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DIVERSITY OF HERBACIOUS PLANT COMMUNITIES AND *ARTEMISIA HERBA-ALBA* ASSO. AT DIFFERENT GOVERNORATES' OPEN-LANDS IN JORDAN

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Abstract

AL-GHZAWI; A. L. A., K. A. JUMA'A, I. M. AL-RAWASHDEH, S. D. AL-KOFAHI and E. Y. BSOUL, 2016. Diversity of herbacious plant communities and *Artemisia herba-alba* Asso. at different governorates' open-lands in Jordan. *Bulg. J. Agric. Sci.*, 22: 897–905

Jordan is a small country located in the Fertile Crescent region and is very rich in plant taxa due to the variability of its bio-geographical regions and ecosystems. Plant diversity in Jordan is at risk due to demographic reasons, land use problems, human and environmental stressors. The objective of this research was to evaluate the floral diversity in different ecosystems in Jordan (Al-Shoubak, Al-Tafileh, Madaba and Al-Mafraq governorates) with special concern given to *Artemisia herba alba* diversity. *Artemisia herba alba* is an endangered medicinal plant species. The transect-quadrate method was used and three sites were examined within each governorate. The collected data were analyzed statistically and descriptively. Statistical analysis did not show evidence of association between the governorate elevation and species diversity indices. No statistical significant variability in species diversity indices among governorates were found. However, Shannon diversity index, evenness, relative density, species density and richness were different among locations. The species density was the highest in Madaba (36 plants/m^2) and the lowest was in Tafileh (21 plants/m^2). But Tafileh showed the highest Shannon diversity index, species richness and evenness. Shoubak showed the highest density of *Artemisia herba alba* along with frequency and relative frequency. Shoubak ecosystem considered the best of those studied for growing and maintaining this plant. Mafraq showed the lowest Shannon diversity, species evenness and density of *Artemisia herba alba*. This indicates that this region is intensively disturbed and conservation efforts are urgent to maintain its species and genetic diversity. Managing the collection of *Artemisia herba alba* and adoption of domestication programs will conserve it, specifically in Mafraq region.
Key words: Artemisia, species richness, evenness, Transict, Jordan

Introduction

Forty one percent of the global land considered dry lands. These lands represent a considerable portion of the global land and contain one-sixth of the world's population (CBD, 2000). Jordan is a small (85 500 km^2) dry land country with Mediterranean ecosystems. The Mediterranean ecosystems contain 22% of the hot spots of endemic flora and considered a nuclear center of agricultural origin (Hawkes, 1983). Jordan is very prosperous in plant biodiversity, where it has greater than 30 000 plant taxa of which 50% are endemic (Jaouhari, 1999; Soliman, 2007). Even though, Jordan is a small country, it has a vascular flora of around 2500 species (Watson et al., 2000) of around 250 000 vascular plant spe-

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cies in the world. Many crops of a global significance, such as oat, lentil, barley and wheat as well as many fruit trees were domesticated in this place (Feuerstein, 1986; Al-Waili, 1986). The daily foods of around 40% of the world's population are plants originated from the Mediterranean region (UNDP, 2007).

Jordan located in the extreme southwestern part of the Fertile Crescent, which is the center of diversity and botanic regions due to the presence of various climatic conditions that create different ecosystems. Moreover, Jordan has four bio-geographical regions (Mediterranean, Irano-Turanian, Saharo-Arabian and Sudanian-Penetration) (McArthur et al., 2001; Newman et al., 2003). To a certain extent, this variability characterizes this region with high diversity and species richness (Ajlouni et al., 2009; 2010). Yet, plant diversity in Jordan, has turned down remarkably over the past two centuries (Al-Eisawi, 2003). A lot of Jordanian native species were missed. This reduction was due to population inflation, urban expansion and sprawl on agricultural land (Abu-Irmaileh and Afifi, 2000), over-grazing, deforestation, illegal collection of plants, soil erosion and depletion of water resources (Al-Mustafa and Al-Thunibat, 2008; Al-Eisawi, 2003).

Jordanian authorities recognized the importance to conserve and preserve the biodiversity in their lands (Ajloni et al., 2009; 2010). About 4% of Jordan's land area is declared as nature reserves (Ajlouni et al., 2010). Areas outside the boarders of these reserves contained a lot of globally important landraces and wild relatives of cultivated species which are subjected to the previously mentioned threats (Ajlouni et al., 2010; Al-Mustafa and Al-Thunibat, 2008; Al-Eisawi, 2003; Abu-Irmaileh and Afifi, 2000). *Artemisia herba-alba* is an example, *A. herba-alba* Asso, Syn, Aragon (Feinbrun-Dothan, 1978) has been widely used as traditional medicine for treatment of gastric disturbances, abdominal cramps and healing of external wounds (Feuerstein et al., 1986), diabetic symptoms (Al-Rawashdeh, 2015; Jaouhari, 1999; Al-Waili, 1986, 1988a, 1988b). Essawi and Srour (2000) reported that *A. herba-alba* has been used to activate the function of the liver, heals rash and joints, inflammations, rheumatoid arthritis and its extract can be used as antiseptic material. In addition, *A. herba-alba* shoots contain antioxidant material that could be used as anti-diabetic agents (Al-Mustafa and Al-Thunibat, 2008) and can be used to produce different essential oils such as the α-thujone, 1,8-cineole and camphor (Al-Ghzawi et al., 2012). Uncontrolled collection of this medicinal herb adds it to the list of endangered plant species (Abu-Irmaileh and Afifi, 2000).

Al-Ghzawi et al. (2012) reported that *A. herba-alba* grows in the mountains and valleys of Jordan. But, the floral diversity usually is different among different ecosystems (Al-Rawashdeh et al., 2007) and different elevations (Sang, 2009; Zhang and Zhang, 2007). So far, limited studies have been carried out to assess the diversity among different ecosystems and different elevations in Jordan. The diversity of *A. herba alba* in Jordan needs to be assessed. Therefore, this research was conducted to assess and evaluate the floral diversity in different ecosystems in Jordan and special focus was given to assess the diversity of *A. herba alba* in different regions in Jordan (Al-Shoubak, Al-Tafileh, Madaba and Al-Mafraq governorates) where the specie naturally grows.

Materials and Methods

Site Selection

Four climatologically different governorates were selected in Jordan to conduct the study within these areas: Al-Tafileh, Al-Shoubak, Madaba and Al-Mafraq. Three sites were selected within each target area to represent different habitats. The Global Positioning System (GPS) was used to locate the coordinates of the visited sites. Site characterization and coordinates were reported in Al-Ghzawi et al. (2012). Shoubak is located approximately 200-250 km south the capital Amman. In Shoubak, three sites were investigated and they are Fujaij, Tafileh-Shoubak cross, Adreuh-Shoubak cross (Altitudes 1280-1333 m). Al-Tafileh is located 180-200 km southern capital Amman. The observed sites are Al-Hareer, Al-Qadesiah and Addabeh (Altitudes 1275 m). Thirty to fifty km southwest of Amman is the third location, Madaba, where the chosen sites are Jabal-Neibo, Al-Habees, and Muragemat-Ashaghanbeh at altitudes of 661-736 m. The fourth location is Mafraq with altitude ranges from 689-764 m and located 80-100 km to the north of Amman. The selected sites were Khanasreh 1 (Outside the Khanasreh Research Station), Khanasreh 2 (Inside the Khanasreh Research Station) and Erhab. The survey was conducted during April 2009.

Methodology

The transect-quadrate method was used for sampling. Three transects of 50 m long were placed. Each transect included five quadrates of 1m x 1m spaced alternatively every 10 meters. Survey data of the selected governorates and sites within governorates were used to calculate biodiversity indices. Species richness represents the total number of species in the field (Rajan, 2001). Shannon diversity index commonly used to study plant species diversity (Khafagi et al., 2013; Farrag, 2012; Rad et al. 2009); Shannon diversity index (Ambasht, 1982; Kent and Coker, 1993) was calculated as follows:

$$\text{Diversity } H' = -\sum_{i=1}^{s} \text{pi ln pi}$$

Where, s is the number of species, pi is the proportion of individuals or the abundance of the i^{th} species expressed as a proportion of the total number of plants and ln pi: is the natural logarithm of pi. The Shannon Index takes both species richness and the relative abundance of each of these species into account. Species evenness E_H describes how even are the number of individuals in the species, its values ranged between 0 and 1.0 where 1.0 is complete evenness which means that all species are equally abundant, they have equal numbers of individuals with same size and it can be calculated according to the formula described by Ambasht (1982):

$E_H = (H'/\ln S)$, where:

H'= Shannon diversity index; S = Species richness.

The species frequency was calculated as the number of quadrates in which a species present over the total number of quadrates sampled multiplied by 100. The relative frequency is the number of occurrence of a species over the number of occurrences of all species (Ambasht, 1982; Rajan, 2001). The species density was calculated by dividing the total number of individual plants over the area sampled (Ajlouni et al., 2010). The relative species density is the number of individuals of a given species over the area sampled.

Statistical analysis

The collected plant species in each quadrat were counted, identified and sorted for the analysis. The data were analyzed using SAS 9.2 (SAS Institute, 2011). Parametric and non-parametric analysis were used at statistical significance of $\alpha = 0.05$. Parametric analysis, analysis of variance (ANOVA), was done where the normality test indicated normally distributed data (Species evenness, Shannon diversity index and species density). Non-parametric analysis (Kruskal-Wallis test) was used for the non-normally distributed data (species richness). Pearson's correlation test was used to assess the possible association between species richness and governorates elevations. Spearman correlation was used to test for association between species evenness, Shannon diversity index and species density with governorates elevations. Descriptive analysis was also employed to express the relative differences of the calculated indices, the frequency and relative frequency of plant species among governorates.

Results

Pearson's and Spearman's correlation tests showed no evidence of association between the governorate elevation, from 689 to 1333 m, and species richness, species evenness, Shannon diversity index, and species density. Different locations showed differences in the Shannon diversity index, evenness, relative density, species density and richness values. However, the Analysis of Variance and Kruskal-Wallis test for the measured indices showed no significant differences among the governorates studied. So, the results were explained descriptively and relative to each other.

Tafileh region was the highest in diversity as indicated by the high Shannon diversity index and the species distribution were more even in that region relative to the other locations studied (Table 1). The species density was the highest in Madaba (36 individual plant/m^2). The lowest density (21 individual plants/m^2) was noticed in Tafileh (Table 1). The relative species density was 4 individual plants of *A. Herbs-Alba*/m^2 in Shoubak followed by Tafileh and Madaba with 3 individual plants of *A. herba-alba*/m^2. The lowest relative density was found in Mafraq (2 individual plants of *A. herba-alba* /m^2) (Table 1).

Table 1

The Shannon diversity index, species evenness, richness, density (individual plant/m^2) and the relative density (*A. Herba-Alba* individual/m^2) in the four studied ecosystems in Jordan

Studied Region	Shannon Diversity	Species Evenness	Species Density	Relative Density
Tafileh	1.99	0.74	20.64	3.04
Shoubak	1.28	0.58	27.40	3.84
Mafraq	0.96	0.42	27.53	1.73
Madaba	1.53	0.57	36.2	3.17

Species richness was ranked the highest in Tafileh (8.33), then Madaba, followed by Marfraq and the lowest was in Shoubak (4.5) (Table 2, Figure 1). Figure 1 shows the relationship between the number of quadrates and the cumulative number of species identified (species richness). The average cumulative number of different species identified in the studied regions leveled off (stabilized) between quadrats 7 to 12. Figure 1 shows the cumulative number of species identified averaged over the three sites of each region. The cumulative number of different species identified in Tafileh was 35, and 30 in Mafraq. These were higher than that identified in Madaba (23) and Shoubak (21).

Tables 3, 4, 5, 6 showed the species frequencies and the relative frequencies of *A. herba-alba* in the four governorates. The relative frequency of *A. herba-alba* in the three sites of Tafileh was the highest (15–39%) among the 35 plant species identified. Some other species were dominating the sites, but occupy the second rank, such as *Centaurea can-*

Table 2

The Mean rank and median of species richness in the four studied ecosystems in Jordan

Studied Region	Mean rank Richness	Standard Deviation	Median
Tafileh	8.33	8	21
Madaba	7	3	14
Mafraq	6.17	8	11
Shoubak	4.50	6.6	9

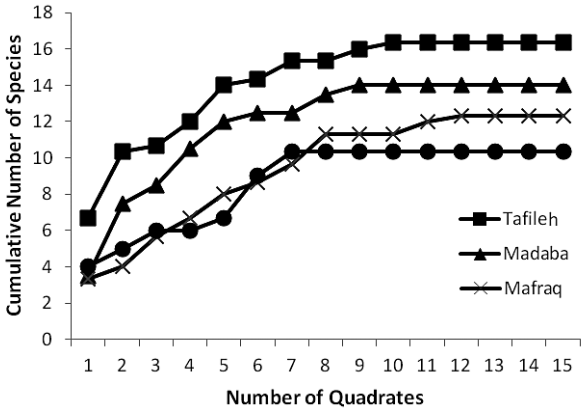

Fig. 1. The average cumulative count of different species identified in the studied regions relative to the number of quadrates studied in each site

tus (28%), *Colchicum sp.* (17%), and *Rununculus arvensis* (15%) (Table 3). In Madaba, the relative frequency of *A. herba-alba* was 17–22%, which was similar to other species dominating the studied sites in Madaba (Table 4). The relative frequency of *A. herba-alba* in Mafraq sites were low in sites no. 1 (Khanasreh, outside Research Station) and no. 3 (Erhab), they were 20% and 25%, respectively. On site

Table 3

The species freqency (F) and relative frequency (R.F) of *A. herba-alba* and other species within Tafileh region*

Site	Species	F	R.F.
1	2	3	4
Tafileh 1 Addabah	*A. herba-alba*	93	39
	Centaurea cantus	67	28
	Scorzonera judaica	7	3
	Erucaria sp.	7	3
	Hordeum glaucum	7	3
	Astragalus spinosus	20	8
	Colchicum sp.	40	17

Table 3

Continued

1	2	3	4
Tafileh 2 Al-Qadisiah	*A. herba-alba*	100	19
	Anchusa strigosa	13	3
	Paronychia argentea	13	3
	Achillea santolina	40	8
	Centaurea cantus	27	5
	Centaurea iberica	20	4
	Echinops polyceras	20	4
	Tragopogon collinus	20	4
	Biscutella didyma	13	3
	Cardoria draba	20	4
	Erucaria sp.	20	4
	Sisymbrium irio	13	3
	Tuberaria guttata	20	4
	Cephalaria syriaca	13	3
	Dactylis sp.	13	3
	Astragalus spinosus	20	4
	Colchicum sp.	53	10
	Reseda decursiva	27	5
	Cerasus microcarpa	20	4
	Sarcopoterium spinosum	20	4
	Bifora testiculata	20	4
Tafileh 3 Al-Hareer	*A. herba-alba*	60	15
	Silene aegyptiaca	13	3
	Carthamus nitidus	7	2
	Centaurea cantus	27	6
	Echinops polyceras	40	10
	Filago desertorum	27	6
	Tragopogon collinus	13	3
	Euphorbia terracina	13	3
	Erodium malacoides	20	5
	Hordeum glaucum	33	8
	Ziziphora clinopodiodes	7	2
	Ziziphora tenuior	7	2
	Astragalus spinosus	7	2
	Colchicum sp.	20	5
	Urginea maritima	7	2
	Roemeria hybrida	20	5
	Rununculus arvensis	60	15
	Cerasus microcarpa	7	2
	Bifora testiculata	13	3
	Bupleurum sp.	7	2
	Parietaria alsinifolia	7	2

*Relative frequencies were calculated on a site by site basis

Table 4

The species frequency (F) and relative frequency (R.F) of *A. herba-alba* and other species within Madaba region*

Site	Species	F	R.F.
Madaba 1 Jabal Neibo	*A. herba-alba*	80	22
	Anchusa aegyptiaca	13	4
	Atriplex holocarpa	7	2
	Centaurea iberica	13	4
	Echinops polyceras	7	2
	Biscutella didyma	7	2
	Bromus sp.w	13	4
	Ballota undulate	33	9
	Erygia creticum	13	4
	Salvia dominica	73	20
	Asphodelus aestivus	13	4
	Lathyrus sativus	7	2
	Trifolium resupinatum	7	2
	Reomeria hybrid	7	2
	Adonis aestivalis	13	4
	Apium graveolens	20	6
	Eryngium creticum	33	9
Madaba 2 Murageмat-Ashaghanbeh	*A. herba-alba*	53	19
	Anchusa aegyptiaca	13	5
	Paronychia sp.	7	2
	Anthemis bornmulleri	13	5
	Centaurea iberica	7	2
	Echinops polyceras	27	9
	Carthamus tenuis	40	14
	Gundelia tournefortii	53	19
	Colchicum sp.	53	19
	Erygia creticum	7	2
	Teucrium polium	13	5
Madaba 3 Al-Habees	*A. herba-alba*	53	17
	Centaurea iberica	13	4
	Gundelia tournefortii	7	2
	Colchicum sp.	13	4
	Erygia creticum	27	9
	Salvia dominica	27	9
	Asphodelus aestivus	40	13

*Relative frequencies were calculated on a site by site basis

Table 5

The species frequency (F) and relative frequency (R.F) of *A. herba-alba* and other species within Mafraq region*

Site	Species	F	R.F.
Mafraq 1 Khanasreh outside Research Station	*A. herba-alba*	60	20
	Anchusa strigosa	7	2
	Achillea fulcata	7	2
	Carthamus nitidus	7	2
	Centaurea iberica	13	4
	Crepis sancta	7	2
	Gyrmnartinen micrantum	13	4
	Scolymus hispanicus	7	2
	Scorzonera judaica	7	2
	Torularia torulosa	7	2
	Ephedra sp.	20	7
	Poa sp.	80	26
	Erodium malacoides	7	2
	Iris histrio	7	2
	Lathyrus gorgonei	7	2
	Vicia sativa	7	2
	Allium hierochunticum	20	7
	Asphodelus lutea	7	2
	Roemeria hybrida	7	2
	Reseda lutea	7	2
	Eryngium glomeratum	7	2
Mafraq 2 Khanasreh-inside of Research Station	*A. herba-alba*	53	35
	Atriplex halimus	7	4
	Fumana thymifolia	7	4
	Hirschfeldia incana	60	39
	Sinapis alba	27	17
Mafraq 3 Erhab	*A. herba-alba*	67	25
	Anthemis scrbicularis	67	25
	Gundelia tournefortii	7	3
	Scolymus hispanicus	7	3
	Hirschfeldia incana	7	3
	Sinapis alba	33	13
	Aegilops peregrina	13	5
	Hordium glaucum	13	5
	Iris histrio	7	3
	Eryngium glomeratum	40	15
	Bifora testiculata	7	3

*Relative frequencies were calculated on a site by site basis

Table 6
The species frequency (F) and relative frequency (R.F) of *A. herba-alba* and other species within Mafraq region*

Site	Species	F	R.F. Frequency
Shoubak 1 Tafileh-Shoubak cross	*A. herba-alba*	100	33
	Centaurea cantus	33	11
	Echinops polyceras	13	4
	Helianthemum sp.	7	2
	Ephedra sp.	7	2
	Stipa sp.	13	4
	Asphodelus sp.	7	2
	Colchicum sp.	100	33
	Adonis aestivalis	20	7
Shoubak 2 Adreuh-Shoubak cross	*A. herba-alba*	100	41
	Centaurea cantus	13	5
Shoubak 2 Adreuh-Shoubak cross	*Cardaria draba*	33	14
	Eryngium creticum	100	41
Shoubak 3 Fujaiaj	*A. herba-alba*	100	19
	Rochelia disperma	13	3
	Atriplex holocarpa	20	4
	Achillea santolina	73	14
	Anthemis bornmulleri	33	6
	Anthemis tinctoria	33	6
	Carthamus nitidus	27	5
	Centaurea ammocyanus	33	6
	Centaurea cantus	40	8
	Echinops polyceras	7	1
	Filago desertorum	33	6
	Erodium malacoides	20	4
	Avena latcua	27	5
	Stipa sp.	7	1
	Astragalus sp.	40	8
	Adonis aestivalis	7	1

*Relative frequencies were calculated on a site by site basis

no. 2 (Khanasreh, inside Research Station) of Mafraq, the relative frequency was high (35%) compared to the other sites. The other species that were dominating the sites are *Poa sp.* (26%), *Hirschfeldia incana* (39%) and *Anthemis scrbicularis* (25%) in sites no. 1, 2, and 3, respectively (Table 5). The highest relative frequency in site no. 1 in Shoubak was 33% for *A. herba-alba* and *Colchicum sp.* On site no. 2, the highest relative frequency was 41% and that was for *A. herba-alba* and *Eryngium creticum*. The *A. herba-alba* relative frequency was the highest (19%) among other species in site no.3 but it was low relative to the other studied sites in Shoubak (33 and 41%) (Table 6).

The species frequencies (percentage of quadrates that contain a species of concern) among governorates and among sites were varied. In Tafileh, the frequency of *A. herba-alba* was high in all sites (60%, 93% and 100%) (Table 3). At Madaba sites, the highest frequencies were 53% and 80% for *A. herba-alba*; 73% for *Salvia dominica* and 53% for both *Colchicum sp.* and *Gundelia tournefortii* (Table 4). In Mafraq, the highest frequency was for *Poa sp.* (80%) and the target species frequencies were 53%, 60%, and 63% (Table 5). Shoubak region showed the highest frequency (100%) of *A. herba-alba* in all the sites, in addition to 100% frequency for the species *Eryngium creticum* and *Colchicum sp.* (Table 6).

Discussion

The selected governorates are varied in elevation; this allowed comparing the species diversity indices among elevations. Tafileh and Shoubak are mountainous areas while Madaba and Mafraq are low lands. Al-Rawashdeh et al. (2007) reported that floral diversity depends on latitude, altitude, climate, soil type and environmental stress. The results of this research and correlation tests showed no evidence (in this case specifically) that there are association between elevations and the species diversity. The values of measured indices were similar for governorates with different elevations like Shoubak (elevation=1275 m) and Madaba (elevation=765 m). For example, Shannon diversity index, Evenness, and "number of different species identified" for Shoubak and Madaba were (1.28, 1.53), (0.58, 0.57), and (21, 23), respectively. The species density of Shoubak (elevation=1275 m) and Mafraq (elevation=765 m) are the same (≈27.5). Similarly, Shoubak and Tafileh shared the same elevation (1275 m) but showed different values of species richness, species density, and "number of different species identified".. Our results contradict that reported by Zhang and Zhang (2007) that plant diversity expected to be different with different elevations. Similarly, Sang (2009) and Al-Rawashdeh (2015) reported higher species richness with higher elevation. This inconsistency probably because the researchers investigated the variability in species diversity among different elevations within the same region but not different regions different elevations.

The relative species density of *A. herba-alba* was high in Tafileh, Shoubak and Madaba (3.04-3.84 individuals/m^2),

but was low (1.7 individuals/m^2) in Mafraq. This is probably due to the harsh climatic conditions such as higher temperature and fluctuation in the amount of rainfall that characterize Mafraq governorate. The trend of annual rainfall in Mafraq is decreasing based on analysis of rainfall data collected for the period 1980-2007 (Al-Mashagbah and Al-Farajat, 2013). In addition, Mafraq residents disturb this species specifically because of its medicinal properties, and other species due to intensive grazing behavior and inflation in populations in Mafraq compared to the other studied governorates. The Syrians refugees reside in Zaatari Camp reached 83 497 Capita; 73 145 Syrians and non-Syrians reside in Urban (UNHCR, 2015). Shannon diversity (0.96) and evenness indices (0.42) of Mafraq were the lowest compared to that of the other governorates because of the previously mentioned reasons. The frequency of *A. herba-alba* compared to other dominant species in Mafraq was low. Low frequency indicates that a species is unevenly distributed (Shameem and Kangroo, 2011). This negative impact on species biodiversity is expected to be more serious these days because of the huge number of Syrian refugees who occupied Al-Za'atary camp in Mafraq (83,497 capita) (UNHCR, 2015).

Among the studied governorates, Mafraq was the only governorate that had dominant species other than *A. herba-alba.* The species *Poa sp.* and *Hirschfeldia incana* were the most frequent species in Mafraq with high frequency and relative frequency. The cumulative count of different species (Figure1) ensures that more quadrates will not likely to change this research results. Fifteen quadrates of $1m^2$ in each site (45 quadrates/study region) were sufficient to express the number of different species and biodiversity status in the studied regions. This is because the "number of different species found" stabilized at quadrates no. 12. Quadrates 13-15 did not lead to increase in the number of different species found (species richness).

The species diversity information is useful for ecologists, botanists (Sang, 2009), planning strategies and long term conservation programs (Akwee et al., 2010). For example, the high rank of species richness, high number of different species (30 species) in Mafraq indicated that this region contains a high genetic diversity, but the low species density in Mafraq indicated that this region is intensively disturbed and conservation efforts are urgent to maintain its diversity and genetic diversity. This is crucial importance because *A. herba-alba* populations in Mafraq contain a chemical composition that is different from that of other regions in Jordan and considered a promising plant for production of camphor oil (Al-Ghzawi et al., 2012). Domestication of this plant probably will help in conserving it and ensure economical production that will help local people improve their income. Management plan of *A. herba-alba* should be established in full consultation with local communities and key stakeholders for effective *in situ* conservation to maintain the genetic diversity of these populations. However, other populations of *A. herba-alba* that is naturally grown in Shoubak, Tafileh and Madaba could be used to extract different kinds of essential oils (Al-Ghzawi et al., 2012) and needs to be protected from disturbance.

Based on the frequency data, there was no one quadrate of those thrown in Shoubak lacking *A. herba-alba*. In Shoubak, the frequency of *A. herba-alba* was 100% in the three sites and the relative frequency was the highest among the other governorates. This was consistent with Al-Rawashdeh (2015) who reported that *A. herba-alba* was dominant in Shoubak. This indicates that Shoubak ecosystem potentially favors this medicinal plant over many other plant species. High species frequency values indicates the greater uniformity and dispersion of the species (Ambasht, 1982) and reflects higher ability for adjustments and adaptations, and larger gene pool that supports the evolution of that species (Krivtsov et al., 2000). But *A. herba-alba* was coexisted with other species. The presence of other species in the same sites with high frequency (100%) like *Colchicum sp.* and *Eryngium creticum* probably referred to: first, there are minimal shared resources among these species which made them compatible species to grow together. Second, the resources needed for these species are plenty enough to satisfy the species needs without competition. But, Shoubak species richness and "number of different species" were the lowest (rank 4.5; 21) compared to the other governorates (rank 6.17-8.3; 23-35), respectively. So, this result supports the first reason for having the previously mentioned species together in the same ecosystem with high frequency. Further research is needed to understand the relationship between these species in Shoubak.

Conclusion

The variability in species diversity among the studied governorates failed to be detected statistically probably because they were mosaic enough not to detect a specific trend. Forty five quadrates per governorate were sufficient to capture most of the variability. Mafraq governorates experienced harsh climatic conditions, intensive grazing, species collection and high population and consequently were the lowest in terms of Shannon diversity and evenness indices. Mafraq also showed low species density with high species richness which indicated that this region in the past was diversity-rich spot and it being disturbed and very susceptible to loss their biodiversity unless conservation programs are

launched. The relative species density, frequency and relative frequency of the medicinal plant *A. herba-alba* were the lowest in Mafraq compared to the other governorates. So conservation programs, residents' involvement in conservation and domestication of such species and others of importance are recommended. The Shoubak governorates showed 100% frequency of *A. herba-alba* in all the studied sites with the minimum species richness that support the idea of considering Shoubak ecosystem more suitable for *A. herba-alba* conservation.

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