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Weed Communities of *Juniperus procera* in Southwestern Saudi Arabia

مجتمعات الأعشاب الضارة المصاحبة لنبات العرعر بجنوب غرب المملكة العربية السعودية

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Abstract: This study deals with the recognition and description of the weed communities of *Juniperus procera* in the Al-Soudah area in southwestern Saudi Arabia. Species cover matrix of 34 annual and perennial species recorded in 80 stands were classified using cluster analyses and ordinate using DCA. Six vegetation groups were generated after the application of cluster technique. Life-form spectrum was found to be of high percentage of annual and perennial herbs and low percentage of perennial shrubs. The annual and perennial herbs are characterized by higher species richness and lower species turnover. The effect of soil variables (soil salinity, organic matter, K, N and Mg) on species diversity and abundance of these communities were assessed.

Keywords: *Diversity, weed, classification, phytosociology, ordination, mountain, vegetation*.

المستخلص: تهتم هذه الدراسة بتعريف ووصف مجتمعات الأعشاب الضارة المصاحبة لنبات العرعر بمنطقة السودة الواقعة في جنوب غرب المملكة العربية السعودية . تم تقسيم 80 موقعا تحتوي علي 34 نوعا حوليا ومعمرا إلي ست مجموعات نباتية، بناءا علي التحليل الدليلي ثنائي الاتجاه. أظهرت الدراسة أن طرز الحياة الشائعة هي الأعشاب الحولية والمعمرة ثم يتبعها الشجيرات القصيرة المعمرة وهي الأقل شيوعا. وتتميز الأعشاب الحولية والمعمرة بوفرة نوعية عالية وبعائد نوعي منخفض. أظهر تنسيق المواقع بطريقة التحليل التقابلي تأثير تركيز أيون الهدروجين والنتروجين والبوتاسيوم والمغنسيوم في التربة علي الكساء الخضري.

كلمات مدخلية : *التنوع، الأعشاب الضارة، التصنيف، علم الاجتماع النباتي، التنسيق، الجبال، الغطاء النباتي.*

INTRODUCTION

The southwestern region of Saudi Arabia is unique with regard to its nature, landform, climate and water availability (Abulfatih, 1984). Several ecological studies have been made in some of the phytogeographical regions of Saudi Arabia. Inthese studies Asir region has received the least attention. Most of the studies carried out in the different regions of Saudi Arabia were based on qualitative field observations and authors interpretation. Although these studies were concerned with preparing floristic lists (Baierle, *et al*. 1985; Vessey-Fitzgerald, 1955), some of them gave detailed description of the plant communities in relation to some ecological factors, e.g., edaphic conditions, climate, aridity and topography (Zahran, *et al*. 1985; Younes, *et al*. 1983; and Batanouny and Baeshin, 1983).

Weeds represent a highly successful and biologically important component of the environment (e.g., arable lands, range lands, forests, and aquatic bodies). Their success is especially remarkable in view of the efforts directed towards their eradication. This very success warrants greater attention in order to understand the nature of weeds and to analyze interactions between crops, weeds and the environment (Radosevich and Holt, 1984), and how to reduce their effects on crops. The losses caused by weeds to agriculture are more than those caused by all the pests put together (Sen, *et al.* 1984). More recently, Hegazy, *et al.* (1998) has performed a detailed phytosociological analysis of the vegetation along an elevation gradient in Asir mountains, whereas Alshehri (2005) studied the distribution of some forest trees and their associated lower plants in Jabal Al-Soudah (Asir Mountains), southwestern region of Saudi Arabia, and El–Beheiry (2006) studied the ruderal plant communities of Asir region in southwestern Saudi Arabia.

The present study aims at assessing the relationship between the floristic composition and *Juniperus procera* plantations in Al-Soudah region. This study aims also at evaluating the importance of soil variables in relation to weed communities prevailing in the *Juniperus procera* plantations, and to evaluate the severity of their spread.

STUDY AREA

Al-Soudah is situated in the southwestern parts of Saudi Arabia on the highlands of Asir, about 25 km of Abha, in a mountainous area. It is about 90 km east of the Red Sea and about 220 km north of Yemen (lat. 18° 13 N´ and 42° 36 E´; Figure 1). The highest part which is accessible to vehicles is approximately 2,740 meters above sea level (masl). The area is rocky in most parts with rocks of various sizes. The soil is sandy or sandy loam with various depths. The highest part of Al-Soudah overlooks a deep valley to the west which drops down to about 1,800 masl. The valley and the surrounding lowlands are called locally “Tihama”. Geologically, the study area belongs to the greater Afro-Arabian shield which is a part of the Precambrian crustal plate, generally exposed and locally covered by Tertiary volcanic rocks (Schmidt, *et al.* 1978).

According to the climatic normals of Asir region (averages of 1990-2000), the area is under the influence of the prevailing south westerly winds during most of the year. These winds primarily originate in Africa and along the Arabian Sea and then pass over the Red Sea before reaching the Asir highlands. In general, the climatic conditions in Al-Soudah area are characterized by cool rainy summers and cooler, rainy and foggy winters. Mean annual rainfall recorded at Abha is 342.5 mm and at Al Soudah about 640.4 mm. In Abha, the mean maximum temperature is 20.4 °C and the minimum is 12.8 °C. In Al-Soudah mountains the mean maximum temperature is 17.3 °C and the minimum is 9.5 °C (Anonymous, 2000; Table 1).

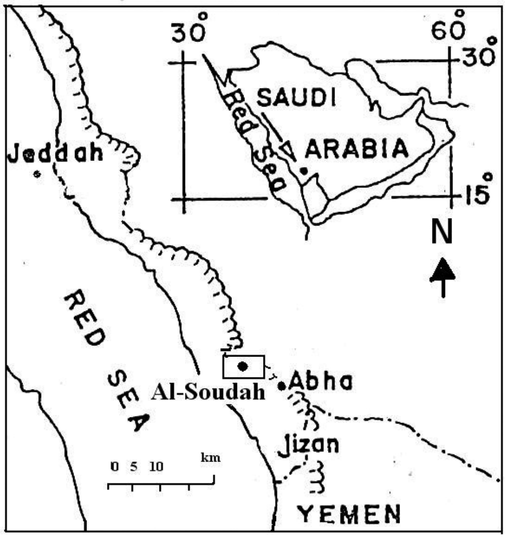

Fig. 1. A map showing Asir Mountains in the southwest of Saudi Arabia. The area under study (Al-Soudah) is enclosed in a rectangle near Abha.

Table 1. Temperature, relative humidity and rainfall for Abha and Al-Soudeh (1990-2000). Mean annual wind speed = 11.3 km / hr and Mean maximum = 13.4 km /hr.

Station	Mean							
	Annual		Summer		Winter		Annual	Annual
	Temp. (°C)		Temp. (°C)		Temp. (°C)		R.H. %	Rainfall (mm/ana)
	Max.	Min.	Max.	Min.	Max.	Min.		
Abha	20.4	12.8	26.4	13.2	18.4	7.7	87.3	342.5
Al-Soudah	17.3	9.5	9.5	11.6	12.8	6.4	94.2	640.4

MATERIALS AND METHODS

Eighty stands (20 X 20 m^2 each) were sampled in the study area. In selecting each stand, care was taken to ensure a reasonable degree of physiographic and physiognomic homogeneity of both habitat and vegetation. These stands covered the main physiographic variations of the region as described by Mandaville (1973) and Boulos (1985).

Species richness (alpha–diversity) was calculated as the average number of species per stand. The extent of species replacement or biotic change along environmental gradients (species turnover) or (beta-diversity) was calculated as the ratio between the total species in a certain plant community and its species richness (Whittaker, 1972). The species turnover gives an idea about the species replacement or biotic change along the environmental gradients (Wilson and Shmida, 1984).

Three soil samples (0–50 cm depth) were collected from each stand. Texture and organic matter of the soil samples were estimated using the Bouyoucos hydrometer and loss-on-ignition at 450°C methods, respectively. Electric conductivity (EC) and soil reaction (pH) were estimated in 1: 5 soil - water extracts using electric conductivity and pH-meters. A flame photometer was used for the determination of K, Ca and Na. Molybdenum blue and indo-phenol blue methods were applied for the determination of P and N, respectively, using a spectrophotometer. Fe and Mg were determined using atomic absorption (Allen, *et.al*. 1974).

A floristic composition list was prepared for each stand, the first and second dominant species and visual estimates of the total plant cover (%). Classification of stands was assessed using the agglomerative clustering technique. The detrended correspondence analysis (DCA) and the Principal Component Analysis (PCA) were used as ordination techniques. The classification and ordination techniques, applied were according to STAT-ITCF program (Foucart, 1982; Roux, 1985). Floristic identification are according to Täckholm (1974), Migahid (1978), Collenette (1985) and Mandaville (1990).

RESULTS

The application of the Detrended Correspondence Analysis (DCA) resulted in classifying the 80 sampled stands into 6 groups (Table 2), each group is characterized by certain species (Figure 2A). These clusters are well segregated along the ordination plane (Figure 2B). The characteristic species of the groups are: *Datura innoxia* (group I); *Arnebia hispidissima, Cynodon dactylon* and *Conyza incana* (group II); *Cynodon dactylon, Otostegia fruticosa, Datura innoxia* and *Cyperus rotundus* (group III); *Pulicaria arabica, Trifolium fragiferum* and *Cornulaca monacantha* (group IV); *Cynodon dactylon* and *Lavandula dentata* (group V) and *Cynodon dactylon, Datura innoxia, Arnebia hispidissima* and *Dodonea angustifolia* (group VI) (Table 3).

Group II had the highest total number of annuals and perennials (17 and 12 species, respectively), while group V had the lowest number of annuals and perennials (5 and 4 species, respectively). With regard to the richness of annual species, group II and IV had the highest values (4.8 and 4.9 species/stand, respectively) and group III and VI had the lowest values (2.8 and 2.4, respectively). On the other hand, group IV had the highest richness of the annual species (5.3). The vegetation clusters II and III had the widest distribution range (20 stands out of 80 sampled stands, i.e., 25%); meanwhile, some clusters had very limited range of distribution (I and IV) (Table 3).

The soils of group I are characterized by high content of sand (85.1%) and low organic matter (2.2%). Group IV are characterized by high pH (8.1) and high contents of P (12.4 mg/100g) and Mg (590 mg/100 g). Group VI are characterized by high content of clay (38.6%) and organic matter (OM) (9.8%) (Table 4). Table (5) shows that pH, N, K, Mg and OM have significant negative correlation with axis I, while K, Mg, OM, EC, Ca and pH have significant correlations with axis II.

Table 2: Percentage presence of the species in the 6 vegetation groups (derived after cluster analysis).

Species	Vegetation group						Total P (%)
	I	II	III	IV	V	VI	
Number of stands	**4**	**20**	**20**	**16**	**12**	**8**	
Herbs							
Anarrhinum pubescens	-	22	11	-	-	-	3
Arnebia hispidissima	2	11	8	3	4	12	4
Blepharis ciliaris	-	9	-	8	-	-	6
Cynodon dactylon	5	8	13	20	23	9	12
Cyperus rotundus	-	-	-	-	-	7	2
Datura innoxia	3	12	7	11	11	8	6
Eragrostis papposa	5	9	-	4	-	-	5
Erodium laciniatum	-	-	8	9	-	22	9
Filago abyssinica	-	3	-	4	-	-	8
Hypoestes forsskali	-	-	42	7	-	-	7
Maytenus undatus	6	6	-	8	8	12	11
Medicago lupulina	-	-	-	17	-	-	3
Micromeria biflora	5	12	-	4	-	-	4
Otostegia fruticosa	5	23	14	17	12	8	4
Pennisetum setaceum	-	5	8	-	8	-	4
Picris babylonica	6	8	3	3	-	-	7
Plantago boissieri	-	12	10	-	9	-	10
Pulicaria arabica	-	-	-	13	-	-	2
Stipa capenis	8	8	-	2	-	-	6
Themeda triandra	-	-	-	-	6	5	2
Trachynia distachya	-	-	22	-	-	-	10
Tricholaena tenerrifae	5	9	-	-	22	-	4
Trifolium fragiferum	14	12	-	12	-	-	7
Shrubs							
Conyza incana	11	-	8	3	-	7	12
Cornulaca monacantha	7	23	13	8	9	4	19
Dodonea angustifolia	-	9	6	9	-	8	9
Euryops arabica	-	16	-	5	-	-	6
Lavandula dentata	6	8	7	3	3	11	6
Lycium shawii	5	-	-	-	-	13	3
Onopordon sp.	6	-	-	-	-	12	2
Periploca aphylla	8	-	-	-	-	3	2
Rhamnus staddo	-	-	12	-	-	6	2
Solanum incanum	-	6	14	4	-	-	2
Solanum nigrum	-	8	3	-	-	-	2
Total species	**17**	**22**	**18**	**22**	**11**	**16**	**34**

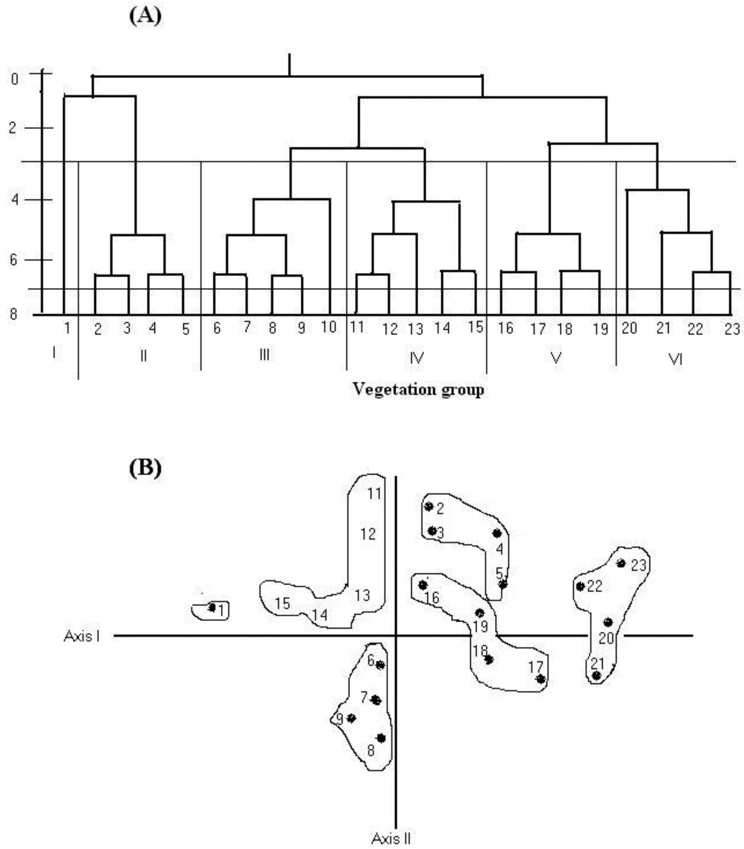

Fig. 2. **A:** Dendrogram resulting from the cluster analysis of the 80 stands, the 6 vegetation groups at level 3 are indicated (I – VI). **B:** Stand ordination along the PCA axes I and II.

Table 3: Characteristics of the 6 vegetation clusters identified in the study area. Ann.: Annual species, Per.: Perennial species.

Vegetation group	No. of Stand	Total species		Species richness		Species turnover		Cover	Characteristic species
		Ann.	Per.	Ann.	Per.	Ann.	Per.	%	
I	4	8	7	3.5	3.3	2.3	2.1	50.4	***Datura innoxia***
II	20	17	12	4.8	3.6	3.5	3.3	45.6	***Arnebia hispidissima***
								13.6	***Conyza incana***
								66.8	***Cynodon dactylon***
III	20	10	7	2.8	2.8	3.6	2.5	22.6	***Cyperus rotundus***
								23.4	***Datura innoxia***
								44.3	***Cynodon dactylon***
								19.8	***Otostegia fruticosa***
IV	16	12	8	4.9	5.3	2.4	1.5	20.1	***Pulicaria arabica***
								33.7	***Trifolium fragiferum***
								22.8	***Cornulaca monacantha***
V	12	5	4	1.2	1.2	4.2	3.3	18.8	***Lavandula dentata***
								24.6	***Cynodon dactylon***
VI	8	7	7	2.4	3.3	2.9	2.1	21.9	***Dodonea angustifolia***
								22.8	***Datura innoxia***
								13.8	***Arnebia hispidissima***
								11.4	***Cynodon dactylon***

Table 4: Results of the one way analysis of variance of the soil characters of the 6 vegetation groups. SD: Standard Deviation. * = P ≤ 0.05, ** = P ≤ 0.01, *** = P ≤ 0.001.

Soil variable	vegetation group						Mean ± SD	F-value
	I	II	III	IV	V	VI		
Clay (%)	12.6	3.2	4.8	9.9	6.3	2.4	6.53 ± 3.63	3.77
Silt (%)	2.3	17.4	26.1	8.9	29.4	38.6	20.45 ± 12.3	6.06*
Sand (%)	85.1	79.3	71.2	82.4	64.9	58.7	73.6 ± 34.5	5.15*
O.M (%)	2.2	3.7	5.4	2.4	6.1	9.8	5.41 ± 2.52	7.42***
CaCO3 (%)	3.4	2.9	4.8	3.3	4.5	4.4	3.88 ± 0.7	3.51**
EC (mmhos/cm)	2.7	1.4	2.2	1.6	3.1	2.5	2.25 ± 0.5	5.16*
pH mg/100g	7.8	7.8	7.9	8.1	7.7	7.9	7.86 ± 0.1	4.79***
N mg/100g	128	122	123	134	143	111	128.8 ± 10.1	5.43***
P mg/100g	10.5	7.9	7.4	12.4	9.4	6.5	9.01 ± 2.0	4.41**
Na mg/100g	177	291	222	167	176	207	206.6 ± 42.3	4.61*
K mg/100g	44.6	43.9	56.2	50.6	77.5	44.9	52.9 ± 11.7	2.15**
Ca mg/100g	1498	1232	1176	2315	2739	1275	1705 ± 601	3.55*
Mg mg/100g	432	584	354	590	445	362	641.1 ± 94.9	7.82***

Table 5: Simple linear correlation coefficients (r) between the PCA axis I and II and the soil variables. E.C: Electrical conductivity, O.M.: Organic matter. * = P ≤ 0.05, ** = P ≤ 0.01, *** = P ≤ 0.001.

Soil variable	Ordination axis					
	Axis I			Axis II		
	r	F	R^2	r	F	R^2
Clay (%)	0.06	1.2	0.553	-0.127	0.88	0.442
Silt (%)	0.168	1.5	0.654	0.154	0.95	0.356
Sand (%)	-0.218	2.6	0.763	0.048	1.7	0.563
O.M (%)	-0.345**	4.4	0.632	-0.574**	7.1	0.786
CaCO3 (%)	0.453	3.9	0.628	0.331	4.1	0.443
EC (mmhos/cm)	-0.278*	1.4	0.521	0.413**	3.1	0.256
pH mg/100g	-0.776***	2.6	0.794	-0.556**	1.3	0.765
N mg/100g	-0.564***	6.7	0.651	-0.621*	4.5	0.376
P mg/100g	0.143	7.9	0.742	0.321*	9.4	0.634
Na mg/100g	0.231*	2.6	0.443	-0.409*	1.6	0.395
K mg/100g	-0.582***	1.4	0.776	-0.509***	0.7	0.712
Ca mg/100g	-0.159	1.2	0.454	0.441**	1.3	0.435
Mg mg/100g	-0.564***	8.2	0.631	0.597***	3.5	0.669

DISCUSSION

Six vegetation groups were generated in the present study after the application of the agglomerative clustering technique (Roux, 1985). These were named after their dominant species as follows: *Arnebia hispidissima, Cornulaca monacantha, Cynodon dactylon, Datura innoxia, Otostegia fruticosa,* and *Lavandula dentata*. After the earlier surveys (Mandaville, 1973), a number of studies on the vegetation of southwestern Saudi Arabia were carried out. Among these are those of Boulos (1985) who provided a list of common plant species found over the high mountains of Asir. Chaudhary, *et al*. (1988) recorded the plant species of Raidah escarpment located west of Abha. General information on the flora and vegetation of Saudi Arabia exist in the publications by Migahid (1978), Zahran, *et al*. (1985), Collenette (1985), Chaudhary (1987 and 1989), Abulfatih, *et al*. (1988) and Abulfatih and Nasher (1988).

The main factors influencing species diversity of a given area are the mildness and heterogeneity of environmental conditions and the past and present sources of the flora (Danin, 1978; Whittaker, 1972). Species diversity increases as the number of species per sample increase, and as the abundance of species within a sample becomes even (Pielou, 1975). Therefore, the plant communities of group II and group IV in the present study are more diverse than those of other vegetation groups. High diversity of such communities is associated with the increase in annuals during spring. This is supported by the conclusion made by Precsenyi (1981) who found that the diversity of certain communities decreased from spring to autumn. Al-Sodany, *et al*. (2003) indicated that *Juniperus phoenicea – Sarcopoterium spinosum* is the most prominent vegetation type in the Mediterranean matorrals where its diversity and cover increases with elevation reaching the Mediterranean forests at the highest elevated sub-humid zones.

According to Al-Hubaishi and Hohenstein (1984), the southern Arabian phytogeographical region (including Yemen) contains 2000 – 2500 species of flowering plants. The most important tropical genera in Arabia are *Acacia, Indigofera, Euphorbia, Solanum, Aristida, Caralluma, Tephrosia, Pulicaria, Barleria, Grewia, Commiphora,* and *Cadaba*. About 20% of the floristic elements of southern Arabia are endemic (Schwartz, 1939). The present study records 34 species in Al-Soudah region, of which 23 are annuals and 11 are perennials.

Newton (1980) regarded Southern Arabia and Ethiopia as a single phytogeographical unit, the Eritreo-Arabian province. Zohary (1973) reported that the floristic composition of Southwest Arabia, especially those of the interior deserts show some floristic affinities to the Irano – Turanian and Mediterranean territories. The study area represents a continuation of the Sudanian tropical region with close similarity in climatic and topographic conditions. Therefore most of the recorded species in this study are considered as Afro-Tropical.

The correlation analyses between the soil variables and ordination axes in the present study indicates that pH, organic matter, K and Mg are the most effective variables in stand ordination. The ratio Na/(Ca + Mg) and K/(Ca + Mg) determines the absorption pattern of these cations by exchange complex (Waisel, 1972). Therefore, it may be concluded that the distribution of vegetation in the study area is controlled edaphically by four main parameters: pH, N, K and Mg.

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