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TRENDS IN SPECIES RICHNESS AND DENSITY OF *Teucrium polium* L. (LAMIACEAE) OVER TIME AND SPACE

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ABSTRACT

The aim of this study was to investigate the species diversity and species richness of vegetation cover with a focus on *Teucrium polium* L. species. Density and other diversity parameters were used to assess the impact effect of climate change at four sites within Al-Sult area of Jordan over 2010 to 2012 period. A total of 179 quadrates of 1m² each were used to survey the species richness and density and to estimate the Shannon diversity index based on the nature of vegetation. The rainfall recorded by the Agricultural Department-Statistics section was used to characterize the climatic conditions. The results of diversity among studied sites showed higher species richness and density in the West sites compared to the rest of the sites. Shannon diversity index was highest at Southern site (19.3) and showed a decrease from 2010 to 2012 which could be explained by the trend in rainfall.

Key words: Jordan, Medicinal plant, Species density, Species diversity

INTRODUCTION

Jordan's flora is rich and highly diverse compared to other countries in the Middle East. Around 2,500 species of vascular plants have been recorded, belonging to 152 families, and about 700 genera, representing about 1% of the total flora of the world (Al-Eisawi 1996). Al-Eisawi (1996) mentioned that Jordan can be divided into four different bio-geographical zones; the Mediterranean, Irano-Turanian, Saharo-Arabian and Sudanian penetration and within these diverse zones, there are 13 different vegetation types each representing different elements of flora and fauna. The climate in Jordan is mostly semi-arid to arid-desertic with an average precipitation ranging from less than 70 mm in the Eastern and Southern desert areas arising to 350 mm in the middle, and up to 600 mm per annum in the North-West part of the country.

Biological diversity is the variety of life which encompasses the spectrum of biological organization from gene to biomes, and the spectrum of geographic locations from microsites to the biosphere (Salwasser, 1990). Various indices of diversity such as species richness, species diversity and evenness and other models can be used for species diversity assessment (Ejtehadi *et al*., 2007). Species richness is defined as the number of species within restrict area represented with quadrat. It is the most widely used measure of diversity of a biological community (Kéry and Schmid 2006). Magurran and Queriroz (2010) pointed out that species richness provides a good estimate of knowing how much diversity there is present in a given area. Hayat *et al*. (2010) stated that species richness is one of the most important elements in biodiversity and can allow the comparison among sites. Climate change affects all levels of biology and is a major threat for biodiversity (Lepetz *et al*., 2009). Establish long-term studies along natural gradients (altitudinal or latitudinal) on the same species/ habitats to cover a large geographic scales are used to assess and understand the responses of species to climate change. Climate change in addition to its negative impacts on biological systems can also exacerbate the impacts of other stressors (Prowse and Brook, 2011). Sensitivity of species composition to climate change was

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investigated by Lasch *et al*. (2002) using Shannon's and Simpson's species diversity indices) and habitat and structural diversity Seibert's index.

The spatial analysis showed a positive effect of precipitation on species richness, with each 100 mm increase in rainfall adding more than 1 species per m², on average (Adller and Levine, 2007). Ejtehadi *et al*. (2007**)** found higher species richness and species density indices in the north aspect than in the others, but this trend was not true for species evenness indices. Correlation analyses are the most frequently used approaches to analyze the effects of climate change (Lepetz *et al*., 2009). Whitfield *et al*. (2007) stated that developing correlative analysis was used based on monitoring of simple parameters such as individuals counts, presence/ absence data and density. Major factors that affect biological diversity include conversion of natural habitats to agriculture, industry and other human uses, their fragmentation, over-exploitation, and to the effects of pollution and climate change (Salwasser, 1990). Species diversity in natural habitats is high in warm and humid areas and decreases with increasing latitude and altitude; additionally, terrestrial diversity is usually higher in areas of high rainfall and lower in drier areas (Swingland, 2001). This study was carried out to assess the status and trends of *Teucrium polium* L. (Lamiaceae) medicinal plant species and vegetation cover at four selected areas of Al-Sult governorate in Jordan including the potential effects of climate change on its distribution.

MATERIALS AND METHODS

Study area

The present study was conducted in Al-Sult area located in the mountains close to Amman with an altitude of 300-800 m above sea level. Species surveys were conducted using three 50-m long transects in the three different directions, the first transect selected towards the south-north aspect and the second and third transects were selected perpendicular. Along each transect, five wood frame quadrates of 1mx1m were located randomly based on the nature vegetation of area. The quadrates were used to assess the diversity of vegetation cover particularly the medicinal plant *Teucrium polium* L. species. Global position system (GPS) was used to record the geographic coordinates and the elevation. The surveys were conducted over three years 2010-2012. The amount and distribution of rainfall for Al-Sult area was obtained from the from documents of Wadi-Shueib Agricultural Station.

Statistical analysis

Repeated measures during 2010, 2011 and 2012 concerned species richness and density and Shannon diversity index (Shannon and Weaver, 1949) estimated using PAST software program ver. 2.18c (Hammer *et al*., 2001).

RESULTS

The coordinates and altitudes of studied areas are reported in Table 1. The monthly and annual rainfall were recorded from the closest meteorological station of Wadi Shueib (Figures 1 and 2). The total amount of rainfall during 2010, 2011 and 2012 was 486 mm, 345.6 mm and 299m, respectively (Figure 1). It appears that early rainfall during December is essential for seed germination and rapid growth of plants in the arid dry areas (Saoub *et al*., 2011). A total of 179 quadrates were surveyed by the same observer during the three consecutive seasons.

The field botanic surveys showed variation in species richness over different directions within the site. In 2010, the number of species was 22, 33, 27 and 30 in the site East, West, South and Middle areas, respectively (Table 1). In 2011, species richness was highest at West part (19), followed by East (17), Middle (15) and South (11) parts. In 2012, the highest species richness was recorded at Southern part (22), followed by West (18), East (15) and was lowest in the Middle part (10) (Table 1). Over the three years, the western part showed consistently the highest species richness. This richness could be attributed to the exposition aspect of the western part and the higher humidity. For Shannon diversity index, it was highest during year 2010 in which East had the highest value (19) then East and West (17.3), respectively, whereas middle site has a value of 14.5. In 2011, the values of Shannon diversity were 15.2, 14.6, 11.9 and 11.9 for East, West, and South and Middle sites, respectively. During 2012, South site registered the highest Shannon diversity index value (18.5), followed by West (18.2), East (14) and Middle (8.9) (Table 1).

The densities registered during the three consecutive years (2010 to 2012) were 0.33, 0.13 and 0.07, respectively. *Anagallis arvensis* species showed the highest density (0.67) over the three years (Table 2). In 2010, *Filago pyramidata, Helianthemum salicifolium* and *Sarcopoterium spinosum* showed the highest densities of 0.47, 0.40 and 0.40, respectively. In 2011, the density values of 0.53, 0.33 and 0.33 were recorded for *Filago pyramidata*, *Linum pubescens* and *Anagallis arvensis*, respectively. In 2012, *Asphodelus ramosus*

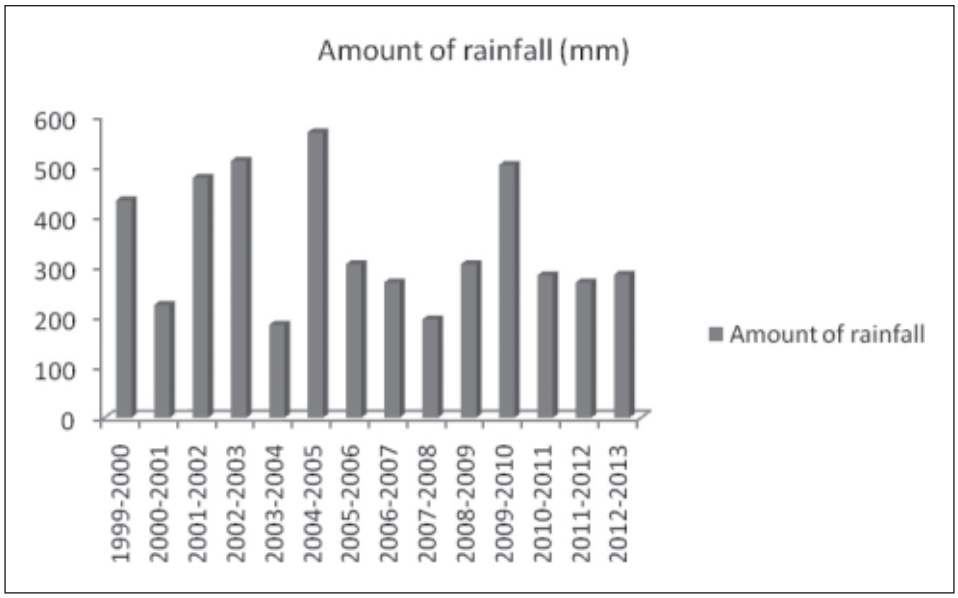

Fig. 1. The amount of rainfall (mm) during the period 2000 to 2012 at studied areas of Al-Sult governorate. (Documents of Agriculture department of Al-Sult, 2012).

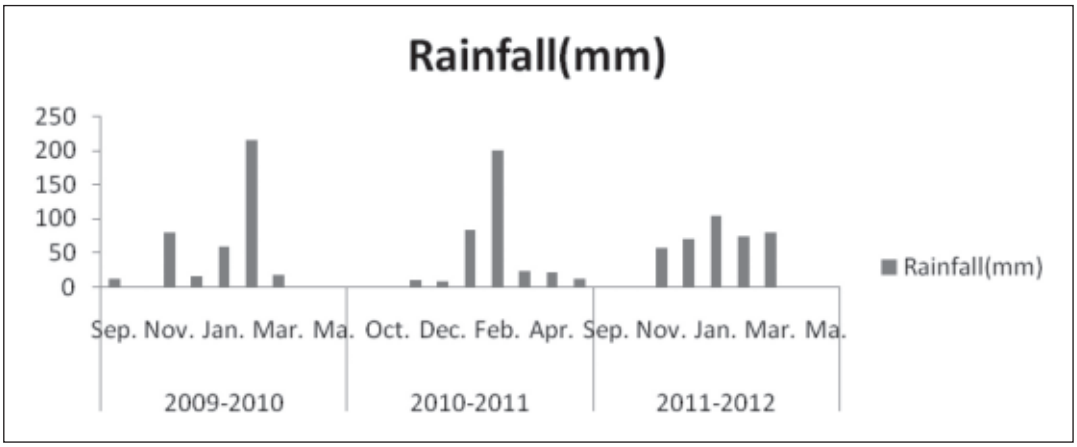

Fig. 2. Distribution of rainfall during Sep. to March months of a period 2009 to 2012.

Table 1. The coordinates, altitude, species richness and Shannon diversity for *Teucrium polium* L. a medicinal plant at four sites in Al-Sult governorate at Jordan

Direction and Site	Coordinates E°	Coordinates N°	Altitude (m)	Species richness			Shannon diversity			Total of Quadrates/ three years
				2010	2011	2012	2010	2011	2012	
East-near Mahus District	03514.936	3159.463	590	22	17	15	17.3	15.2	14.0	45
West- east of dead sea	03543.024	3201.060	831	33	19	18	17.3	14.6	18.2	44
South-east of Alkarameh	03540.088	3156.457	85	27	11	22	19.3	11.9	18.5	45
Middle-wadi Al-Sult	03544.082	3159.039	477	30	15	10	14.5	11.9	8.9	45

Table 2. Density of *Teucrium polium* L. medicinal plant and present plant species of East area of Al-Sult governorate

2010		2011		2012	
Species	Density	Species	Density	Species	Density
Aegilops peregrina	0.07	*Aegilops peregrina*	0.2	*Anagallis arvensis*	0.46
Anagallis arvensis	0.2	*Anagallis arvensis*	0.33	*Anthemis palaestina*	0.13
Anthemis palaestina	0.4	*Anthemis palaestina*	0.4	*Asphodelus ramosus*	0.67
Asphodelus ramosus	0.13	*Asphodelus ramosus*	0.27	*Astragalus tribuloides*	0.7
Bromus fasciculatus	0.27	*Bromus fasciculatus*	0.2	*Centaurea iberica*	0.7
Calendula arvensis	0.07	*Coronilla scorpioides*	0.27	*Coronilla scorpioides*	0.7
Coronilla scorpioides	0.27	*Eryngium creticum*	0.27	*Cynodon dactylon*	0.27
Eryngium creticum	0.13	*Filago pyramidata*	0.53	*Crepis* sp.	0.07
Filago pyramidata	0.47	*Galium judaicum*	0.13	*Eryngium creticum*	0.07
Helianthemum salicifolium	0.4	*Linum pubescens*	0.33	*Helianthemum salicifolium*	0.07
Hippocrepis unisiliquosa	0.2	*Plantago afra*	0.07	*Linum pubescens*	0.2
Hordeum glaucum	0.07	*Picris altisima*	0.13	*Plantago afra*	0.27
Linum pubescens	0.13	*Sarcopoterium spinosum*	0.4	*Senecio vernalis*	0.13
Linum strictum	0.07	*Scorpiurus muricatus*	0.27	*Teucrium polium*	0.07
Medicago sp.	0.07	*Teucrium polium*	0.13	*Trifolium resupinatum*	0.07
Plantago afra	0.13	*Torilis tenella*	0.07		
Picris altisima	0.07	*Varthemia iphionoides*	0.13		
Sarcopoterium spinosum	0.4				
Scorpiurus muricatus	0.13				
Teucrium polium	0.33				
Trifolium resupinatum	0.2				
Varthemia iphionoides	0.2				

and *Anagallis arvensis* showed the highest densities of 0.67 and 0.46, respectively. *Linum pubescens* and *Ononis sp*. species showed the highest density (0.90) over the three years (Table 3). In 2010, *Astragalus tribuloides*, *Picris altisima* and *Filago pyramidata* recorded the highest densities, 0.60, 0.60 and 0.50, respectively. For *Teucrium polium* L. medicinal plant species, dense population was found at Eastern part of Al-Sult area (Table 2). The densities registered during the three years (2010, 2011 and 2012) were 0.40, 0.47 and 0.40, respectively. In 2011, the highest plant densities were shown for *Picris altisima* and *Echinops adenocaulos* with values of 0.60 and 0.53, respectively. In 2012, *Linum pubescens* and *Ononis* sp. showed the highest densities of 0.60 and 0.60, respectively (Table 3). The densities recorded for *Teucrium polium* L. medicinal plant found at South West- part of Al-Sult area were 0.93, 0.93 and 0.67, respectively for the three consecutive years 2010, 2011 and 2012 (Table 4). In 2012, the density of *Teucrium polium* L. medicinal plant grown at middle- part of Al-Sult area was depicted at (Table 5). The density registered during three studied years 2010, 2011 and 2012, 0.53, 0.47 and 0.40, respectively.

DISCUSSION

Species richness and density appear to provide an easiest approach to assess the status and trends of plant biodiversity. The recorded data can provide an idea about the status and trends of plant biodiversity in one area located with the Fertile Crescent center of diversity. In our study, species richness decreased from West toward East and from South to the North, this decrease can be explained with the aridity gradients from North to South and from West to East. El Esawi (1998) and Saoub *et al*. (2011) confirmed the effects of rainfall amount and distribution on species richness and density. Early rains favors more annual species while shrubs benefit more from late rains. However the presence and absence of some species could also be attributed to soil types (González and Mata, 2005).

Oroud (2006) showed that with the current percentage of areas planted with trees and vegetables in the Jordan Valley, acclimate change (+2C, 15% reduction in precipitation) would increase irrigation water needs in the Jordan Valley by approximately 20-25 million m^3. In conclusion: preserve biodiversity can help in reduces the negative impact of climate change and flexibility of ecosystems. Studying variables affect on species composition, richness and diversity under base areas of medicinal plants or vegetation cover will directed us to promote the highly effective management plan to suit land use change within the case of national, regional and international climate change. Policy makers, non-governmental organizations and societies should integrate their efforts to combat the external factors that causes biodiversity degradation

Table 3. Density of *Teucrium polium* L. medicinal plant and present plant species of West area of Al-Sult governorate

2010		2011		2012	
Species	Density	Species	Density	Species	Density
Adonis microcarpa	0.30	*Anagallis arvensis*	0.27	*Anagallis arvensis*	0.20
Anagallis arvensis	0.20	*Anthemis palaestina*	0.27	*Bellevalia desertorum*	0.10
Anchusa aegyptiaca	0.10	*Asphodelus ramosus*	0.07	*Carthamus glaucus*	0.10
Anthemis palaestina	0.30	*Bromus fasciculatus*	0.20	*Eryngium creticum*	0.10
Astragalus tribuloides	0.60	*Calendula arvensis*	0.13	*Filago pyramidata*	0.30
Avena sterilis	0.10	*Echinops adenocaulos*	0.53	*Gundelia tournefortii*	0.10
Biscutella didyma	0.30	*Erodium* sp.	0.33	*Helianthemum salicifolium*	0.20
Bromus fasciculatus	0.40	*Filago pyramidata*	0.33	*Hordeum glaucum*	0.20
Calendula arvensis	0.10	*Helianthemum salicifolium*	0.13	*Linum pubescens*	0.60
Centaurea iberica	0.10	*Hordeum glaucum*	0.13	*Medicago*	0.10
Coronilla scorpioides	0.30	*Linum pubescens*	0.20	*Ononis* sp.	0.60
Echinops adenocaulos	0.10	*Ononis* sp.	0.27	Papaver subpiriforme	0.10
Erodium sp.	0.40	*Parietaria lusitanica*	0.20	*Plantago afra*	0.10
Euphorbia peplus	0.10	*Picris altisima*	0.60	*Ranunculus asiaticus*	0.20
Filago pyramidata	0.50	*Ranunculus asiaticus*	0.20	*Silybum marianum*	0.20
Galium judaicum	0.30	*Silybum marianum*	0.07	*Sinapis alba*	0.20
Helianthemum salicifolium	0.20	*Teucrium polium*	0.47	*Teucrium polium*	0.40
Kickxia aegyptiaca	0.10	*Trifolium campestre*	0.13	*Trifolium campestre*	0.20
Lathyrus cassius	0.10	*Varthemia iphionoides*	0.20		
Linum pubescens	0.90				
Ononis sp.	0.90				
Parietaria lusitanica	0.30				
Picris altisima	0.60				
Ranunculus asiaticus	0.20				
Rhagadiolus stellatus	0.30				
Sarcopoterium spinosum	0.10				
Silybum marianum	0.20				
Teucrium polium	0.40				
Trifolium campestre	0.20				
Trifolium resupinatum	0.40				
Torilis tenella	0.30				
Valerianella vesicaria	0.20				
Varthemia iphionoides	0.10				

through well establish of strategic planning and legislations. Recreational and ecotourism management helps in conserve biodiversity in target areas. Further studies should be included examine the rates of habitat and species migration under climate change and research is needed on effects of changed seasonal climate variables.

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Table 4. Density of *Teucrium polium* L. medicinal plant and present plant species of South-West area of Al-Sult governorate

2010		2011		2012	
Species	Density	Species	Density	Species	Density
Aegilops sp.	0.13	*Aegilops peregrina*	0.27	*Ajuga chia*	0.07
Aegilops peregrina	0.20	*Anagallis arvensis*	0.27	*Anagallis arvensis*	0.53
Ajuga chia	0.20	*Anthemis palaestina*	0.53	*Anchusa aegyptiaca*	0.07
Anagallis arvensis	0.40	*Fagonia mollis mollis*	0.l3	*Androcybium paleastinum*	0.13
Anchusa aegyptiaca	0.33	*Helianthemum salicifolium*	0.13	*Anthemis palaestina*	0.45
Anthemis palaestina	0.27	*Lathyrus cassius*	0.0.7	*Biscutella didyma*	0.07
Asphodelus ramosus	0.07	*Medicago rigidula*	0.13	*Calendula arvensis*	0.13
Bromus fasciculatus	0.13	*Parietaria lusitanica*	0.13	*Calendula palaestina*	0.13
Calendula arvensis	0.33	*Salvia horminum*	0.20	*Crepis* sp.	0.13
Centaurea iberica	0..07	*Stipa capensis*	0.07	*Erucaria hispanica*	0.27
Cynodon dactylon	0.07	*Teucrium polium*	0.93	*Euphorbia peplus*	0.07
Erodium sp.	0.07			*Gagea* sp.	0.27
Erucaria hispanica	0.27			*Filago pyramidata*	0.53
Fagonia mollis	0.07			*Iris* sp.	0.13
Filago pyramidata	0.07			*Lathyrus marmoratus*	0.07
Gundelia ournefortii	0.13			*Medicago*	0.13
Medicago rigidula	0.07			*Plantago afra*	0.20
Onobrychis crista- galli	0.13			*Ranunculus asiaticus*	0.20
Parietaria lusitanica	0.07			*Salvia horminum*	0.07
Plantago afra	0.20			*Senecio glaucus*	0.13
Picris altisima	0.07			*Senecio vernalis*	0.07
Rhagadiolus tellatus	0.13			*Teucrium polium*	0.67
Salvia horminum	0.13				
Senecio vernalis	0.07				
Stipa capensis	0.07				
Taraxacum cyprium	0.13				
Teucrium polium	0.93				

Table 5. Density of *Teucrium polium* L. medicinal plant and present plant of Middle- area of Al-Sult governorate

2010		2011		2012	
Species	Density	Species	Density	Species	Density
Aegilops peregrina	0.07	*Anagallis arvensis*	0.20	*Eryngium creticum*	0.20
Ajuga chia	0.07	*Anthemis palaestina*	0.13	*Galium judaicum*	0.13
Anagallis arvensis	0.13	*Bellevalia desertorum*	0.27	*Gundelia tournefortii*	0.20
Anchusa aegyptiaca	0.20	*Bromus fasciculatus*	0.40	*Linum pubescens*	0.27
Anthemis palaestina	0.13	*Centaurea iberica*	0.27	*Papaver subpiriforme*	0.07
Avena sterilis	0.07	*Filago pyramidata*	0.07	*Plantago afra*	0.07
Bellevalia eigii	0.47	*Gundelia tournefortii*	0.13	*Ranunculus asiaticus*	0.07
Bromus fasciculatus	0.40	*Helianthemumsalicifolium*	0.07	*Salvia horminum*	0.27
Campanula punculus	0.13	*Linum pubescens*	0.20	*Sarcopoterium pinosum*	0.67
Centaurea iberica	0.20	*Ononis* sp.	0.13	*Teucrium polium*	0.40
Cichorium pumilum	0.07	*Salvia horminum*	0.27		
Coronilla corpioides	0.13	*Sarcopoterium spinosum*	0.60		
Erodium sp.	0.07	*Teucrium polium*	0.47		
Eryngium creticum	0.07	*Torilis tenella*	0.20		
Filago pyramidata	0.07	*Varthemia iphionoides*	0.13		
Galium judaicum	0.20				
Gundelia tournefortii	0.13				
Linum pubescens	0.20				
Medicago rigidula	0.07				
Phagnalon rupestre	0.13				
Picris altisima	0.07				
Ranunculus asiaticus	0.07				
Raphanus rostratus	0.20				
Retama raetam	0.07				
Sarcopoterium spinosum	0.53				
Sinapis alba	0.13				
Teucrium polium	0.53				
Torilis tenella	0.13				
Urospermum picroides	0.13				
Varthemia iphionoides	0.07				

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