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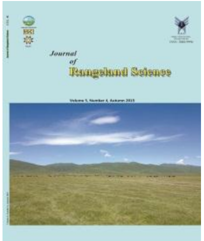

Research and Full Length Article:

Effects of Harvester Ants' Nest Activity (*Messor spp.)* on Structure and Function of Plant Community in a Steppe Rangeland (Case Study: Roodshoor, Saveh, Iran)

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Abstract. Harvester ants are known as one of the most renowned bio-disturbances in the arid and semi-arid ecosystems that affecte vegetation by collecting seeds and harvesting plants. It seems that physiognomy of plant association in steppe shrub land of Roodshoor, Saveh, Iran has been highly changed by harvester ants' activities that caused to conduct this research. The study was carried out on active and inactive nests and control site from June to August 2012. Diversity indices and functional groups such as vegetative form, longevity, and photosynthesis type were analyzed as compared to criteria in three sites. Results showed that richness, diversity, and vegetation cover in the ant colonies through increasing the annual forbs and rare species (*Campanula stricta* and *Lepidium vesicarium*) were more than the control site. For evenness index, however, there was no significant difference between the control and nest sites. In contrast, the function of plant community in the active nests due to the decrease of dominant shrub frequency of the area that is *Artimisia siberi* by *Messor* spp. was less than the control site. Low diversity, richness, plant function, and high vegetation cover in inactive nests were also observed as the results of the presence and activities of the ants in the active nests. Hence, the ant activities in the active and inactive nests can bring out micro sites with different plant associations so that regarding high density and quantity of the ant nests in all the area, it can decrease the key plants and change their functions. It therefore will debilitate the stability and function of this rangeland ecosystem.

Key words: Harvester ants, Plant structure, Plant function, Rangeland, Iran, *Messor* spp.

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Introduction

Such information as habitat environment, awareness of dynamic and stability of terrestrial ecosystem in short and long term periods can be achieved by studying the plant community in a given area (Ruiz & Aide, 2005) so that plant diversity is regarded in the survey (Geldenhuys, & Murray, 1993). As it is pointed out that the plant diversity is of the important indices to evaluate an ecosystem circumstances and applications (Hickman *et al.*, 2004). Desirable plant diversity can regulate many elements in the ecosystem including the maintaining of atmospheric gases equilibrium, cycling of trophic matters, regulating of hydrology and weather cycles, and finally soil conservation and its fertilization (Macneely, 2002). Increasing and protecting the plant diversity are ecologic management layouts to conduct the terrestrial ecosystems (Fakhimi-Abarghoie *et al.*, 2011). Two aspects of plant diversity involving plant richness (number of species) and evenness (monotonic distribution and abundance of species individuals) are simultaneously evaluated (Bello *et al*., 2009).

Expanding the plant richness and evenness in an ecosystem represents the species cooperation and correlation which can be caused more stability of species against the diseases, pests, and disequilibrium condition of the ecosystem (Ghahraman, & Atar, 1999). In recent years, however, in accordance with global agreement, consideration of function and dispersion of each species has been concerned more than its frequency (Díaz, & Cabido, 2001; Malchair *et al.*, 2010).

In connection with this theory, evaluation and survey of functional varieties and regarding key species in a given area have been imported apropos of species diversity to stability of an ecosystem while increasing its function and managing it to use for future (Bengtsson, 1998; Tilman *et al.*, 1997; Hewitt *et al.*, 2008). Species richness or diversity index cannot be obtained as stable and functional concepts for an ecosystem because complex relationships and reactions exist between species and their functions (Bengtsson, 1998). Regarding different physiological and morphological traits of plants, they can perform various functions and roles in the ecosystem some of which may be longevity, photosynthesis type, vegetation form, rooting depth, leaf size, primary production, shooting vigour, fixation potency of nitrogen, transforming of temperature, hydrologic dynamism and food production to other plants and animals (Tilman *et al.*, 1997; Díaz & Cabido, 2001). Hereunto, decreasing and omitting the species which have the most important roles in the ecosystem stability and dynamism are much significant than decreasing a species with more frequency (Malchair *et al.*, 2010).

Abiotic and biotic disturbances at spatial and time scales are the most important factors to change and shift the plant community’s diversity and composition (Alba-Lynn & Detling, 2008) as these factors can help to establish some rare or less density species and may omit or decrease some other abundant species (Kirkham & Fisser, 1966).

A few researches have been conducted on different animals, especially insect with respect to their effects on the function of plant communities (Thornton & Millenbah., 2000). Ants as insects are the most effective biotic disturbers of plant communities in the arid lands (Holldober & Wilson, 1990) that they have been considered less in global positions, especially Iran.

Their abundance and multi-reactions have adapted them into one of important activators in the ecosystem function (Beattie & Culver, 1977; Cannicci *et al.*,

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2008) so that they have been called the ecosystem engineers due to their performances to change the surface vegetation formation and soil structure (Macmahon *et al*., 2000).

With relation to the ant activity and life, it can be divided into harvester, leaf-cutters, woody ants, invaders, predators, or honeydew ants (King, 1977; Farji-Brener & Ghermandi, 2000). The harvester ants as one of the most abundant ant species in the arid lands play a more significant role in changing the structures of plant communities (Ciesielski, 2008).

These ants due to their biological behaviour and nutritional function tend to collect seeds and other parts of the plants and store them in their nests, but they evict the twigs, seeds and fruit skins to the outside in a manner that this process helps to form a covered area with plants surrounding the nests which are different from the milieu vegetation (Ginzburg & Steinberger, 2008).

The significance of seed collection by the harvester ants and consequently the changes made by them in the plant community had been reported in various studies (MacMahon *et al.*, 2000; Alba-Lynn & Detling, 2008).

In this respect, Brown *et al*. (2012) in their investigation on the effects of harvester ants (*Messor ebeninus* Forel) in the deserts of Saudi Arabia reported that due to the increase of rarely-grown annual plants around their nests, the activity of these species help to increase the plant richness and diversity in the surrounding nests. The evaluation of another species of the harvester ant called *Acanthomyops Claviger* in grassland has shown that the activity of this ant had no impact on the plant diversity (Ciesielski, 2008).

Because of small and big colonies of the harvester ants *Messor spp*. in the long-term exclosure (40 years) in the Roodshoor shrub-land (Saveh, Iran) and according to researchers of Natural Resources Organisation, some bio-disturbances have been seen in the plant community and structures so that current research tries to answer three questions: 1) Is there a significant difference between the plant richness, diversity, cover, and uniformity of the ant nests of *Messor spp*. and the control area? 2) Has the activity of the ants *Messor spp*. had any effect on the species and forms of a typical plant? 3) Is there a significant difference in the plant function between the nests of the ants *Messor spp*. and the control area? 4) Will the changes continue after the death and inactivity of a nest as well?

Materials and Methods

Study area

This study was conducted in order to evaluate the effects of Harvester Ants on structure of plant community in the shrub lands of Roodshoor, Saveh, Iran. This region is located at 60 km of Tehran-Saveh highway with the latitude of 35˚41′56″ to 35˚43′36″N and the longitude of 50˚35′8″ to 50˚34′52″E, and the altitude of 1120 m was selected during June to August 2012. The average slope of the area is 5% with the mean annual rainfall of 204 mm. January and July are the coldest and warmest months, respectively so that a drought period starts from mid-May to late-August. Soil texture in this area forms loamy-sandy and gravel formations.

The dominant plant cover of the area includes *Artemisia sieberi* and *Stipa hohenackeriana* along with *Salsola tomentosa*, *Brassica deflexa*, and *Poa sinaica* as co-dominant species (Mahdavi *et al.*, 2009).

Physiognomically, the area is formed by shrubs and perennial grasses referring to a steppe area. Long-term exclosure (30 ha, 40 years) as the research site exists in the area. Sheep and goat herds graze in winter and autumn periods in the outside. There are many ant colonies in the exclosure area (Fig. 1).

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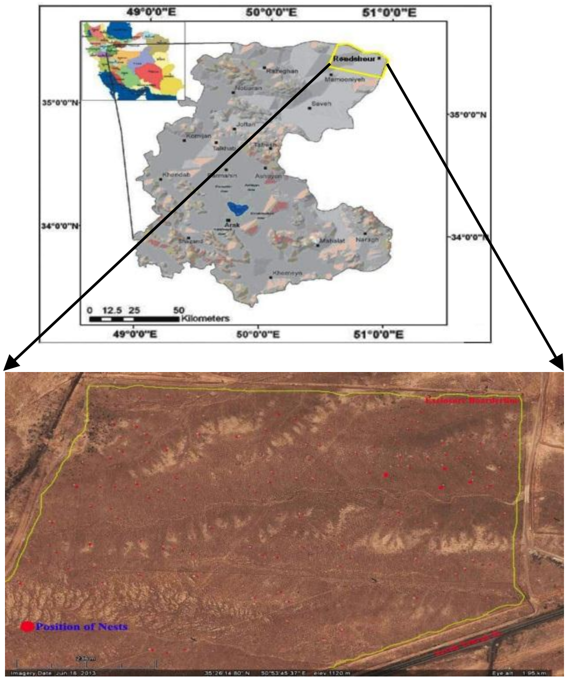

Fig. 1. Location of the Study Area and ants' colonies in the exclosure area, Roodshoor, Saveh, Iran

Ant Species Characterization

Regarding the object of this study, three sites such as active and inactive nests and control area were selected. In order to determine the dominant active ants, the sampling and picketing were done along 10 transects (with the length of 200 m) in the area. Some traits of each nest involving number of nests, geographic longitude and latitude of each nest, nest size, date and area name were recorded in each sampling point. Aspirator instrument was used to collect the ants from each nest point and the ant nests were separately kept in vials with pregnant 85% alcohol and all the traits were recorded on label of vials (Agosti *et al.*, 2000). Three ant genera were identified in sampling period that were *Messor*, *Catygilyphis*, and *Profomica* (Table 1) from Hymenoptera (order), Formicidae (family) and Myrmicinae (sub family). However, the identification of all species could not meticulously be conducted because it was time-consuming and difficult, and the separation of species was made easily and carefully in terms of differences in size and colour of the workers including different structures of nests. Hence, the survey was carried out on *Messor* genus because of their nest size (mean diameter of nest was 2.3 m), and frequency in the area (8.3 nests per ha) and finally the observed changes by this genus. As a notification, all *Messor* nests were located at the bottom of *Artemisia sieberi* species (Fig. 2).

The harvester ants such as *Messor spp.* which are seen as one of the dominant species dwelling in the hot desert areas where the workers were observed in small and medium sizes in black formed circular flat nests in large scales and in great length. These nests noticeably observed over the area are classified in two groups: the central nests including several entrances and devoid of any plantation (where its mean diameter was 1.15 m in our given area.) and the circular region surrounding the nests, which was covered with plants and leaf litters as well as different parts of the plants (where its mean diameter was 1.35 m in our given area) (Table 1).

In addition, these ants when we were tracking their nests and movements during their seed collection, left routes of traces with different lengths, while there was just one route for certain nests with this number increasing up to four routes for some others as well.

In this study site, the nests of these species were sometimes widely closer together (the closest distance estimated between two nests was 4 m) and farther away from each other (the farthest distance estimated between two nests was 9 m). The longest diameter of the whole nests for the given species was 5.5 m and the shortest diameter was 1.15 m.

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Table 1. Colonies traits of Ants the study area

Genus Name	Function Group	Typical Habitat	Colour	Size	Nest Shape	Nest Density ha^{-1}	Nest Diameter (m)	Material Composition
Messor spp.			Black	Small & medium	Flat	8.3	2.5	Seed, plant, soil
Messor spp.	Harvester	Dry region	Black &red	medium	Dome	0.9	1.46	Seed, plant, soil
Messor spp.			Black	Small	Pore	0.1	-	Soil
Catygilyphis spp.			Black	Large	Pore	1.7	-	Soil
Catygilyphis spp.	Scavenge	Steppe & desert	Black &red	Medium	Flat	0.5	0.95	Soil
Catygilyphis spp.			Orange	Small	Pore	0.2	-	Soil
Proformica spp.	Forager	-	Brown	Small	Pore	0.1	-	Soil

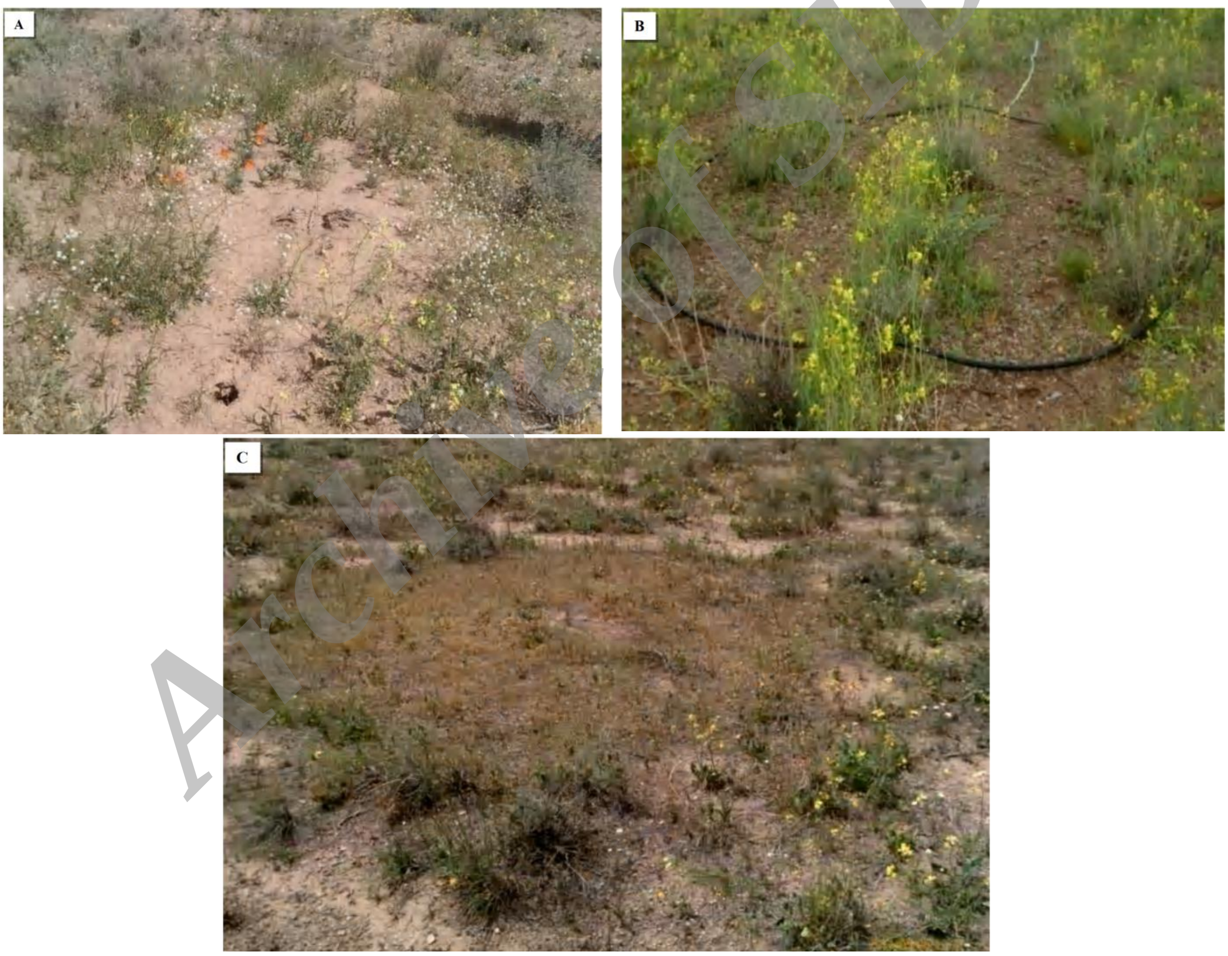

Fig. 2. (A) Nest of *Messor* spp. in Roodshoor & dead *Artemisia sieberi* in central of mound, (B) Control site, and (C) Inactive nest of *Messor* spp.

Vegetation Sampling

The sampling from plants was executed in mid-spring when the plants were in flowering phenological stage. To compare plants on equal-sized patches, we measured the diameter of the nests for *Messor spp.* because of various nest sizes and the need to equal comparisons of treatments was measured using a measuring tape to determine a plot with a fixed size. After measuring the nest diameter, the most frequent size in the

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active and dead nests of the given ant species was estimated to have a mean of 3.5 m; therefore, the circular plot in a diameter of 3.5 was determined to serve the sampling purpose in 18 active nests of *Messor spp.* located in 3 m away from each nest within 18 control plots and 7 dead nests, all of which have a diameter of 3.5 m. Plant density and cover percent were estimated in each plot regarding a quadratic method (Mesdaghi, 1999). Plant functions were also accessed via shrub forms, annual and perennial grasses and annual and perennial forbs as C_3 and C_4 format (Tilman *et al*., 1997).

Statistical Analysis

In order to determine plant richness, species individuals were calculated in each plot. The Shannon-Winner index was used to obtain the plant diversity as below formula (Equation 1):

$$H' = -\sum_{i=1}^{s} P_i \, Ln(P_i) \qquad \text{(Equation 1)}$$

Where, P_i is the i^{th} species number to whole number of species ratio.

The evenness index of Shannon-Winner was used to calculate the species evenness by the means of following formula (Humphries *et al*., 1996) (Equation 2):

$$E = \frac{H'}{S} \qquad \text{(Equation 2)}$$

Where, H' is plant diversity and S is the number of plants.

In order to find out the ecologic range, Importance Value Index (IVI) was applied to calculate any species using below formula (Mesdaghi, 2006; Adam *et al*., 2007) (Equation 3):

$$\text{IVI} = \frac{\sum \text{R}(\text{D}_\text{i} + \text{C}_\text{i} + \text{F}_\text{i})}{300} \times 100 \qquad \text{(Equation 3)}$$

Where, R is a relative value, and D, C, and F are density, cover, and frequency of each species, respectively. Letter i also represents the species number. In given formula, any species reaches to 300%, it will determine the ecological condition of environment.

After all, plant diversity indices were estimated using $PAST_{2.3}$ software and in order to analyze the signifying level and perform comparisons between treatments, $SPSS_{22}$ was applied using ANOVA approach and Duncan test.

Results

Means Comparisons of Plant Diversity in Three Sites

In total, 31 plant species were identified in the area where 22 species were forbs, 5 grasses, and 4 shrubs. 27 species in the active nests, 31 plant species in the control site, and 6 species in the inactive nests were recorded. Data evaluation showed that the plant diversity and richness in the active nests were more than the control site (Table 2) with regard to the result that the mean number of the species in the nests (12.33) was two times more than that of control site (6.44) and six-fold more than the inactive nests (2.85).Vegetation cover in the active nests (67.88%) was approximately one and half fold higher than the control site (45.88%). The inactive nests, however, had higher values of vegetation cover (82.57%) and reversely the least plant richness and diversity as compared to the active and control sites. The evenness of plants had not also differed between the active nests and control sites, but it was significantly different from the inactive nests with less evenness (Table 2).

Table 2. Mean of Plant species richness (S), diversity (H'), and evenness (E) in the active, inactive, and control sites (Mean ± SE)

Indices	Active nests (n=18)	Control site (n=18)	Inactive nests (n=7)
Vegetation Cover (%)	67.88 ^{b}	45.88 ^{c}	82.57 ^{a}
Richness (S)	12.33 ^{a}	6.44 ^{b}	2.85 ^{c}
Diversity (H')	2.26 ^{a}	1.73 ^{b}	0.39 ^{c}
Evenness (E)	0.45 ^{a}	0.40 ^{a}	0.13 ^{b}

The means of the rows with same letters were not significantly different based on DMRT P<0.05 method

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Important Value Index (IVI) of species in sites

As species had been floristically analysed, the maximum rates of IVI in the active nests for annual rarefied forbs of *Campanula stricta* were 18.78% and 1.03% for active nests and control site, respectively. Another rare annual forb that is *Lepidium vesicarium* was in the second rank of IVI (15.07%) in the active nests as it was 1.21% in the control site. Three rare species which were infrequently found in the area were *Scabiosa Olivieri* (5.89%), *Papaver tenuifolium* (6.1%) as annual forbs, and *Achillea tenuifolia* (7.11%) as perennial forb with higher values of IVI.

Some annual forbs which were found in the control site as well had higher IVI in the active nests; they were *Anthemis gilanica*, *Erodium oxyrrhnchum*, and *Alyssum marginatum* (Table 3). The highest rates of IVI in the control site were related to perennial grasses involving *Stipa Hohenackeriana* (9.14%)as an annual forb, *Brassica deflexa* (7.07%), and shrub *Artemisia sieberi* (5.54%) whereas *A. sieberi* was found as a dead plant in the active nests. Although *Stipa Hohenackeriana* existed in the nests, its IVI for control site (9.14%) was significantly higher than the active nests (1.12%).

The IVI rate for *Brassica deflexa* had no difference in both nests and control sites. Some shrubs were only rooted out in the control sites such as *Salsola laricina* (2.95%), *Salsola tomentosa* (2.74%), and *Ephedra strobilacea* (2.15%).

Regarding IVI calculation, some annual plants incline to attend the nests; they were *Taraxacum vulgare, Ziziphora tenuir, Euphorbia sororida, Centaurea bruguierane*, *Cousinia belanger*, *Senecio vernalis, Aegiplos columnaris*, and *Bromus tectorum* while the other annual and perennial species such as *Centaurea behen, Poa sinaica, Astragalus chaborasicus, Hordeum morinum, Echinops pungenstraut, and Ferula hirtella* were found in the control site. The IVI rate for *Silene chaetodeonla*, *Valerlanella*, and *Sisymbrium officinales* had no significant ($P<0.05$) difference between the control and nests sites. In the inactive nests, *C. stricta* almost covers the site in order that the IVI rate of the species was 45.03%. *S. Olivieri* (1.03%), *P. tenuifolium* (1.05%), *A. gilanica* (1.07%), *B. deflexa* (1.03%), and *A. tenuifolia* (1.13%) species however have had less IVI rate as they were seldom found in the inactive sites. Considering other species in the area, they were not seen in the inactive nests as the ants evacuated the nests (Table 3).

Comparison of Plant Function Groups in Three Sites

Findings showed that functional groups of the plant community were different between the site treatments so that the control site had more various functions including life form, longevity, and photosynthesis operation apropos of the active and inactive nests (Table 4).

The functional groups had more roles than the control site with regard to the active and inactive nests. Cover percent of annual plants in the active and inactive nests was 62.38% and 81.42%, respectively and it was significantly more than perennial species for both sites given as 5.0 % and 2.14 %, correspondingly. Regarding the fact that the percentages of annual and perennial species were relatively more and less in the inactive and active nests rather than control site, perennial plants (26.44%) had more cover percent than annual plants (19.44%).

In general, there was 45.88% of vegetation cover in the area where the annual and perennial species had 19.44% and 26.44% cover, respectively. In the nests, however, from total of 67.38% cover, about 62.38% and 5.0% were attributed to the annual and perennial species, respectively. In terms of vegetative form, the forb was of the

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maximum values in the active (62.94%), inactive (82.57%), and control (21.83%) sites. There was no shrub form in the active nests as 9.22% of it was in the control site (Table 4). Grass form (4.44%) was less in the control and more (14.83%) in the active nests. Grass and shrub forms did not exist in any inactive nests while annual forbs were higher than perennial forbs in three sites. The control site however had more perennial forbs than the other sites. Photosynthetically, the function was 67.88% and 83.57% in the active and inactive nests, respectively which the total of them was C3 species. In the control site, they were 2.16% and 43.72% for C_4 and C_3 species, respectively.

Table 3. Mean of importance value index (IVI) for plants species in *Messor spp*. mounds, Control & Dead mound

Family	Species Name	IVI			Life Form	Longevity	Photosynthesis Type
		Control	Active Nest	Inactive Nest			
Campanulaceae	*Campanula stricta*	1.03	18.78	45.03	F	A	C3
	Silene chaetodeonla	1.11	1.1	-	F	A	C3
	Salsola laricina	2.07	-	-	SH	P	C4
	Salsola tomentosa	2.54	-	-	SH	P	C4
Compositae	*Achillea tenuifolium*	1.47	7.11	1.13	F	P	C3
	Anthemis gilanica	2.35	3.56	1.07	F	A	C3
	Artemisia sieberi	5.54	-	-	SH	P	C3
	Centaurea behen	3.84	3.01	-	F	A	C3
	Centaurea bruguierane	1.04	1.21	-	F	A	C3
	Cousinia belanger	1.07	1.25	-	F	A	C3
	Echinops pungenstraut	1.18	1.05	-	F	A	C3
	Senecio vernalis	1.06	1.12	-	F	A	C3
	Taraxacum vulgare	1.32	1.61	-	F	A	C3
Cruciferae	*Alyssum marginatum*	2.11	3.17	-	F	A	C3
	Brassica deflexa	7.07	7	1.03	F	A	C3
	Lepidium vesicarium	1.21	15.07	-	F	A	C3
	Sisymbrium officinale	1.05	1.06	-	F	A	C3
Gramineae	*Stipa hohenackeriana*	9.14	1.12	-	G	P	C3
	Aegilops columnaris	1.07	1.17	-	G	A	C3
	Bromus tectorom	1.21	2.09	-	G	A	C3
	Hordeum morinum	2.11	1.2	-	G	A	C3
	Poa sinaica	2.15	1.07	-	G	P	C3
Ephedraceae	*Ephedra strobilacea*	2.15	-	-	SH	P	C3
	Euphorbia sororida	1.14	2.02	-	F	A	C3
Dipsacaceae	*Scabisa oliveri*	1.1	5.89	1.03	F	A	C3
Geraniaceae	*Erodium oxyrrhnchum*	2.2	3.4	-	F	A	C3
Labiatae	*Ziziphora tenuir*	1.62	2.73	-	F	A	C3
Papaveraceae	*Papaver tenuifolium*	1.09	6.07	1.05	F	A	C3
Papilionaceae	*Astragalus chaborasicus*	2.08	1.1	-	F	P	C3
Umbelliferae	*Ferula hirtella*	2.12	1.11	-	F	P	C3
Valerianaceae	*Valerlanella oxyrrhyncha*	1.02	1.04	-	F	A	C3

A= annual, P= perennial, F= forb, G= grass, SH=shrub
The underlined data has higher values of IVI for treatments

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Table 4. Mean (± SE) cover percent of different function groups of plants in control, active, and inactive sites

Functional Groups	Control Site	Active Nests	Inactive Nests
Annual	19.44 ± 0.02 c *	62.38 ± 0.21 b	81.43 ± 0.14 a
Perennial	26.44 ± 0.05 a	5.00 ± 0.004 b	1.14 ± 1.80 c
Grass	14.83 ± 2.30 a	4.44 ± 0.01 b	-
Forb	21.83 ± 0.42 c	62.94 ± 0.94 b	82.57 ± 1.30 a
Shrub	9.22 ± 0.01	-	-
Annual grass	2.16 ± 0.03 b	2.50 ± 0.02 a	-
Perennial grass	12.66 ± 3.20 a	1.94 ± 0.74 b	-
Annual forb	17.27 ± 2.20 c	59.88 ± 1.2 b	81.42 ± 0.14 a
Perennial forb	4.55 ± 0.75 a	3.05 ± 0.70 b	1.14 ± 1.30 c
C3 photosynthesis type	43.72 ± 2.50 c	67.38 ± 2.4 b	82.57 ± 0.01 a
C4 photosynthesis type	2.16 ± 0.001	-	-

The means of the rows with same letters were not significantly different based on DMRT P<0.05 method

Discussion

According to the obtained results in the area, *Messor* spp. species could clearly change the plant community in the nests so that the plant diversity, richness, and cover were higher around the nests. Variety in plant functio, such as life form, longevity, and photosynthesis structure in the control site was more than nests. The inactive nests of the other sites, however, had higher values of vegetation cover, richness, diversity, and functional vigour. Plant association generally was different around the nests as compared to the other areas. This case was on account of tendency for the harvester ants to collect the species seeds and aggregate them around and inside the nests as it was emphasized by many researchers in different climatic conditions and different species of ants (Dauber *et al.*, 2006). Increase of diversity and richness in nests site was caused by increasing different plant species and the presence of rare and annual species in nests which had been rarely found in the region (Wilby *et al.*, 2001; James *et al.*, 2008) so that IVI also was underscored by these species concerning the ecologic conditions of nests. This result is in accordance with other researches in connection with different species of the *Messor* genus (Wilby *et al.*, 2001; Brown *et al.*, 2012). During this investigation, changes in plant communities in the nests were due to several reasons. In the case of ants, the collection and distribution of plant seeds directly or changes of soil indirectly reduced competition by removing the seeds and harvesting some plants in their nests (Farji-Brener& Ghermandi, 2000).

In spite of that, most of researches about the harvester ants' activities put emphasis on grass forms in the nests rather than the other forms (Peters *et al.*, 2005; Nicolai *et al.*, 2008), but in the area, the *Messor* ants had more effects on the increase of forbs in comparison with the other plant forms; this result is confirmed by some researchers' reports (Whitford, 1988; Danin & Yom-Tov, 1990). Attendance and increase of annual scarce forbs such as *Campanuala stricta, Lepidium vesicarium, Papaver tenuifolium, Scabiosa Olivieri*, and perennial forbs like *Achillea tenuifolia* in the nests had highly related to the ant activities. Some annual forbs also increase the nests although they can be found around the nests (Table 3). Even though *Aegilops columnaris* and *Bromus tectorum* as grass forms can be observed in the nests, but they comprise less formation in plant composition of the nests. On the subject of this result, many researches had showed that modification and changes in the nests by different ants and their activities can contribute to the rehabilitation, establishment, density increase, and dispersion of some rare species showing the complicated-bilateral relationship between ants and plants (Lesica & Kannowski, 1998).

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Improving soil properties, ameliorating and increasing soil fertility considered as limiting factors to plant growth in dry areas can be modified by the *Messor* ants and consequently, the plant cover, diversity, and richness are increased in the area (Ghobadi, 2013). According to Brown and Human (1997) study, vegetation cover of annual forb *Lipidum nitidum* in the *M. anderei* nests was two times more than the cover around the nests because of soil reforms and changes. Whiteford *et al.* (2008) also revealed that the increased *Eroduim texanum* in the nest of *Pogonomyrmex rugosus* was due to the heightening of soil nitrogen as an important factor which was obtained by decomposing grasses and perennial plant roots. Harvester ants also increase the temperature, weathering, humid, and soil flaccidity. Hence, their nests are suitable to establish some plants (Satti *et al.*, 2003; Farji-Brener & Chermandi, 2008). As much as rain and thermal differences are taken into account as limited factors in the arid lands, the harvester ants remove plants and their remnants in the nest surface and help to direct sunlight and as a consequence, the temperature to breed larva and queen is increased (Brown *et al.*, 2012). In this regard, soil water capacity will be increased because of micro corridors (Cammeraat *et al.*, 2002). Increasing soil moisture in the nests can help the plant germination and growth when rainfall is less or drought periods start (Nicolai *et al.*, 2008). Differences in soil properties therefore can make various micro-sites of plant community in the area. According to Farji-Brener & Ghermandi (2000) study, increase of plant diversity and richness in the nests of Leaf-eating ants called *Acromyrmex lobicornis* in comparison with surrounding areas was caused by modifying the soil, not by the seeds collected because both exotic and native plants were increased around nests. But in our region regardless of *Brassica deflexa* as one of the dominant plants in the same nest and control area, most of the dominate plants decreased in *Messor spp*. nests as compared to control area (Table 3). So, we can say that changes in plant community around the nests in addition to soil improvement can be more effective and as a result, they have emerged by harvester ants seeding and also reducing plant competition. Some studies had reported a high rate of seeding by harvester ants, declined cover, richness and diversity of plant (King, 1977; Nowak *et al.*, 1990; Azcárate & Begoña, 2007). However, regarding the harvester ant colonies in seed collecting, feeding them or just feeding seeds of Elaisome, the other seeds can remain and help the growth and production of plant ecosystems, especially in drought years when plant seeding is associated with a sharp decline (Andersen *et al.*, 2000; Fokuhla *et al.*, 2012). Then, the harvester ants act with respect to the distributed preferred plant seeds in better sites around their nests so that it can help them to increase the reproduction and distribution.

On the other hand, the nest making by *Messor spp.* with the dominant plant of *Artemisia siberi* in the area and killing of it caused the absence of this in the nests although it could reduce the competition and increase the resources for other plant species in the nests in a manner that they are few or rare in the desired region but because of different life forms and differences in their structure and function, different effects can be observed on ecosystem processes (Bestelmeyer *et al.*, 2006); also, the key role of this shrub plant which is always important for multiple sources in dry environment by extensive root system concerning its effects on the soil water balance, climate cycle as compared to grass and forbs (Hooper & Vitousek, 1997; Eldridge *et al.*, 2009) can be harmful to the stability and dynamics of the region. *A.siberi* damaging by *Messor spp.* in the center of nests can have some reasons given that

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there can be more food sources, better soil conditions and thermal balance that can be a good place to start nests. According to some studies, the richness and presence of ants have positive correlations with shrub cover and they are suitable for nest building and housing (Casanova *et al.*, 2006). Ants using *A.siberi* resources can reduce the available resources, too (Jurgens *et al.*, 2006). It is possible that *Messor spp*. may attract some materials and elements in different parts of *A.siberi* and different parts of roots of this plant have been destroyed; another reason may be formic acid or toxins produced by the ant body as high acidity may be harmful to this plant (Morawetz *et al.*, 1992); however, complete identification of destruction needs more investigation. Other perennial grasses such as *Stipa hohenackeriana* are important as one of the key plants in this area and also in steppe ecosystems due to drought resistance by increasing the flow of water and nutrients (Palmer *et al.*, 2001) due to few comparisons with control sites, the absence of other shrub species like *Salsola tomentosa*, *Salsola laricina* and *Ephedra strobilacea* despite presence of this plant and other grasses like *Poa sinaica* and *Hordeum morinum* in nests (Table 3). It can be claimed that the shrubs and grass species were few in the composition of nests. However, forbs were the dominant form in control plots but grasses and shrubs had much greater proportion than nests. In this regard, Wilby *et al.* (2001) reported that the activity of *M. ebeninus* increased forbs of *Antemis pseudocotula* and decreased grass *Stipa capensis* in nests as compared to control areas. Accordingly, *S. capensis* is one of the most common plants that their seeds with high rate are collected by *M. ebeninus*.

Also, all the processes and activities of *Messor spp*. decreased perennial plants, palatability and different photosynthetic performance around their nest (Table 4). Importance of C3 and C4 photosynthetic as two distinct pathways (Matsuoka & Hatha, 1987) and due to the survival of species, short-lived plants are more vulnerable and variable to the stresses than long-lived plants with more resistance (Bengtsson, 1998; Díaz & Cabido, 2001) considered as functional characteristics. Brown *et al.* (2012) showed the effects of *M. ebeninus* Forel nests in Kuwait desert on the increased annual plants so that these plants with the establishment in nests as suitable sites were adapted, grown and produced soon**.** The growth of these plants decreased the seed germination of other native plants due to the increased competition and declined resources (Farji-Brener &Ghermandi, 2000; Brown *et al.*, 2012). So, ants can reduce competitiveness through seeding or harvesting the plants, and support rare plants or low-power to grow around their nests (Dostal, 2007). All of them can indirectly contribute to the function of plant community in the nests.

In this study, *Messor spp.* leaving their nests caused different plant community and soil properties as studies on soil characteristics of dead nests showed that after leaving the nests, all soil changes get back to its original state over time (Ghobadi, 2013). Also, all plant characteristics had changed, this was a reason that queen did not choose the sites with high plant diversity to build a nest and therefore, it was not due to initial differences in plant community in the area (Lesica & Kannowski, 1998; Nowak *et al.*, 1990). In dead nests, diversity, richness, and function of plants were significantly decreased. In contrast, vegetation cover increased strictly (82.57%) more than active nests (67.88%) and control site (46.88%). As almost all surfaces of dead mounds with vegetation, especially *C. stricta* were covered and regarding high amount of this plant in active nests, it can be argued that high amounts of seeds were collected

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by *Messor spp.* and the remaining seeds were grown in dead nests after leaving. In addition, some species such as *S.oliveri, P.tenuifolium, A. gilanica, B.deflexa* and *A.tenuifolia* had few presences in dead mound indicating that their seeds are collected by ants too, but the absence of *L.vesicarium* that was one of the most abundant plants in the active nests and also other species may be because of their dependence on seed collection or soil improvement by ants as after ants left their nests, all these activities were stopped; also, another reason can be high rate of seeding for these plants by ants.

Conclusion

In the area, the harvester ants (*Messor spp.*) changed the vegetation structures so that they caused to increase the species diversity and richness in the nests. They, however, were not useful with a view to functional aspects. The ant activities caused to decrease the key species such as *A. sieberi* and *S. hohenackeriana* whereas rare and annual species were increased in the area. Although the ant activities affected small areas, the number of nests countervails this paucity. Even after evacuating the ants from nests, plenteous non-key species were observed in the inactive nests. It seems that lack of grazers in the exclosure area caused to make the harvester ants active so that they are changing the vegetation function without any annoyance. The long term exclosure can cause the changing of vegetation structures and features in a similar area via the activation of some small living things such as ants.

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اثرات فعالیت و لانه‌های مورچه دروگر (*Messor spp.*) بر ساختار و عملکرد جامعه گیاهی مراتع (منطقه موردی: مرتع استپی رودشور ساره)

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چکیده. مورچه‌های دروگر به عنوان یکی از شناخته شده ترین نوع اختلالات زیستی در اکوسیستم‌های خشک و بیابانی محسوب می‌شوند که با دو مکانیسم جمع‌آوری بذر و دروی گیاهان بر ساختار فلورستیک هر منطقه تاثیر می‌گذارند. به نظر می‌رسد سیمای ظاهری جامعه گیاهی منطقه استپی رود شور ساوه (ایران) تحت تأثیر مورچه دروگر (*Messor spp.*) دچار تغییرات شدیدی شده که انگیزه‌ای برای این تحقیق شده است. مطالعه بروی لانه‌های فعال و غیر فعال هم اندازه و نیز سایت شاهد انجام شد. شاخص‌های تنوع و گروه‌های عملکردی نظیر فرم رویشی، طول عمر و نوع فتوسنتز گیاهان، بعنوان معیارهای مورد مقایسه بین سه سایت، مورد تجزیه و تحلیل قرار گرفتند. نتایج نشان داد که غنا، تنوع و پوشش گیاهان در لانه‌های ***Messor* spp** به واسطه افزایش گیاهان فورب به ویژه برخی از فورب‌های یکساله و نادر منطقه مانند ***Campanula stricta*** و ***Lepidium vesicarium*** بیشتر از منطقه شاهد بود، اما از لحاظ یکنواختی گیاهان تفاوت معنی داری بین منطقه شاهد و لانه‌ها مشاهده نشد. عملکرد جامعه گیاهی در لانه ***Messor* spp.** بواسطه از بین بردن گیاهان غالب منطقه ***Artimisia siberi*** توسط این نوع مورچه نسبت به شاهد پایین‌تر بود. کاهش معنی‌دار تنوع، غنا، عملکرد گیاهی و افزایش چشمگیر پوشش بعد از تخلیه لانه‌ها و مرگ مورچه‌ها نیز نشان دهنده تاثیراتی بوده که در نتیجه حضور و فعالیت مورچه‌ها در لانه‌های فعال رخ داده است و ناشی از تفاوت‌های اولیه مکان نیست. بنابراین فعالیت مورچه‌های ***Messor* spp.** در لانه‌هایشان و همچنین بعد از ترک لانه‌ها می‌تواند باعث بوجود آمدن سایت‌های مجزای منطقه‌ای با جامعه گیاهی متفاوت در این مرتع شود که اگرچه باعث افزایش تنوع و پوشش گیاهی خواهد شد اما این اثر با توجه به تعداد و تراکم لانه‌های ***Messor* spp.** در مقیاس منطقه می‌تواند در بلند مدت به دلیل کاهش گیاهان کلیدی و گروه‌های عملکردی متفاوت برای پایداری و عملکرد این اکوسیستم مرتعی مناسب نباشد.

کلمات کلیدی: مورچه‌های دروگر، ساختار گیاهی، عملکرد گیاهی، مرتع، ایران، ***Messor* spp.**

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