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Evaluation of plant diversity indices and the biomass of *Pistacia atlantica* under drought stress in grazing and enclosed area (case study: Tag-e Ahmad Shahi, Nehbandan, Iran)

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Abstract

Preparing floristic composition is very important to determine vegetation potential in an area to achieve the best pasture management. In order to plant identification in grazing and enclosed areas (each 4 hectares) 40 plots were established (10*10 m) in Tag-e Ahmad Shahi, Nehbandan. This area has involved in a long period of drought and grazing and the effect of these two factors were studied. All plants were collected and identified and according to Raunkiaer system life-forms were determined. To estimate biomass, height and DBH of all *Pistacia atlantica* were measured and in order to calculate diversity indices, BIO-DAP (Biodiversity Data Analysis Package) was used. In general, in enclosed area 46 species, 41 genus belong to 21 families were identified and Asteraceae with 15 species was the most spacious families, while in grazing area 9 species, 9 genus belong to 8 families were identified. Shannon and Simpson indices in enclosed area were 2.82 and 0.92, while it was 2.09 and 0.12, respectively. Biomass was 93.75 kg/ha and 62.5 kg/ha in enclosed and grazing area. Despite 13 year drought and rainfall less than 80 mm in recent years, the number of seedling and sapling has been increased in enclosed area and grazing is the main factor to reduce plant species in grazing area.

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Introduction

Although there have been many studies conducted on biodiversity assessment in the past (e.g. Ghollasimood 2006), there are still insufficient information for Natural Resource Department to act upon especially for the consolidation of plant resources in pastures. So species diversity is needed to provide quantitative basic information. A primary requirement is to assess the status, condition, and conservation value of the pasture. Studies of the flora could enable us to determine the number of species, and which could be protected from extinction if the integrity and stability of the areas could be secured (McElhinny *et al.* 2005).

How to explain the species diversity is fundamental (Zimmerman *et al.* 2008) and to get significant floristic information of an area and provide structure and plant composition need a great effort. Botanists have long-standing interest in the distribution of biodiversity over different spatial and temporal scales (Whittaker *et al.* 2001, Lomolino *et al.* 2004). The most accurate ways to collect biogeographical data on species distributions are intensive ground surveys or inventories of species in the field. Inventory is a continuing attempt and inventory projects can make a significant contribution to improved planning of management activities and control (Slik 2003).

Grazing modifies the species composition, richness and plant traits (Rodriguez *et al.* 2003; Altesor 2005). Compensatory growth in plants subjected to herbivory may alleviate the potential deleterious effects of tissue damage, whether to vegetative or reproductive organs. These effects have been discussed in different regions (Rostampoor *et al.*, 2008; Ghollasimood *et al.*, 2006; Nikan *et al.*, 2009; Mahmoodi *et al.*, 2011; Noroozi, *et al.* 2007). The result showed grazing exclusion is an effective way to restore the degraded grassland, and significantly influences the vegetation compositions and soil properties.

Biomass estimation is often used as a parameter to study the primary productivity of an area and biomass has been widely used as a unit of yield and it is a more useful measure than volume as it allows comparisons to be made between trees as well as among tree components (Brown 1997). Generally, regional and national biomass and C stock estimates for aboveground biomass are derived from plot-level inventory data by applying allometric biomass equations and biomass expansion factors (Jenkins *et al.* 2001, Brown 2002, Goodale *et al.* 2002). Some studies carried out to establish allometric equation for estimating crown, trunk and total tree dry weight of Pistacia tree (Adl 2007; Sohrabi and Shirvani, 2012). Objective of this study was to identify and describe the changes in plant community structure as a result of grazing by domestic herbivores and the size class distribution of the wild pistachio as an endemic tree.

Methods and materials

Study area

This study was conducted in Tage-e Ahmad Shahi (Figure 1) 65 km far from Nehbandan (Southern Khorasan) located in 60° 11' to 60° 14' E and 31° 55' to 31° 50'N. The average annual rainfall is less than 100 mm, the climate is typically arid, with hot and sunny and intensive radiation most of the time in summer, the elevation is 1800 m above the sea level and the texture is deep soil.

Plot censuses

All plant species were recorded and enumerated in April 2013. In total 80 plots (100 m² each) were sampled to cover the physiognomically different vegetation types across the area in enclosure and grazing areas. Species identification took place at the herbarium of Faculty of Agriculture by means of taxonomic keys and reference books (Akhani, 2005; Assadi *et al.*, 1988-2010; Mozafariyan, 2009) flora. Plant phenotypes were determined according to the Raunkiaer's life form specifications. In order to determine the biomass of *P. atlantica* and the effect of grazing on seed germination rate, height and DBH (Diameter Breast Height) of all individuals were measured.

Biomass Measurements

One alternative is a certain the allometric relationship between dry weight and an easily measured dimension, usually tree diameter (D), by measuring and weighing representatives samples of a number of trees (Whitmore 1984, Montagu *et al.* 2006). In different regions allometric biomass equations have been developed for trees species. Recently, efforts have been undertaken to derive equations for national and regional biomass estimates (Jenkins *et al.* 2003, Van Camp *et al.* 2004, Lambert *et al.* 2005, Peichl and Arian 2007, Chave *et al.* 2005). Leaf biomass of *Pistacia atlantica* leaf was calculated as the following formula (Adl 2006):

$$LnY=-1.314+1.49\ Ln\ (DBH)$$

Y: Leaf biomass (kg dry matter)

DBH: Diameter Breast Height (cm).

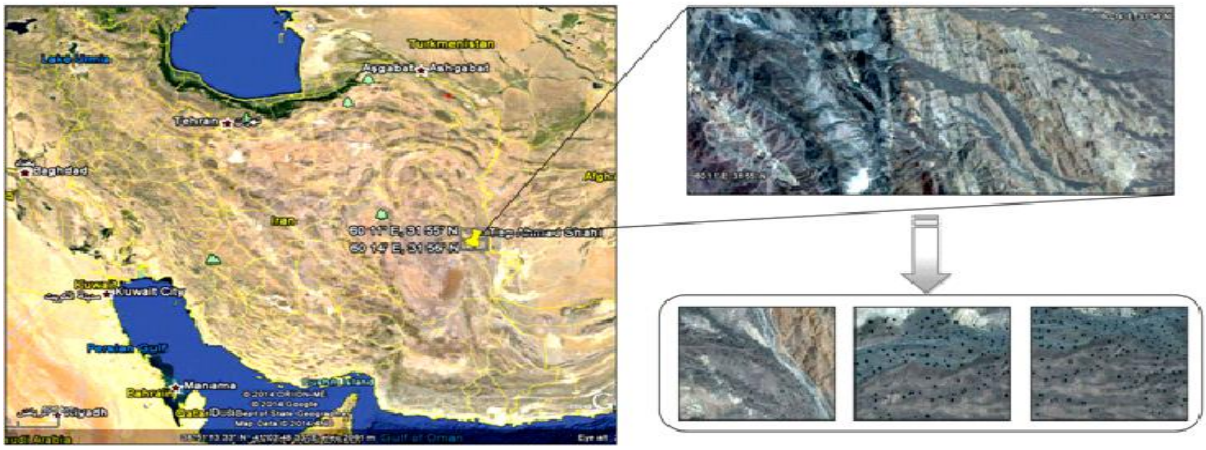

Fig. 1. The situation of study area in Southern Khorasan Province.

Plant diversity Indices

To evaluate diversity indices including Simpson, Shannon-Wiener and McIntosch, BIO-DAP was used. Statistical analysis using SPSS 17.0 for Windows and a series of ANOVAs were performed in this study.

Results and discussion

Floristic composition

A total of 46 species, 41 genus belong to 21 families were encountered within 4 ha in enclosed area (Table 1, Fig 2). The most spacious rich families were Asteraceae (15 species, 32%), Liliaceae (4 species, 9%) followed by Lamiaceae and Poaceae (3 species, 6.5%). As many as 13 families (62%) were represented by only one species, 3 families (14%) by two species and 5 families (23.8%) by more than two species. Families with high numbers of species are Asteraceae, Poaceae and Lamiaceae. The prevalence of Asteraceae in several areas in Iran has been reported by Ghollasimod *et al.* (2014), Basiri *et al.* (2011), Moradi *et al.* (2010) and is regarded as one of the most successful families of flowering plants due to its extreme flexibility in the adaptive responses of critical environmental conditions such as drought.

The ratio of monocots to dicots in the area is 6 to 40 species. This area was particularly rich owing to a much greater number of therophytes with 43.5% showed the highest life-form followed by hemicryptophytes 24%, chamaephytes 13% phanerophytes 11% and geophytes 8.7%. This result also coincides with the study carried out in semi steppe pastures in Zagros mountain (Ghollasimod *et al.* 2014) and Dolatkhahi *et al.* (2009) in Fars Province. The high proportion of therophytes reveals an effective tactic for avoiding water losses due to humidity extremes and water insufficiencies. Destruction factors such as drought, cutting trees and grazing are the most important factors in the dominant of therophytes (Van Rooyen *et al.*, 1990; Shifang, *et al.* 2008).

Despite low rainfall, this community is stable in result of 15 years under reservation management.

In 4 ha grazing area 9 species, 9 genus belong to 8 families were encountered (Table 2) where Asteraceae was found to be the dominant family. Our investigation has shown that heavy grazing of tends to remove the more palatable and replaced by unpalatable species and half-shrubs (Astragalus sp., Ephedra sp.). In this scenario, seed dispersal become limit and these disturbances may also significantly lower plant species richness. Long-term grazing produced variables effects on native and exotic species richness and cover (Fridley 2007, Fattahi 2004)).

Table 1. The list of species in enclosed area in Tag-e Ahmad Shahi.

Family	Species	Plant Form
Anacardiaceae	*Pistacia atlantica*	PH
Apiaceae	Ferula sp.	He
Apiaceae	*Eryngium noeanum*	H
Asteracae	Cousinia sp.2	H
Asteraceae	*Koelpinia tenuissima*	TH
Asteraceae	*Crepis elbursensis*	TH
Asteraceae	*Gundelia tournefortii*	H
Asteraceae	*Lactuca seriola*	TH
Asteraceae	*Lactuca glaveiifolia*	TH
Asteraceae	*Artimisia scoparia*	CH
Asteraceae	*Tragopogon caricifolius*	TH
Asteraceae	*Onopordon leptolepis*	TH
Asteraceae	*Onopordon earamanicum*	TH
Ateraceae	*Achillea wilhelmsii*	H
Asteraceae	*Laziopogon muscoides*	TH
Asteraceae	*Cousinia eryngioides*	H
Asteraceae	Gundelia sp.	H
Astercaeae	*Aegopordon berardioides*	TH
Boraginaceae	Matiostrum sp.	TH
Brassicaceae	*Allyssum hirsutum*	TH
Caryophyllaceae	*Acanthoplyllum sordidum*	CH
Dipsaceae	*Scabiosa rotate.*	TH
Ephedraceae	*Ephedra strobilacea*	PH
Ephedraceae	*Ephedra procera*	PH
Euphorbiaceae	*Euphorbia boissieriana*	H
Fabaceae	*Astragalus schistocalyx*	CH
Fabaceae	Astragalus sp.	TH
Geraniaceae	*Erodium scariola*	TH
Iridaceae	*Iris songrica*	G
Lamiaceae	Nepeta sp.	TH
Lamiaceae	*Eremostachys macrophylla*	G
Lamiaceae	*Ziziphora tenuior*	TH
Liliaceae	*Gajea reticulata*	TH
Liliaceae	Allium sp.	G
Liliaceae	*Eremorus persicus*	G
Papaveraceae	*Hypecum pendulum*	TH
Papaveraceae	*Papver bracteatum*	TH
Papaveraceae	*Glaucium oxylobum*	TH
Plumbaginaceae	*Acantholimon acmostegium*	CH
Poaceae	*Boisseria squarrosa*	H
Poaceae	*Stipagrostis paradise*	H
Poaceae	*Stipa lessingiana*	H
Polygonaceae	*Petropyrum aucheri*	PH
Rosaceae	*Amygdalus lycioides*	PH
Schrophulariaceae	*Linaria michauxii*	TH
Zygophyllaceae	*Peganum harmelea*	CH

Table 2. The list of species in grazing area in Tag-e Ahmad Shahi.

Familiy	Species	Life form
Anacardiaceae	*Pistacia atlantica*	PH
Asteraceae	*Artimisia scoparia*	CH
Asteraceae	Scariola sp.	CH
Boraginaceae	*Heliotrophium aucheri*	TH
Ephedraceae	*Ephedra strobilacea*	PH
Fabaceae	Astragalus sp.	CH
Poaceae	Bromus sp.	TH
Polygonaceae	*Petropyrum olivieri*	PH
Zygophyllaceae	*Peganum harmelea*	CH

DBH

The frequency distribution in different size classes in both grazing and enclosed areas (Figure 3,4) showed reverse-J, revealed a negative exponential relation in population size between the size classes (Ghollasimood *et al.* 2011, Seng *et al.* 2004). Pandy and Shukla (2003) stated reverse J distribution, indicate uneven-aged stands among several DBH. Increasing in the number of seedling and sapling with DBH<1 was significant (42%) while class 150-200 cm showed the least (3%). Plumptre (1995) found that the density of seedlings rises exponentially with an increase in the number of trees over 50 cm dbh but some species of large old trees (>70 cm DBH) showed a decline in fruit production, in which this was the same in enclosed area. According to Appanah (2000), the bigger trees within the species usually produce more seedlings than the smaller individuals. Thus, it is crucial to leaving behind sufficient undamaged good quality reproductive trees to ensure good regeneration in the residual stands.

Table 3. The amount of diversity and evenness indices in enclosed and grazed areas.

Index	Enclosed	Grazed area
Shannon-Wienner	2.82	2.09
Simpson	0.94	0.12
McIntosh	0.81	0.82

Table 4. T-student results for diversity in in enclosed and grazed areas.

Area	Shannon	t-student	d.f	Siq. (2-tailed)
Enclosed	2.82	6.22	38	0.0001
Grazed	2.09			

Tledo-Acewes and Swaine (2007) noted that seedling regeneration depends on the presence of seedlings on the forest floor before exploitation and the ability of these seedlings to remain alive for a long period enough. Upon inspection, our data confirmed that pistachio trees were rare in the smaller size classes (Fig. 3). In grazed area, DBH<1 and DBH≤35 cm class are missing due to long period of heavy grazing, cutting trees, absence of desirable seedbed and sensitivity of seedlings to drought and other potential causes of mortality. The reduction of genetically superior reproductive trees can adversely affect the genetic quality of the remaining and subsequent regenerating gene pools which was mostly due to irregular seed production from potential mother trees and lack of reproductive trees after being grazed

(Jahanbazi *et al.* 2006). Based on diameter growth rates observed in enclosure area we considered the number of trees in all diameter classes reduced by grazing activities and this revealed that this area is unsustainable because of decreasing regeneration during the last century.

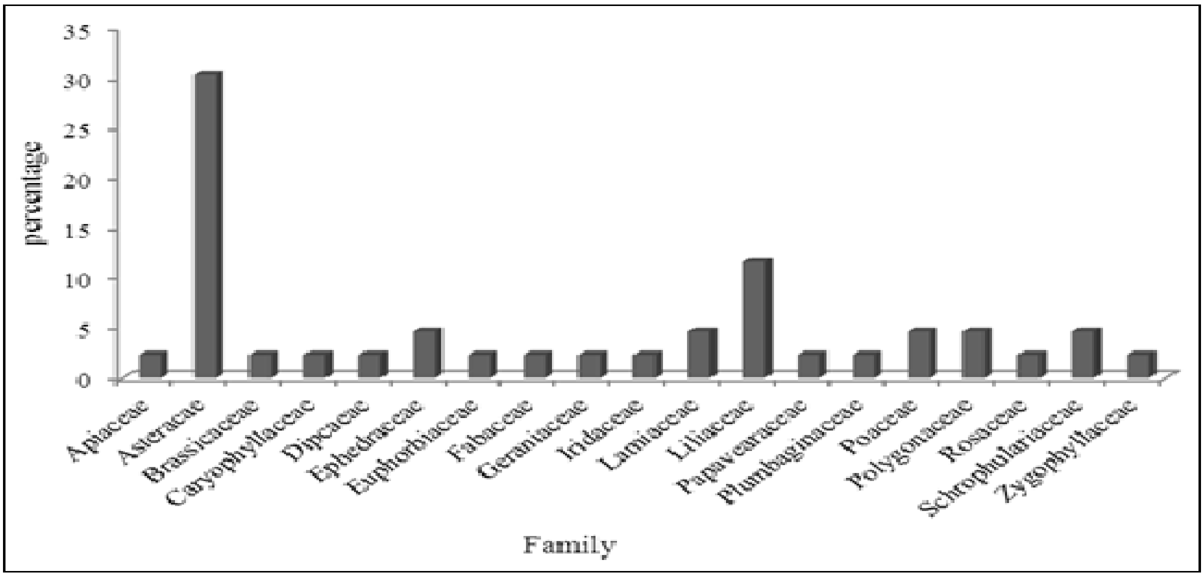

Fig. 2. Frequency of species within families in grazing area in Tage-e Ahmad Shahi.

(El-Moslimany 1986); and Poureza *et al.* (2008) stated drought is considered as the main factor; Arefi *et al.*, 2006 suggested that expansion of Zagros forests is limited by the ability of seedlings to survive the 4-month summer drought.

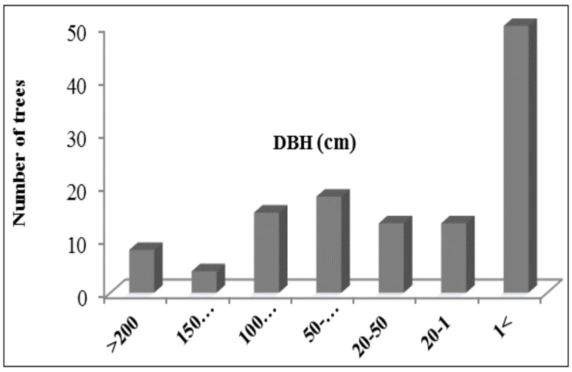

Fig. 3. The density of Pistacia atlantica according to DBH in enclosed area.

Diversity

A variety of commonly used diversity indices were computed in order to permit a more precise comparison of the alpha diversity between the two areas. These indices are widely employed to measure biological diversity (Ghollasimood *et al.* 2011). According to Simpson's dominance index the enclosed area is more diverse than the grazed area. This could be related to the relatively large number of abundant species in that area. The Shannon–Wiener diversity index is usually found to fall between 1.5 and 3.5 and only rarely surpasses 5.0 (Magurran 2004). The values of Shannon–Wiener index for these two areas falls within the expected range.

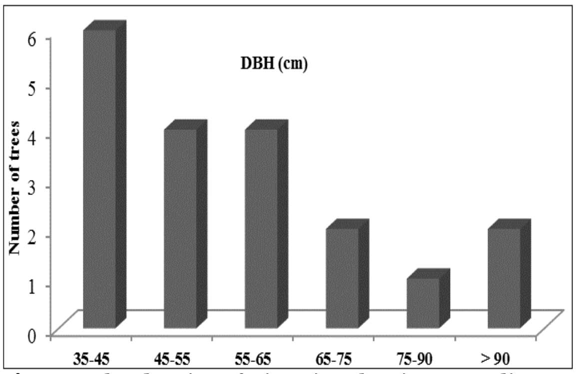

Fig. 4. The density of Pistacia atlantica according to DBH in grazing area.

McIntosh measure of evenness (McIntosh 1976) did not differ much between two communities (Fig 5). Fisher's diversity index, the most widely recommended measure of diversity, revealed that enclosed is more diverse than the grazing area.

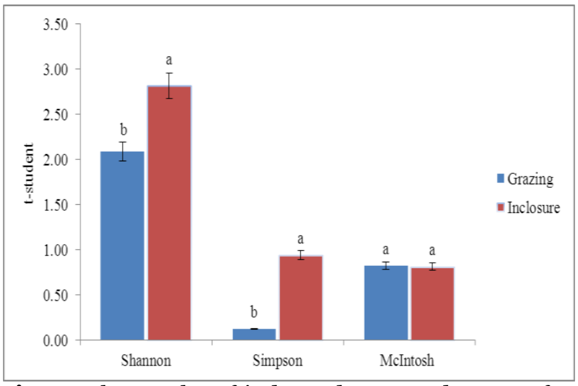

Fig. 5. The results of independent t-student test for evenness and diversity indices within grazed and enclosure areas.

Biomass

The simple allometric model that expresses biomass of a component as a function solely of diameter at breast height and the allometric model with diameter and height were fitted to each biomass component (D'Antonio *et al.* 2007). Leaf biomass in enclosed area was:

Y=92.75 kg/ha but in grazing area was: Y=61/5 kg/h. Adl (2007) revealed in Yasoj Forest 57 kg/ha and showed DBH is the best independent variables. Navar (2009), Wang, (2006), Nowak, (1996) and Medrios *et al.* (2008) got the same results. Biname (1972) reported 67.7 kg/ha in the same forest and after 27 years Farahmand (2007) reported 57.2 kg/ha at the same area. Cutting trees and destruction of the forest were the main reasons of this reduction of biomass. Panahi (2011) measured biomass of *Pistacia atlantica* in Botany Garden, Karaj 69.4 kg/ha. Diameter at breast height is one of the universally used predictors, because it shows a high correlation with all the tree biomass components and is easy to obtain very accurately There is a clear effect of the stage of stand development on the allometry of the trees (D'Antonio *et al.* 2007).

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