species recorded in Wadi Hassan checklist 2010/2011.

Fig. 6. Proportional percentage of chorological types of the recorded species. A, American; IT, Irano-Turanian; ES, Euro-Siberian; M, Mediterranean; SA, Saharo-Arabian; SU, Sudania; TR, Tropical.
Badia. Vegetation cover is mainly concentrated in locations where water accumulates. These results are in agreement with studies in Saudi Arabia (Al-Turki and Al-Olayan, 2003; El-Ghamem et al., 2010; Alatar et al., 2011; Daur, 2012; Alsherif et al., 2013).

4. Conclusion

The present study is the first floristic study of Wadi Hassan and shows the importance of plant diversity in this region. The numbers of species in this region are high, largely because of soil characteristics and water availability. Although we have identified high plant diversity in one small region, this study only reflects a glimpse of the plant diversity of the larger area. Thus, we believe many plant species remain unrecorded and need long-term comprehensive study.

Conflicts of interest

None declared.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pld.2019.05.001.

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