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Original article

Ecology of endangered *Prunus korshinskyi* Hand.-Mazz. in Jabal Al-Lauz, Saudi Arabia: Plant associations, size structure, and nutritional screening

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ABSTRACT

The wild *Prunus korshinskyi* has a restricted distribution in small scattered areas of Jabal Al-Lauz (2580 m above sea level), a mountain in northwestern Saudi Arabia. Major objective of current study is to provide information about *P. korshinskyi* by analyzing its ecology in terms of floristic diversity, plant associations, environmental features, and its size structure and nutritional value. For this purpose, 12 stands of 20 m^2 were selected along the Jabal Al-Lauz mountain ridge. Three plant associations and their environmental variables were identified and characterized after application of a two-way indicator species analysis (TWINSPAN), detrended correspondence analysis (DCA). And canonical correspondence analysis (CCA) as follows: VGI: *P. korshinskyi-Astracantha echinus*, VGII: *Artemisia siberi-P. korshinskyi*, and VGIII: *Retama raetam-Artemisia sieberi*. The edaphic factor affecting the distribution of the associations were pH, potassium and manganese content. The size class frequency distribution of *P. korshinskyi* shows a J-shape in spring and fall for the whole population; there was no regeneration via seed. Nutritional evaluation showed the fruits had a higher content of total carbohydrate, fats, crude protein, phosphorus, and potassium, and lower content of ash, Fe, Ca, Mn, Mg, and Zn than that in stems and leaves. This ecological knowledge gained through this study would be beneficial for managing and conserving of *P. korshinskyi* in a Jabal Al-Lauz area with its distinct and unique vegetation.

1. Introduction

Phytosociological analysis of plant community is the primary basis for the study of any vegetation, as it is a prerequisite to the understanding of community structure and organization. It provides information on the structure and dynamics, external influences, biological responses to change interaction of species/classes and interlinkages amongst species, successional status of key species and ecological restoration of degraded habitats in a community (Kent, 2012). Such studies provide information on distribution of species and also on the affinities between or within the classes results in the valuable assessment of vegetation within the study area (Frenedozo-Soave, 2003). Phytosocological as well as autecological studies are of great significance for their own sake; the progress of the study of plant communities is greatly affected by the lack of evidence regarding the life history and biotic relations of their constituent species.

Jabal Al-Lauz is the highest mountain in the northern Hijaz in northwestern Saudi Arabia. The mountain has a varied vegetation with a great degree of Mediterranean influence. There are several plant species that cannot be found anywhere else in the kingdom. *Prunus korshinskyi* Hand.-Mazz., is one of the dominant species found at high altitudes. In arid regions, the high-altitude areas are certainly the main hotspots with much species diversity in variable habitats (Thomas et al., 2017). The biodiversity in relation to vulnerable ecosystems in arid areas has been largely affected through many factors inconsists of both climate change and

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human impacts (Zhang and Ma, 2008). To our knowledge, there are no previous studies of the ecology, vegetation as well as the floristic features of this area.

As per the IUCN red list of threatened species, *P. korshinskyi* has a vulnerable status (Güner, 1998). It is a small-sized tree, which is distributed in Turkey, Syria, Lebanon, Palestine, and Saudi Arabia, mostly found in northern Hijaz Mountains. Ecology of *P. korshinskyi* in Saudi Arabian habitats has not been studied before, and this is the first study of its kind. It will pave the way for improving the conservation strategies of this endangered plant not only in Saudi Arabia but in other countries as well.

The present study aims to provide information about *P. korshinskyi* by investigating its ecology: (1) floristic diversity, vegetation structure and environmental features and (2) *P. korshinskyi* size structure and nutritional value of its component parts. The characteristics of the individual plant populations along with the conditions under which they grow have great influence on the distribution of the species. This study will help understanding the floristic composition as well as the present and future status of the endangered *P. korshinskyi*.

2. Materials and methods

2.1. Study area

Jabal Al-Lauz is present in northwestern area of Saudi Arabia near Gulf of Aqaba in the Tabuk region (Fig. 1). The Jabal Al-Lauz range consumes about 464 km^2; highest peak (2580 m above sea level) is located at 28°39′15″N 35°18′21″E. To the north is the Wadi Hajy, to the south is the Wadi Houi, to the west is the valley of Afal, and to the east is the Wadi Al'abyd. According to a US Geological Survey report, the peak of Jabal Al-Lauz, consists of light colored, calcium-rich, alkaline granite that is intruded by rhyolite and andesite rock sheet dikes.

The climate is continental, even though influenced sporadically at the Mediterranean Sea. At winter season, the penetration of cool Mediterranean air masses brings frontal rainfall events with high intensities. During summer, 47 °C is highest temperature, and −2°C is lowest during winter. Overall, 28 °C and 12 °C is the on an average temperatures in summer and winter (Alsharan et al., 2001). 20 mm is the average rainfall per annum (Fig. 2), 40 mm is the annual evaporation.

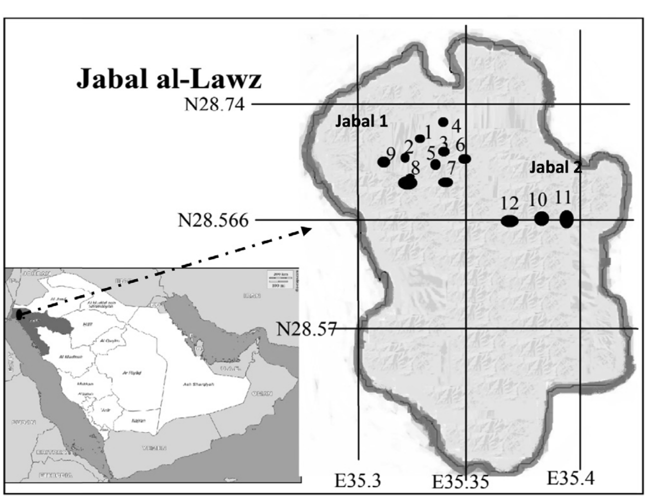


Fig. 1. *Prunus korshinskyi* in Jabal Al-Lauz, N.W. Saudi Arabia showing the samples stands.

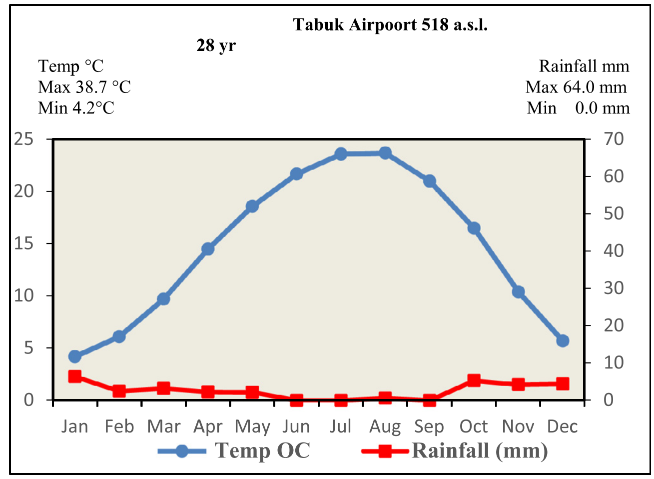


Fig. 2. Tabuk climate diagram, Saudi Arabia (1987–2015).

2.2. Vegetation samples

Totally, 12 samples relevés of 20 × 20 m were established in Jabal Al-Lauz, as two groups: relevés 1–9 were in Jabal 1 group and relevés 10–12 were in Jabal 2 group during the spring and fall seasons of 2016 (Fig. 1). Selected plant specimens were collected as per Collenette (1999) and Chaudhary (1999). The species which are life form is determined by Raunkiaer et al (1934). Based on the chrological analysis, the species which comes under category of floristic and abundance cover are also made (Wickens 1978, Zohary 1973, Kent 2012) (see Fig. 3).

2.3. Nutritional analysis of P. korshinskyi

In April 2016, from each stand, the plant samples were selected stand and separated into stem, leaves, and fruits. Each of these plant parts were further cleaned, dried under shade and powdered with a metal-free plastic mill. Sodium, ferrous, calcium, magnesium, potassium, manganese, zinc and phosphorus were analyzed. Ash content was assessed at 500 °C, total lipids were determined with ether extract. Crude protein (CP) and carbohydrates were calculated. Allen et al (1989) protocol was implemented in this study.

2.4. Size structure of P. korshinskyi

Concerned stands with area 20 m × 20 m the height as H and mean crown diameter as CD measured in different orientations based on uniformity with crown of measured tree in an individual plant of *P. korshinskyi* were measured (cm) in spring and autumn. The size index of *P. korshinskyi* is calculated as H + CD/2 (Crisp and Lange, 1976; Shaltout et al., 2003). Size index values were measured to find the distribution frequency in various size (age) cohorts. Specific size estimations are used for classifying the *P. korshinskyi* population in nine categories (first and second classes represent the juvenile stages). There were no seedlings. Overall density of plant species/hectare were measured in order to assess the characteristics of precise classes. We have also calculated the mean of height, density, size index and crown diameter of *P. korshinskyi* for separate season were also measured.

2.5. Analysis of soil samples

From the similar releves the soil samples were adopted during the similar time along with the plant samples. As per the loss on

Fig. 3. Morphology of the plant and fruits attacked by the insects.

ignition, an organic matter was resoluted at 550 °C. The texture of soil was determined using the method of hydrometer. Soil water extracts were prepared at 1:5, for estimating the pH, electrical conductivity (EC, mS cm^{-1}) and soil nutrient elements (calcium, potassium, sodium, magnesium, ferrous and phosphorus) (Allen et al 1989).

2.6. Vegetation data analysis

Both the plant species cover the soil variable data sets which were subjected to multivariate analyses for classification using TWINSPAN (Hill, 1979a) and confirmed by the ordination using DECORANA (Hill, 1979b) of the Jabal Al-Lauz vegetation. CCA was carried out by Canoco 4.5 for windows to correlate between a derived vegetation and their environmental variable data set (Ter Braak and Smilauer, 2002).

Richness of the species for each vegetation association of *P. korshinskyi* and habitat were measured on an average species number/relevé. This species cover importance values were applied to assess the relative species evenness by index of Shannon-Weaver: $\hat{H} = \sum_{i=1}^{s} pi \log pi$ and the relative species concentration dominance by index of Simpson: C= $\sum_{i=1}^{s} pi^2$; (s) is species no. and (*pi*) is the % cover of the (*i*th) species. More details about these indices are available in Pielou (1975).

2.7. Statistical analysis

Pearson's simple linear correlation coefficient (r) was used to test the relation between DCA axes and environmental variables. The variations of species diversity and soil characteristics in relation with vegetation associations are done by One-way ANOVA analysis (SAS, 1989–1996).

3. Results

3.1. Floristic composition

A total of 44 species from 21 families were recorded; highly signified families; Asteraceae, Cruciferae and Lamiaceae. Sub-shrubs constituted the most common life form (50%), followed by annual herbs (27.3%) and shrubs (15.9%) (Table 1; Fig. 4a). Jabel Al-Louz in the northwestern region influenced with Saharo-Arabian floristic

Table 1
Synoptic table of the recorded species cover in the three vegetation clusters identified after application of TWINSPAN: VGI: *Prunus korshinskyi-Astracantha echinus*, VGII: *Artemisia sieberi-Prunus korshinskyi* and VGIII: *Retama raetam-Artemisia sieberi*. Life forms: Ah: Annual herb, PG: Perennial grass, SSH: Subshrub, SH: Shrub, TR: Tree The chorotypes: AF: African, IT = Irano Turanian, Med = Mediterranean, SA = Saharo Arabian, SM = Somalia Masai, TR: Tropical.

Species	Family	Life form	Chorotype	VG I	VG II	VG III
Prunus korshinskyi	Roaceae	SH	Med	20	15	10
Artemisia sieberi	Asteraceae	SSH	IT	50	60	20
Tanacetum santolioides	Asteraceae	SSH	IT	10	15	.
Alkanna orientalis	Boraginaceae	AH	Med-IT	1	5	1
Retama raetam	Leguminosae	SH	SA	.	5	40
Astracantha echinus	Leguminosae	SH	IT	5	25	.
Ononis natrix	Leguminosae	SSH	TR AF	.	5	8
Nepeta sheilae	Labiatae	SSH	SA	.	2	1
Ferula sinaica	Umbelliferae	SSH	SA	.	2	5
Echinops glaberrimus	Asteraceae	SSH	SA	.	2	5
Centaurea eryngioides	Asteraceae	SSH	IT	1	4	1
Zilla spinosa	Cruciferae	AH	SA	.	.	6
Gypsophila capillaris	Caryophyllaceae	SSH	IT	.	.	1
Picris babylonica	Asteraceae	AH	SA	.	2	.
Sisymbrium erysimoides	Cruciferae	AH	Med-SA	.	1	1
Asparagus sp.	Asparagaceae	SH	Med	.	5	.
Teucrium polium	Labiatae	SSH	Med-IT	.	5	3
Allysum subspinosum	Cruciferae	AH	SA	5	4	2
Anarrhinum forsskalii	Scrophulariaceae	AH	Med	.	2	.
Galium spurium	Rubiaceae	AH	TR-AF	1	.	.
Ballota undulata	Labiatae	SSH	Med	1	5	.
Pterocephalus sanctus	Dipsacaceae	SSH	SA	1	5	.
Noaea mucronata	Chenopodiaceae	SSH	IT	5	5	.
Verbascum sinaiticum	Scrophulariaceae	SSH	IT-SA-SH	1	1	.
Ballota adenophora	Labiatae	SSH	Med	.	1	.
Sisymbrium septulatum	Cruciferae	AH	TR AF	1	.	.
Silene linearis	Caryophyllaceae	SSH	SM	.	2	.
Rosa abyssinica	Roaceae	SH	SM	.	2	.
Stachys aegyptiaca	Cruciferae	AH	TR AF	.	1	.
Antirrhinum orontium	Scrophulariaceae	AH	Med	1	.	.
Diplotaxis harra	Cruciferae	AH	SA	.	1	.
Fagonia mollis	Zygophyllaceae	SH	SA	.	2	.
Atraphaxis spinosa	Polygonaceae	SSH	Med	5	1	.
Deverra triradiata	Umbelliferae	SSH	SA	.	1	.
Campanula erinus	Campanulaceae	AH	Med	.	1	.
Origanum syriacum	Labiatae	SSH	Med	.	1	.
Parietaria alsinifolia	Urticaceae	AH	SA	.	1	.
Ephedra foliata	Ephedraceae	SH	SA-IT	.	.	.
Lavandula pubescens	Labiatae	SSH	SA-IT	.	.	.
Pistacia khinjuk	Anacardiaceae	Tr	Med-IT	.	.	.
Piptatherum miliaceum	Gramineae	Per.grass	Med-SA	.	.	.
Astragalus spinosus	Leguminosae	SSH	IT	.	.	.
Ficus palmata	Moraceae	Tr	SM	.	.	.
Scrophularia deserti	Scrophulariaceae	SSH	SA	.	.	.

elements (31.8%), followed by elements belongs to the Mediterranean region (20.5%). Mediterranean-Irano-Turanian and Tropical-African have the highest value among the biregional elements (6.8%) (Table 1; Fig. 4b).

3.2. Plant associations

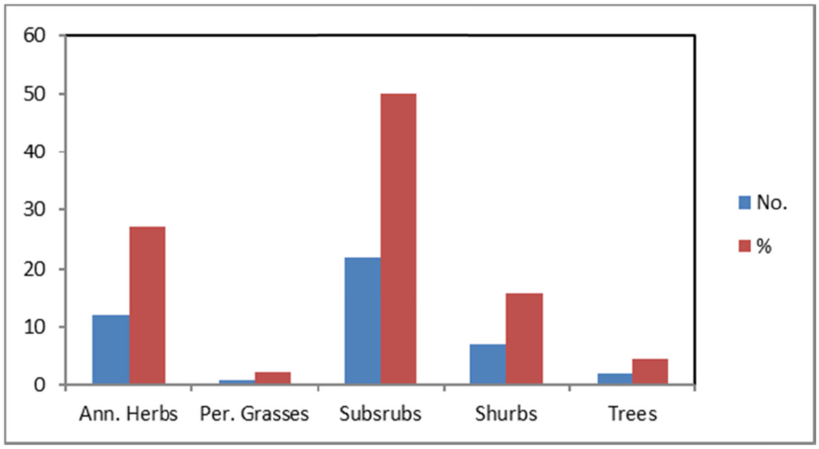
The TWINSPAN -analysis at level 2 indicated three vegetation groups (Table 2; Fig. 5a and b). After the initial and secondary dominant species, these groups were names as VGI: *P. korshinskyi-Astracantha echinus;* VGII: *Artemisia sieberi-P. korshinskyi;* and VGIII: *Retama raetam-Artemisia sieberi*. The DCA -analysis verified the -distinction of these groups (Fig. 5b). The correlation analysis between the environmental variables and ordination axes was verified by CCA (Table 3; Fig. 6). The segregation of relevés along axis 1 is -influenced positively by pH, K, and Mn (Table 3; Fig. 6a). The evenness and Shannon index are positively associated through axis-2, but Mn and species are negatively correlated with axis-2. Annual herbs (such as: *Picris babylonica, Sisymbrium erysimoides, Diplotaxis harra,* and *Parietaria alsinifolia)* are situated at upper positive side of axis-2 and correlates with organic matter, EC, Mg, and sand content (Fig. 6b), while the perennial herbs (*Ballota undulata, Origanum syriacum, Stachys aegyptiaca,* and *Tanacetum santolinoides*) are situated at lower negative side of axis-2 by plant cover, Simpson index, and P content.

3.3. Interaction with species diversity and soil

Total number of species and richness is absolutely associated with pH, sand and Mn content. However, it is negatively associated with clay and silt content (Table 3). Species is positive associated with sand content and negatively associated with clay, silt and phosphorous content. Evenness shows a positive correlation with sand. The Shannon index is significantly associated with pH and sand content and negatively connected with clay content. The Simpson index is significantly associated with clay and potassium and phosphorus content; negatively corelated with sand content.

3.4. Soil characteristics of vegetation group(s)

P. korshinskyi-Astracantha echinus (VG I) had -high values in species evenness, Shannon index, organic matter, clay, magnesium, phosphorus and ferrous content, and the lowest values in total species number, total plant cover, Simpson, pH and manganese a)



b)

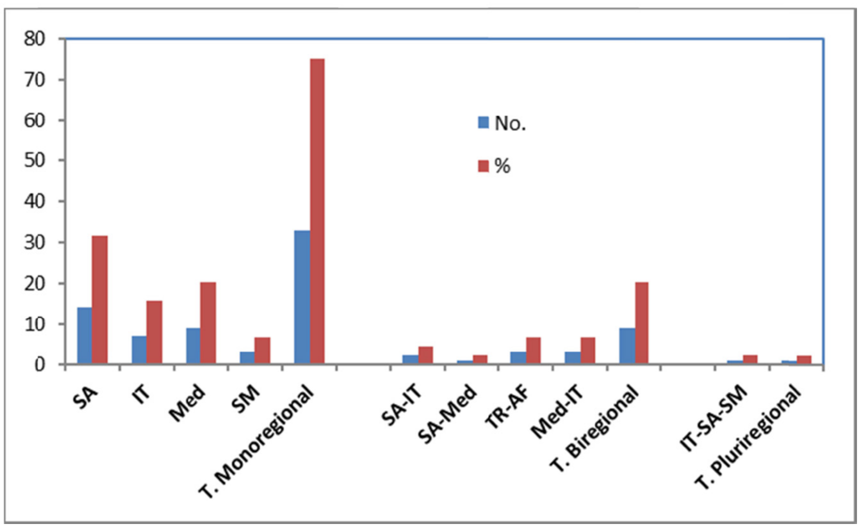


Fig. 4. Life-form relative spectrum of Jabal Al-Lauz vegetation (a). The chorotypes of Jabal Al-Lauz (b): AF: African, IT: Irano Turanian, Med: Mediterranean, SA: Saharo Arabian, SM: Somalia Masai and TR: Tropical.

Table 2
Inter-set correlations between environmental variables and DCA axes in Jabal Al-Lauz.

Variable	Axis 1	Axis 2
Soil Variable		
pH	0.7313***	−0.1554
EC mS/cm	−0.0396	0.0341
Bulk soil %		
Organic Matter	−0.2271	0.2154
Sand	−0.1934	0.0552
Clay	0.1556	−0.2325
Silt	0.1897	0.1239
Macro-elements ppm		
Sodium	0.2603	−0.1200
Magnesium	−0.0270	0.0984
Phosphorus	−0.1239	−0.1032
Potassium	0.4127**	−0.1264
Calcium	0.0372	0.1208
Manganese	0.4977**	−0.4458*
Ferrous	−0.0229	−0.0461
Diversity indices		
Species number	0.2246	−0.0320
Species cover (m100 m^{-1})	−0.0647	−0.5556**
Species richness (spp. $stand^{-1}$)	0.2480	0.1816
Evenness	0.1383	0.5352**
Shannon ($\hat{H}$)	0.3519	0.4904**
Simpson (C)	−0.1985	−0.5500**

* $P \leq 0.05$.
** $P \leq 0.01$.
*** $P \leq 0.001$.

content (Table 4). The *P. korshinskyi-Artemisia sieberi* community (VG II) had higher content of the total species number, total plant cover, richness, Simpson index, sand and lower values of species evenness, Shannon, salinity, clay, silt, potassium, calcium, magnesium, sodium, phosphorus, and ferrous. The *Retama raetam-Artemisia sieberi* community (VG III) had the higher values of species richness, salinity, pH, silt, manganese, potassium, sodium, calcium and lower values of organic matter and sand content.

3.5. Nutritional analysis

Nutritional analysis on the plant parts of *P. korshinskyi* revealed that the stems showed the highest content of ferrous, manganese, magnesium, and zinc and lowest content of fats, crude protein, and sodium. Leaves had the highest content of ash, sodium, and calcium and lowest content of carbohydrate, phosphorus, and potassium. Whereas, the fruits had the highest content of carbohydrate, fats, crude protein, phosphorus, and potassium, and lowest content of ash, ferrous, calcium, manganese, magnesium, and zinc (Table 5).

3.6. Size structure

Population structure studies of *P. korshinskyi* revealed that during the spring and autumn seasons the values of density, diameter and size index are higher in Jabal 1 while height values are higher

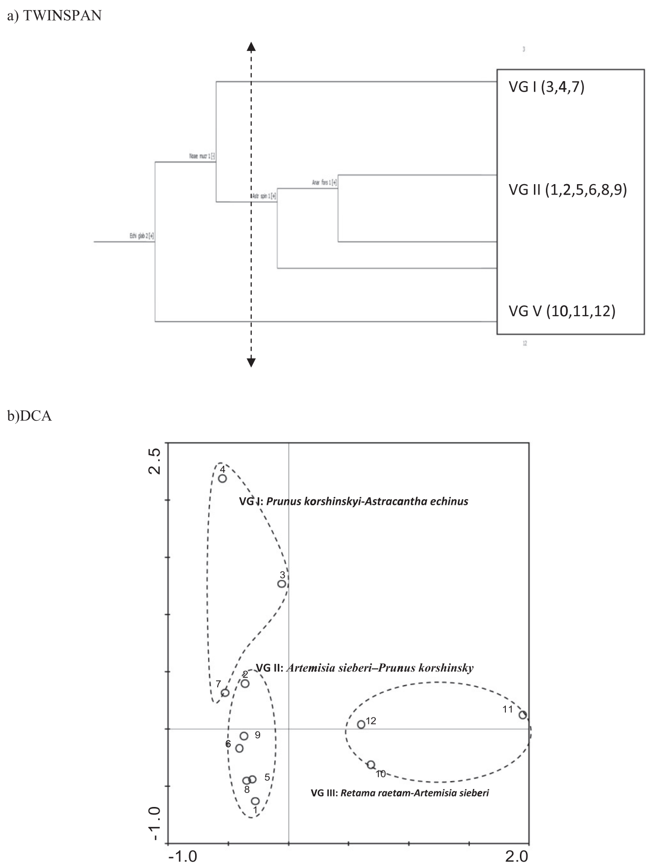


Fig. 5. TWINSPAN classification of sample relevés into three vegetation groups (a) and confirmed by DCA ordination (b).

in Jabal 2 (Table 6). The ratio of height to diameter of *P. korshinskyi* is more than unity, with the trees having a cylindrical habit. The size class frequency distribution of *P. korshinskyi* shows J-shape in both spring and fall for the whole population (Fig. 7a, b).

4. Discussion

In Saudi Arabia limited distribution of *P. korshinskyi* were available from north-western side with few escarpments and slopes of Jabal Al-Lauz. It occurs due to inability of regeneration via seeds of flowers of *P. korshinskyi* is infected through the fruit wasp *Eurytoma amygdali*, which consumes the ovary during the flowering stage itself. This shows that *P. korshinskyi* might be propagated only by vegetative means in Jabal Al-Lauz since we have observed only small juvenile individuals.

Asteraceae, Cruciferae, and Lamiaceae were the most represented families in Jabal Al-Lauz. Similar results have been reported in Migahid (1990), Thomas et al. (2016), and Thomas et al. (2017) in diverse regions especially in northern side of KSA, whereas the vegetation has a typical Saharo-Arabian floristic structure as reported by Quézel (1978) and Al-Hassan (2006). The sub-shrubs (Chamaephytes), followed by therophytes and shrubs were the most common life forms in Jabal Al-Lauz. The high number of Chamaephytes is typical of dry desert vegetation (Deil, 2014). In addition, also therophytes with short life spans are adapted to dry habitats (Kassas and Imam, 1954; Asri, 2003; Shaltout et al., 2010; El-Sheikh, 2013). Our results are in line with other studies in different parts of KSA (Thomas et al., 2017; El-Sheikh et al., 2019).

There is a high share of Saharo-Arabian plants in this study site, as a result of the more convenient environmental factors which provide suitable shelter for Saharo-Arabian species (Ghazanfar and Fisher, 1998). The presence of numerous biregional elements species in Jabal Al-Lauz may be a result of the area being considered to be in a transition region between some floristic zones (e.g., Mediterranean, Irano-Turanian, Tropical and African). Alatar et al (2012) documented the phytogeographical areas have much influence on flora at north side of KSA.

P. korshinskyi is a three plant associations, two of them (VG I and VG II) are characterized by the presence *P. korshinskyi*. It is interesting to notify that *P. korshinskyi* was one of the main plant community components in Jabal Al-Lauz. Talhouk et al. (2000) reported similar results of endangered *P. korshinskyi* in the mountains of Lebanon. *P. korshinskyi* and associated species are found on many sites such as cliffs and between cracks on slopes of the mountain, which have an alkaline silty soil with more minerals composition.

The segregation of the releves laterally for the axis one is powerfully associated with pH, potassium, manganese, organic matter and sand content. Plant distribution and compositions are well known to be determined by the micro environmental features (Keenan and Kimmins, 1993). Annual herbs like *Picris babylonica, Sisymbrium erysimoides, Diplotaxis harra, Parietaria alsinifolia* were situated at upper positive region at both the axis connected with soil factors: organic matter, EC, Mg and sand content. There is an increasing amount of human activities (e.g:, firing, trampling,

Table 3
Correlation analysis of species diversity indices and soil features.

Variable	Species number	Species richness	Species cover	Evenness	Shannon ($\hat{H}$)	Simpson (C)
Soil variables						
pH	0.4112*	0.4310*	−0.0308	0.1875	0.4625*	−0.3796
EC mS/cm	0.0694	0.0025	0.3723	−0.1806	−0.0256	0.1731
Bulk soil %						
Organic matter	0.1833	0.1511	0.2932	0.0833	0.2535	−0.1917
Sand	0.5958**	0.5120**	0.5377**	0.0472	0.5030**	−0.4000*
Clay	−0.5218**	−0.5041**	−0.3315	−0.2238	−0.5920**	0.5262**
Silt	−0.5442**	−0.4148*	−0.6233**	0.1296	−0.3159	−0.0827
Macro-elements ppm						
Sodium	−0.1984	−0.2658	0.2049	0.3021	0.0215	−0.1917
Calcium	0.1074	0.0675	0.3056	0.0111	0.1556	−0.0379
Manganese	0.4712*	0.4227*	0.06630	−0.3676	0.0453	0.1256
Magnesium	0.1746	0.1271	0.3705	−0.0853	0.1273	0.0134
Potassium	−0.1190	−0.1300	−0.3834	0.3131	−0.2897	0.4821*
Ferrous	0.2951	0.2115	0.1146	−0.1528	0.1346	0.0194
Phosphorus	0.0336	−0.0203	−0.5856**	−0.056	−0.3667	0.5671**

* $P \le 0.05$.
** $P \le 0.01$.

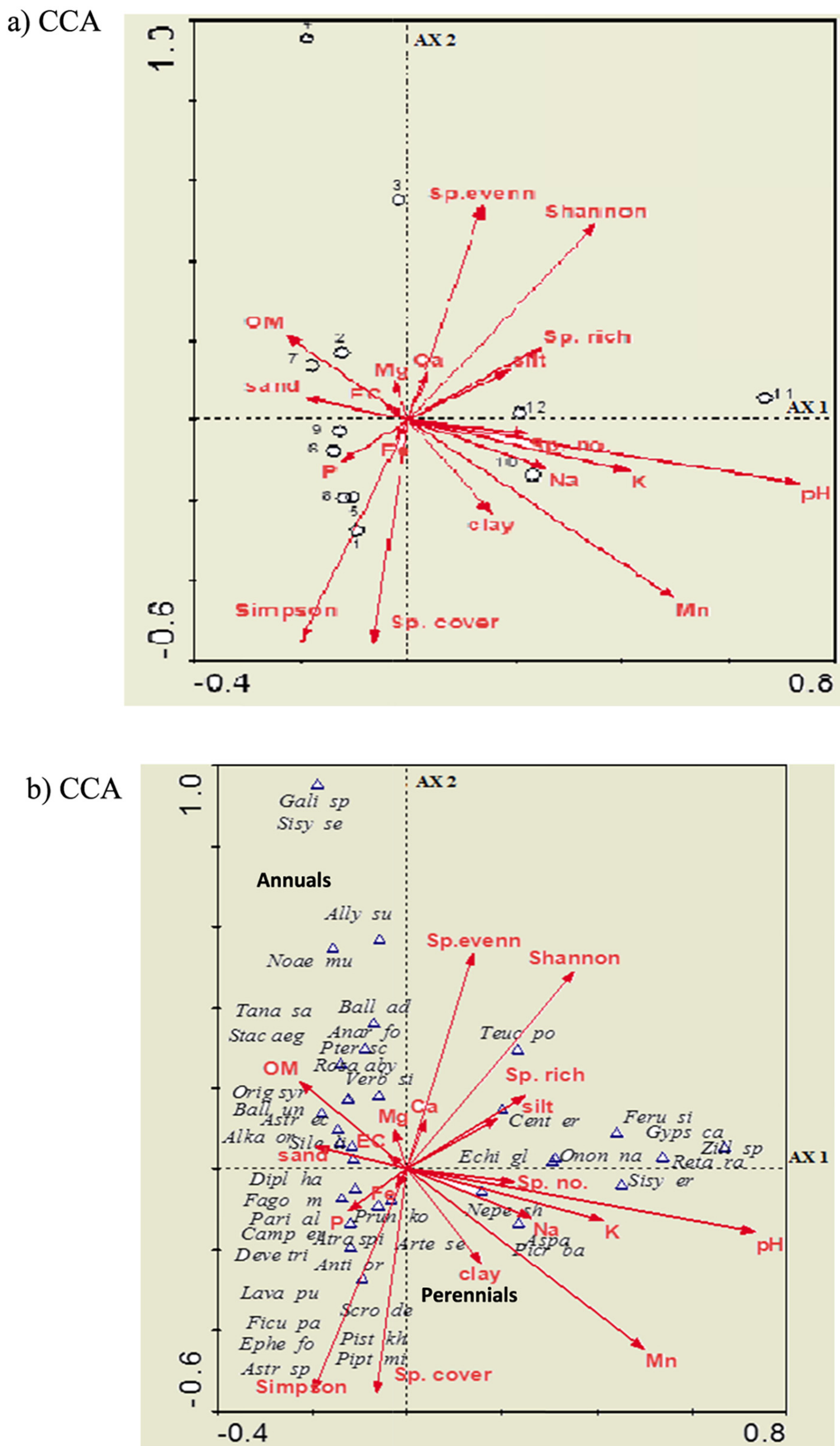


Fig. 6. CCA biplot and environmental variables (arrows), the stands (a) and the species (b). (For complete names of species, see Table 1).

grazing, and cultivation) occurring in Jabal Al-Lauz. Such activities may increase the organic matter and salinity, which alters the community structure and increase the proportion of therophytes (Shaltout and El-Sheikh, 2003).

Species number, cover, and richness were strongly associated with pH, sand and Mn content; negatively connected with clay and silt content. Whereas, the dominance of species "Simpson index" is significantly associated with clay, phosphorous and potassium content; negatively correlated with sand content. Similar -relations were stated by El-Sheikh et al. (2013). These correlation findings clearly illustrate the richness of the association VG II and why *P. korshinskyi* inhabits on sandy soil substrates which are

Table 4
Mean ± standard error of diversity indices and soil variable of three vegetation groups after TWINSPAN: VGI: *Prunus korshinskyi -Astracantha echinus*, VGII: *Artemisia sieberi-Prunus korshinskyi* and VGIII: *Retama raetam-Artemisia sieberi*. Maximum and minimum values are shown in bold.

Variable	VG I	VG II	VG III	F-Value	P-Value
Diversity indices					
Species number	**9.00** ±2.00	**11.08** ±1.73	9.33 ±3.06	3.955*	0.032
Species cover ($m-100\ m^{-1}$)	**44.00** ±23.52	**85.25** ±18.14	58.00 ±25.94	2.563	0.098
Species richness (spp. $Stand^{-1}$)	2.22 ±0.74	**2.26** ±0.29	**2.05** ±0.58	3.687*	0.039
Evenness	**0.84** ±0.02	**0.67** ±0.10	0.78 ±0.07	2.054	0.156
Shannon ($\hat{H}$)	**0.80** ±0.09	**0.68** ±0.08	0.75 ±0.15	2.582	0.096
Simpson (C)	**0.18** ±0.04	**0.29** ±0.07	0.24 ±0.09	2.320	0.122
Soil Variables					
pH	**7.77** ±0.03	7.85 ±0.11	**8.18** ±0.07	13.54***	0.000
EC mS/cm	0.45 ±0.05	**0.38** ±0.17	**0.56** ±0.07	2.205	0.135
Bulk Soil %					
Organic matter	**9.91** ±1.02	9.16 ±4.39	**7.99** ±0.10	0.291	0.878
Sand	76.67 ±3.06	**78.61** ±3.35	**76.33** ±1.53	1.211	0.360
Clay	**7.33** ±1.15	**6.56** ±2.45	7.33 ±1.15	0.659	0.633
Silt	16.00 ±3.46	**14.83** ±1.00	**16.33** ±0.58	1.079	0.413
Macro-elements ppm					
Sodium	102.97 ±4.41	**98.43** ±9.91	**125.43** ±16.46	5.083**	0.014
Magnesium	**2110.83** ±212.92	**1362.55** ±455.61	1956.45 ±152.75	2.080	0.152
Phosphorus	**150.27** ±49.30	**102.04** ±80.43	127.30 ±20.82	1.737	0.212
Potassium	600.29 ±17.91	**477.78** ±192.92	**1002.85** ±100.00	4.149*	0.027
Calcium	236.94 ±14.90	**155.17** ±78.51	**244.96** ±25.17	2.491	0.104
Manganese	**1.86** ±0.45	6.68 ±5.43	**10.19** ±2.08	2.106	0.148
Ferrous	**113.23** ±7.21	**94.39** ±33.25	122.57 ±15.72	1.114	0.398

* $P \leq 0.05$.
** $P \leq 0.01$.
*** $P \leq 0.001$.

Table 5
Mean and ± standard deviation of some nutritional components of *Prunus korshinskyi*. Maximum and minimum values are shown in bold.

Contents	Stem	Leaf	Fruit	Total Mean	F-Value	P-Value
Organic contents %						
Total carbohydrate	37.83 ±1.19	**56.17** ±0.96	**26.27** ±3.48	40.09 ±13.19	141.58***	0.000
Total lipids	**1.53** ±0.38	1.71 ±0.27	**31.08** ±2.46	11.44 ±14.78	416.72***	0.000
Crude protein	**8.18** ±1.95	18.57 ±0.55	**21.10** ±2.81	15.95 ±6.18	35.22***	0.000
Total ash	7.88 ±1.58	**21.30** ±27.46	**6.23** ±0.06	11.80 ±15.50	0.81	0.487
Minerals contents ugl^{-1}						
Sodium	**126.98** ±0.16	**165.22** ±0.39	144.70 ±0.56	145.63 ±16.58	6816.56***	0.000
Ferrous	**252.00** ±0.31	239.79 ±0.72	**130.55** ±0.85	207.45 ±57.92	30144.46***	0.000
Phosphorus	126.59 ±0.88	**113.86** ±0.30	**180.73** ±0.75	140.39 ±30.76	8040.13***	0.000
Potassium	1157.26 ±0.42	**613.40** ±0.76	**3786.3** ±17.74	1852.32 ±1469.51	82104.32***	0.000
Calcium	915.70 ±0.17	**935.24** ±0.38	**355.92** ±0.55	735.62 ±284.90	2048986***	0.000
Manganese	**279.95** ±0.37	108.44 ±0.50	**76.73** ±0.36	155.04 ±94.69	205324***	0.000
Magnesium	**3098.64** ±2.71	1260.55 ±1.49	**1003.22** ±0.48	1787.47 ±989.67	1201390***	0.000
Zinc	**68.65** ±0.93	67.41 ±0.47	**61.93** ±0.65	66.00 ±3.16	76.41***	0.000

*** $P \leq 0.001$.

Table 6
Mean and ± SD values of some demographic variables of *Prunus korshinskyi* during spring and autumn seasons.

Habitat	Density ind. ha^{-1}	Height cm/ind.	Diameter cm/ind.	Height: Diameter H:D	Size index cm	r-value between H and D
Spring season						
Jabal-1	19.0	2573.81 ±1842.46	7650.0 ±5500	2.29 ±0.6	3760.12	0.91
Jabal-2	6.7	5533.33 ±57.74	375.00 ±11.0	1.00 ±0.73	8891.67	0.733
Autumn season						
Jabal-1	18.5	2356.22 ±1652.13	7650.0 ±5500.0	2.89 ±0.56	3698.24	0.86
Jabal-2	6.0	5436.12 ±52.45	374.0 ±10.32	2.21 ±0.67	8834.25	0.67

ind. = individual.

the result of erosion of granite rocks. Certain species of grass have been reported as the main pioneering species of these sandy soil environments; the grasses stabilize the sandy substrate by fixing the sand in place, and also retain nutrients and moisture in the soils, thereby changing the environment and converting into conceivable for remaining larger plants like shrubs and trees to grow (Penney, 2010). In fact, species diversity increases with altitude where moisture content is high, due to the sand particles retained with high moisture under sandy surface and plant roots can reach to it (Deil, 2014). Thus, the higher altitude area of Jabal Al-Lauz in Saudi Arabia is considered to be a biodiversity hotspot and a vulnerable ecosystem due to climate change and increasing of anthropogenic factors (Zhang and Ma, 2008).

Our findings on the soil characteristics of *P. korshinskyi* shows that this species exhibits considerable tolerance to limestone/calcareous soils as well as drought, and it can tolerate cold conditions, and diseases. Therefore, it can be used as a rootstock for peach, plum, apricot and almond. These results are consistent with the results presented by Nicotra and Pellegrini (1989), Vito et al (2001), Gradziel (2008) and Reighard and Loreti (2008).

Many economically important species of *Prunus* as peach, nectarine, European plum apricot, mume, cherry (sweet/sour) and almond have high nutritional value and are cultivated for their fruit and nut production. The nutritional quality of *P. korshinskyi* remains unexplored. Nutritional analysis of the stems, leaves, and fruits of *P. korshinskyi* revealed that the fruits had the highest content of carbohydrate, fats, P, Ca, and K. More studies should be done for enhancing the nutritional value of wild plant varieties. The main reason that limits such research is the lack of awareness about plant metabolism as well as the complex associations and interlinkage of many metabolic pathways. Both traditional plant breeding and advanced recombinant DNA techniques can be used to metabolically engineer underutilized wild plants to obtain desired quality traits.

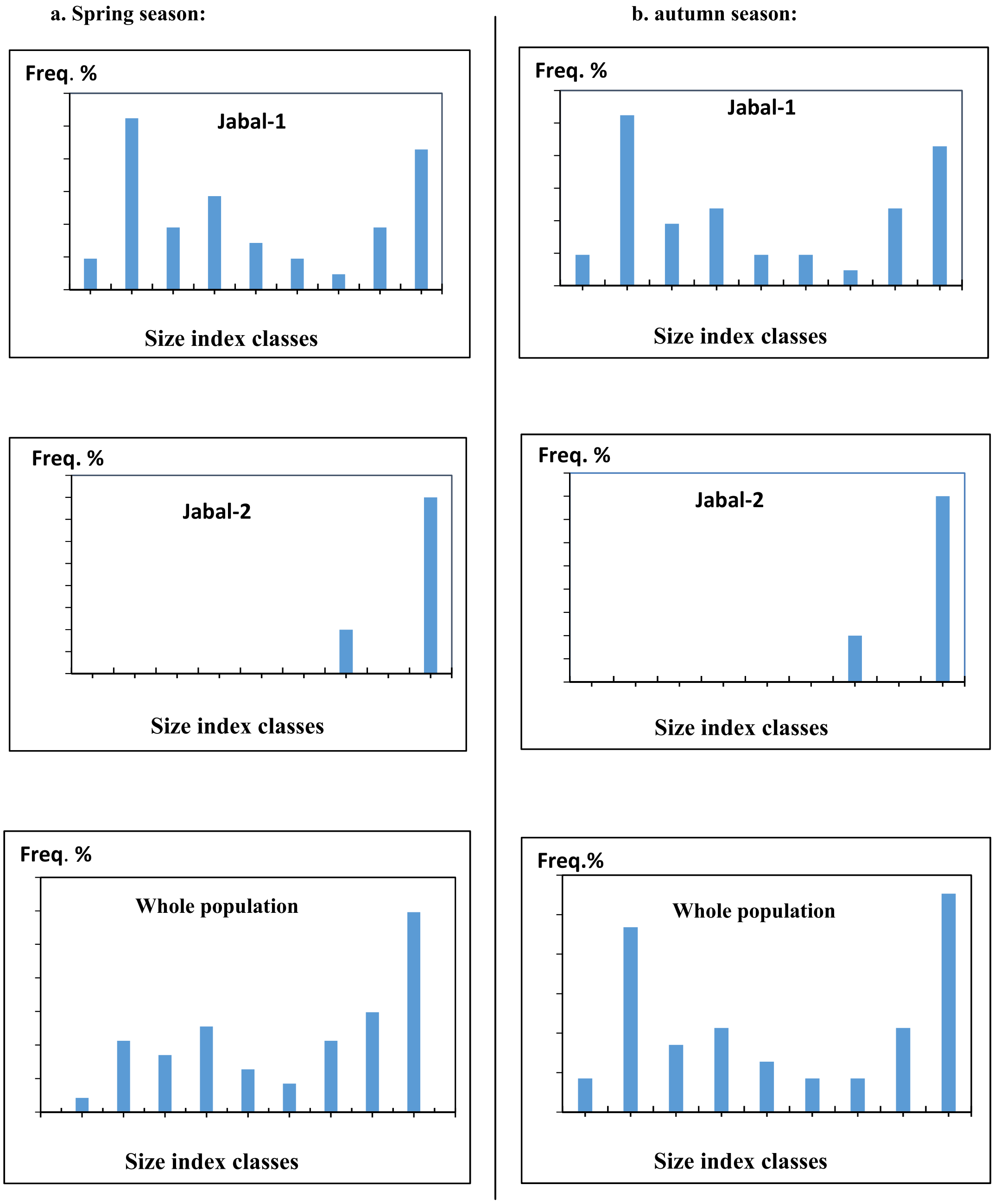


Fig. 7. Size class frequency distribution for *Prunus korshinskyi* in spring and autumn seasons. The ranges of size classes are: 1, ≤500; 2, 501–1000; 3, 1001–1500; 4, 1501–2000; 5, 2001–2500; 6, 2501–3000; 7, 3001–3500; 8, 3501–4000; 9, ≥4000 cm.

P. korshinskyi had attained high productivity in the spring season during which water and minerals are more readily available after the rainy winter season on the Tabuk region with a maximum rainfall of 64 mm (Galal and Fahmy, 2012). After that, the plant succeeds a long dry season during summer and autumn with temperature reaching a maximum of 38.1 °C (Asri, 2003). The height:-diameter ratio of *P. korshinskyi* is more than unity; therefore, the habit of the *P. korshinskyi* appears as cylindrical rather than the cushion shrubby desert habit. Therefore, this habit of the *P. korshinskyi* indicates the habitat of study area as following the Mediterranean region, which is relatively wetter than the desert habitat of the Saharo-Arabian region (Shaltout et al., 2003; El-Sheikh, 2013).

The size class frequency distribution of *P. korshinskyi* are in the whole population shows J-shape, where the plant populations consisted of very few individuals (one or two scattered individuals of an old shrub) which were growing in the grooves between stones that are protected from animal grazing. The chances of successful regeneration by seed of these populations are further reduced as the seeds are attacked and destroyed by the larvae of different pests. Alkassis and Sookar (2006) reported similar observations for almond, where regeneration by seed was reduced by larvae of the fruit wasp *Eurytoma amygdali*. There were no *P. korshinskyi* seedlings in the Jabal Al-Lauz populations. The only regeneration that has been reported has been by vegetative means through the dissemination of fragmented plant organs by grazing animals (Al-Rowaily et al., 2015).

Declaration of Competing Interest

The authors declared that there is no conflict of interest.

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