Middle-East Journal of Scientific Research 13 (10): 1388-1391, 2013
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2013.13.10.1249

Interactions Between *Gundelia tournefortii* and *Psathyrostachys fragilis* in Rangelands of Taleghan

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Abstract: In this study, the interactions between the dominant invasive species, *Gundelia tournefortii* and the dominant forage species, *Psathyrostachys fragilis* in rangelands of Taleghan was investigated. Four transects of 150 meters were considered in sampling unit. Using randomly-systematic method, 15 plots (1m × 1m) were placed along each transect with a distance of 10 m. List of species cover and the number of plant stalks were determined in each plot. Were assessed by studying association, covariation, segregation and distribution pattern (using the Hopkins' index) of plants. Results of this study indicate that competitive interactions occur simultaneously among the dominant plant species (*G. tournefortii* and *P. fragilis*) of Taleghan rangelands. In this study, two dominant species *G.tournefortii* and *P. fragilis* showed a clumped distribution pattern that is related to environmental characteristics. Results of this study can be directly used in restoration of plant species that are endangered by invasive species.

Key word: Competition · Invasive species · Management strategies · Native species · Taleghan

INTRODUCTION

The interaction among species is one of the most important factors influencing the distribution of plants in a given habitat. Generally, species interactions could theoretically include all combinations of positive, negative, or neutral effects [1, 2]. For example, roots foraging for water or nutrients could reduce belowground resource availability for neighbors. Alternatively, root exudates may enhance microbial communities and increase nutrient availability. At the same time, the stems and leaves of one plant may shade a neighbor, reducing light availability, but ameliorating high temperatures, such that the net effect is neutral [2, 3]. Facilitation has been shown to improve the recruitment, growth and survival of the beneficiary species through shading, increased nutrient availability and increased soil stability [4]. On the other hand, negative interactions among the same or different species may be revealed as a result of competition for food, space, light etc. [4-6]. Competition has long been recognized as a force in structuring plant communities [7,8], although its importance is still debated [9-11]. Interactions between the species, although recognized as important by early ecologists (e.g. [12-14], has not received as much attention until recently [4,15,16]. The relative importance of these two processes in structuring particular plant communities can be understood by recognizing and experimentally evaluating the influence of such factors as abiotic stress, consumer pressure, life stage, phenological stages [17], age and density on interaction strengths). As an example for life stage, the effect of *Lupinus lepidus* on survival of other herbs has been shown to be negative in the first year, positive in the second year and appeared even more positive after the death of *Lupinus* [18, 19].

As the previous studies show, the interactions among various plant species should be considered more deeply because it is of much importance in restoration and reclamation of rangelands. So, in this study, the interactions between the dominant invasive species, *Gundelia tournefortii* and the dominant forage species, *Psathyrostachys fragilis* in rangelands of Taleghan was investigated. Variability and distribution pattern of social indicators were studied in one sites in Taleghan rangelands to evaluate the interactions between plant species. The plant species in the studied site include: *G. tournefortii* and *P. fragilis*. Physiogenomically, *P. fragilis* is grass and *G. tournefortii* is forb. These rangelands are located in the Center Alborz mountainous region of Alborz province

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in north of Iran (50°19′30″ E, 36°5′20″ N to 51°11′6″E, 36°23′36″ N). The climate of this region varies from Semi-arid to semi-humidity. Average annual precipitation of the study area ranges from 500-600mm. Minimum temperature is recorded in December (-25°C) while the highest temperature touches +35°C in June.

MATERIALS AND METHODS

Four transects of 150 meters were considered in sampling unit (two transects perpendicular to the slope and two others deployed to the slope). Using randomly-systematic method, 15 plots (1m × 1m) were placed along each transect with a distance of 10 m (due to short-distant valley and changing environmental conditions). Based on this method, along each transect, the elementary point was selected randomly and other points were determined systematically with an interval of 10 meter from the previous point. Therefore, in sampling 60 plots were stationed. List of species cover and the number of plant stalks were determined in each plot. To analyze spatial distribution of dominant species, the following two distances in each plot was measured: 1) the distance between every plant individual from its nearest conspecific neighbor individual, 2) the distance between the nearest plants to the center of each quadrat from its nearest conspecific neighbor.

The spatial patterns among individuals of *G. tourneforti* and *P. fragilis* was measured using Hopkins' index (1954, cited from [20]) as:

$$I_H = \frac{\sum x_i^2}{\sum x_i^2 + \sum r_i^2} \quad (1)$$

Where, h = Hopkins' test statistic for randomness, x_i x_i = Distance from random point i to the nearest organism, r_i r_i = Distance from random organism i to its nearest neighbor, I_H will approach 0.5 for a random pattern, approach 1 for a clumped pattern and approach 0 for a uniform pattern [20].

Test of Association (Two- Species Case): The association between each species pair was determinedly presence-absence data from the quadrats of the two sizes, using a 2×2 contingency table and calculating x^2 (with Yates' correction):

$$x^2 = N\frac{\left[\left|(ad-bc)\right| - \left(N/2\right)\right]^2}{(a+b)(c+d)(a+c)(b+d)} \quad (2)$$

Where: *a* number of quadrats where both species (*a* and *b*) occur, *b* is the number of quadrats where species *a* occurs but not *b*, *c* is the number of quadrats where species *b* occurs but not *a*, *d* is the number of quadrats where neither *a* nor *b* are found. *N* is the total number of quadrats. If the calculated χ^2 is greater than the theoretical value for 1 df at 5% probability level, then the two species are associated. If $a > E(a)$, a positive and if $a < E(a)$, a negative association is resulted. $E(a)$ is the expected value for cell a, calculated from E (a) = ((a + b) (a + c))/ N [21].

The covariation in cover data between species was measured by estimating the percent cover values for each species from the 1m × 1m quadrats using calculation of Pearson's correlation coefficient (r). Pearson's correlation coefficient ranges from -1 (perfect negative correlation) to +1 (perfect positive correlation) [21]. SPSS software (version 15) was used to analyze the data.

Measures of Association (Two- Species Case): Simpson's index (SI) is computed as

$$SI = \frac{2a}{2a+b+c} \quad (3)$$

Jaccard's index (JI) is computed as

$$JI = \frac{a}{a+b+c} \quad (4)$$

Where *a* is the number of quadrats where both species (*a* and *b*) occur, *b* is the number of quadrats where species *a* occurs but not *b*, *c* is the number of quadrats where species *b* occurs but not *a*.

RESULTS

A total of 64 and 145 stalks were recorded with a canopy cover of 4.53% and 12.51% for *G. tournefortii* and *P. fragilis*, respectively (Table 1). Additionally, based on indices used in this study, *G. tournefortii* had clumped distribution pattern.

The results obtained from the associations between species at $1m^2$ quadrat showed that the specie pair *P. fragilis* - *G. tournefortii*, ($P < 0.01$) was negative associated. The changes in Simpson and Jaccard correlation indices were similar to those of chi square (χ^2) (Table 2).

Signs (-) indicate direction of the species association. A chi-square value was computed for correlation of each species pair and compared to the critical table chi-square ($p = 0.01$, df = 1) (6.64). Measurement of the degree of

Table 1: Density, canopy cover and distribution pattern of plant species in Taleghan rangelands, DM: distance methods, QM: quadrate methods

Species	Cover (%)	Density (N of plants in plot 1m^2)	Hopkins' index
Gundelia tournefortii	4.53	64	2.33**
Psathyrostachys fragilis	12.52	145	0.96**

* Significant at p<0.05.

** Significant at p<0.01.

Table 2: Association, covariation and segregation between the species pairs in Taleghan rangelands

			Degree of correlation	
Species pair	χ^2 (1 m^2 quadrat)	Pearson's (r) (1 m^2 quadrat)	SI	JI
G. tournefortii -P. fragilis	-8.47**	-0.98**	0.50	0.33

covariation between species based on the data of canopy cover by Pearson's correlation (r) indicated that there were strong Negative correlations in cover values for specie pair in the study (Table 2).

DISCUSSION

Results of this study indicate that competitive interactions occur simultaneously among the dominant plant species of Taleghan rangelands. The intensity of such interactions may have been affected by some abiotic factors [22, 23]. Type of interaction between plant species affects the spatial structure of plant communities. *G. tournefortii* that is found frequently in Rocky and colluvial lands is compatible to different soils' structures. In mountains with high slopes, this species plays an important role in soil fixation and so, well protect the soil against water erosion [24]. *P. fragilis* is an important species for forage production in studied region (palatable, II), grass species that well grows in colluvial shallow soils. This bunch grass is one of the most important species for soil protection [5]. In our study, this species showed a competitive interaction with *G. tournefortii* (p<0.01). Through randomly systematic sampling, four dominant species were found in Taleghan rangelands. On the other hand, through Hopkins' index, it was found that *G. tournefortii* and *P. fragilis* have a clumped distribution in studied region. This is because they usually grow in rocky and colluvial soils. This is also a result of growth pattern of mother plants, where the establishment and rooting make soil a suitable site for germination and growth of the new seeds.

Altogether, findings of this study highlight the importance of interactions among plants' species in formation of plants' communities in arid and semiarid environments. In addition to the advantages of detecting species interactions in the ecology of the species, determination of interspecific interactions may be useful for restoration and improvement of ecosystems. In this study, it was revealed that *P. fragilis* had higher density as compared to the invasive species, *G. tournefortii*. This means that *P. fragilis* has been well extend its distribution in a competitive interaction with *G. tournefortii*. In many regions of Iran, *G. tournefortii* has become highly invasive species as a result of overgrazing by sheep. So, use of *P. fragilis* in sloppy and colluvial regions such as Taleghan rangelands may be beneficial for preservation of rangelands that are endangered by the invasive species such as *G. tournefortii*. This will enhance the chance of plants establishment leading to success in landscape management strategies.

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