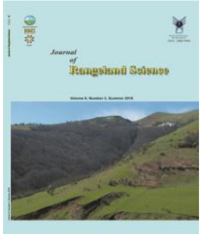
Contents available at ISC and SID

Journal homepage: www.rangeland.ir



Research and Full Length Article:

Changes in Soil Properties by Harvester Ant's Activity (*Messor spp*.) in Roodshoor Steppe Rangeland of Saveh, Iran

Mahsa Ghobadi[A], Mohammad Mahdavi[B], Donat Agosti[C]

[A] Msc. of Rangeland Management, Islamic Azad University, Nour Branch, Mazandaran, Iran (Correspondence Author), Email:Ghobadi.Mahsa@gmail.com
[B] Faculty Member, Department of Rangeland Management, Islamic Azad University, Nour Branch
[C] Research Associate, Department of Invertebrate Zoology, American Museum of Natural History, New York

Received on: 16/01/2016
Accepted on: 17/04/2016

Abstract. One of the most important micro engineers of the terrestrial ecosystems, especially in the arid areas is the harvester ants due to their activity in the soil through nest building; they can make major changes while influencing the surface and subsurface in the rangeland soil. The purpose of this study was to investigate the effects of harvester ants (*Messor spp.*) on some soil properties in Roodshoor Steppe rangeland in Saveh, Iran. Soil samples in four depths (0-10, 10-20, 20-30, and 30-40 cm) were taken in three treatments of active and non-active nests and control area. Soil infiltration test was carried out over ants' nest and control site in dry and wet seasons by double rings method. The results showed that the *Messor spp.* soils had lower pH and higher concentration of organic matter, total carbon, N, P, K, Mg^{+2}, Ca^{+2}, Ec and sand percent in comparison with the control site. The soil infiltration rate regarding the nests was significantly higher than the control area in both dry and wet seasons. In the same habitat, nutrient concentrations did not change along the vertical gradient in contrast to control plots where soil nutrients decreased with depth. This showed homogeneity of different soil layers by ants. On the other hand, investigating the chemical and physical properties of soil did not show a significant difference between the dead nests and the control area. This can be the expression of effects created as the result of the presence of ants in modifying soil in the active nests. These effects disappeared with the passage of time after they left their nests. Therefore, the role of the ants in changing soil properties should be considered, especially in the arid and semi-arid area in which the soil is poor. The presence of ant colonies and their activity in this climate can improve soil conditions and increase soil fertility in most parts of the ground.

Key words: Harvester ants, Soil characteristics, Soil infiltration, Steppe rangeland, *Messor spp.*

Introduction

One of the most important and basic bio-physical resources of rangelands is the soil which is a key element for the health of ecosystems. Knowing about the rangeland soil is very important because soil science shows that some soil functions and properties are highly correlated with soil productivity and stability (Rezaei *et al.*, 2006). Since most of the soil properties can change quickly, the assessment of important chemical, physical, hydrological and biological properties of soil can show the potential ability of ecosystems which are vital for future planning and management (Herrick *et al.*, 2001). Soil plays a valuable role for stability and dynamicity of ecosystem, especially in arid area because of low vegetation cover. In this area, fertility, organic matter content, and mineral particles are fewer and run off and erosion are more than other areas (Wagner *et al.*, 2004). Therefore, knowing about soil properties and processes can decrease the soil losing and provide a suitable environment for the growth of plants and other ecosystem organisms (Bastin *et al.*, 2002; Cammerat *et al.*, 2002). Most of the soil processes and functions are related to the soil biota. They are some microorganisms which belong to the invertebrates group. They are terrestrial and can create mineral and organic structures by moving all over the soil, making nests, pores, channels and tunnels which not only cause obvious changes in soil properties, but also provide resources and new nutrients for other organisms (Whitford *et al.*, 2007; Wu *et al.*, 2010). Presence of ants is very important in many ecosystems, especially warm and desert zones which are frequent and form an important part of the fauna biomass (Robinson *et al.*, 2008). They are like ecosystem engineers that can have some effects on it with their nest making and activity on the soil in addition to other ecosystem processes (Lobryde Bruyn & Conacher, 1994; Folgarait, 1998). In many countries, ants are useful for monitoring. They are considered as a bio-indicator because of their abundance and diversity, their responses to environmental stresses while being easily measured, quantified, interpreted; on the other hand, they are holistic and have integrative effects over time (Underwooda & Fisher, 2006). Ant activities, bioturbation, their vertical movement in the soil, and their transfer and decomposition in both above and underground can change the soil base (Dostal *et al.*, 2005). Many studies have been conducted in different countries and ecosystems with verifying ant species and showed the obvious effects of ants on soil (Bestelmeyer & Wiens, 2003; Lafleur *et al.*, 2005; Whitford *et al.*, 2007; Wu *et al.*, 2010; Jikova *et al.*, 2011). Meanwhile, harvester ants *(Messor spp.)* are one of the most common ant genera in deserts (Crawford, 1981). They harvest plants on the soil surface and build large underground nests which are visible aboveground as round patches surrounded by chaff piles with prominent entrance holes in the middle. Seeds and other plant materials are gathered into the nest chambers for storage and later consumption (MacMahon *et al.*, 2000). Numerous studies have described the contribution of harvester ants to different aspects of desert ecosystems such as the effects on soil hydrology (Lei, 2000; Cammerat *et al.*, 2002), the enhanced nutrient cycling (Boulton *et al.* 2003) and the effects on soil biota abundance and richness (Wagner *et al.*, 1997; Ginzburg & Steinberger, 2008). Content changing of organic matter in the nests is due to food storage, aphid cultivation, and accumulation of faeces and ant remains (Folgarait, 1998; Dostal *et al.*, 2005). Brown *et al.* (2012) tested the effect of *Messor ebeninus* Forel in a desert ecosystem in Kuwait and found more soil fertility in nests than control site. In addition, ants may increase soil infiltration by improving porosity or decreasing infiltration by producing the compacted surfaces which facilitate the runoff (Lobry de Bruyn and Conacher, 1990; Dahms *et al.*, 2010). Cammerat *et al.* (2002) in a soil infiltration analysis by rainfall simulation experiments in a semi-arid rangeland, Spain found higher infiltration rate on the *Messor bouvieri* nests than control site in wet season whereas in dry season, the infiltration was lower on the nests.

According to the mentioned roles of insects including the ants in the soil and ecosystem function, there is lack of research in Iran whereas the ants are considered as the most frequent fauna of arid ecosystem. The purpose of this study was to examine the effects of harvester ant *(Messor spp.)* activity on some soil chemical, physical, and hydrological parameters in Roodshoor Steppe rangeland, Iran. Specifically, the study has been conducted to address the following questions: Do the mounds of *Messor spp.* differ in the soil parameters from their surroundings? And can these differences be explained by colony founding in more fertile sites?

Materials and Methods

Study area

The study area is the steppe rangeland of Roodshoor located in 60 km south of Tehran 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 1120m. The average slope of the site is 5% with the mean annual rainfall of 204mm. January and July are the coldest and hottest months, respectively. The drought period starts in the mid of May and continues until July. The texture of the loamy sand soil covers the heavy soil. The dominant plants of the site include *Artemisia sieberi* and *Stipa hohenackeriana*. Some of the plants derived from this type are *Salsola tomentosa*, *Brassica deflexa*, and *Poa sinaica* (Mahdavi *et al.,* 2009). This area is a long-term research exclosure site (30ha) for Research Forest and Rangeland Institute of Iran since 1964. No sheep and goats are allowed to enter into the site so that it could contribute to the formation and foraging of ant colonies in a large scale that have made changes in the region (Fig.1).

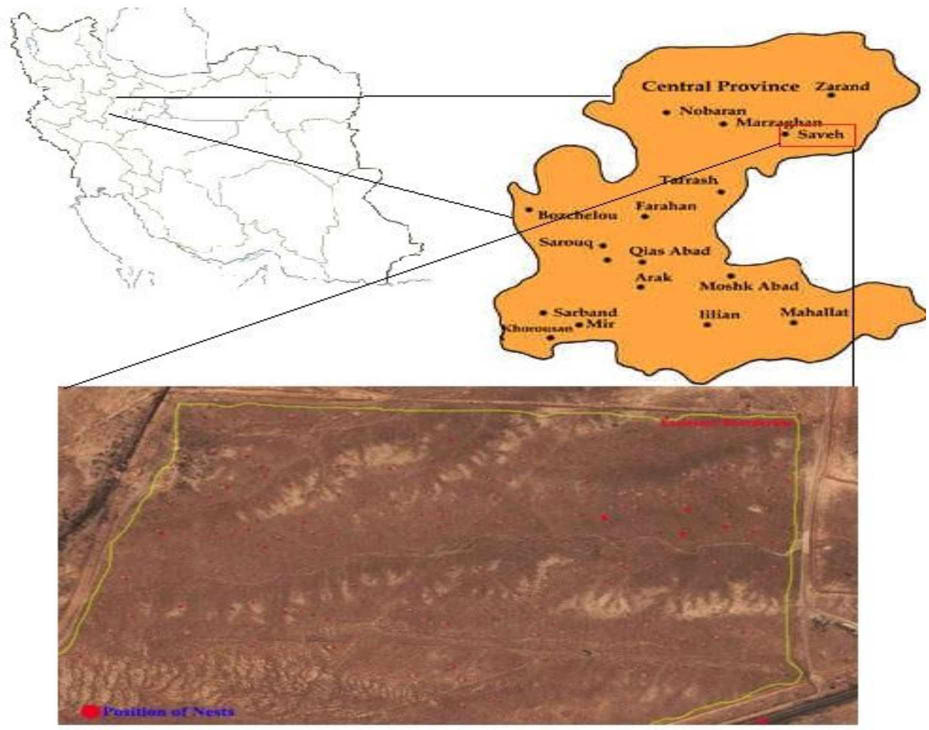


Fig. 1. Map of location of the study area and the red points are the ant colonies in Roodshoor, Saveh, Iran

Ant Species Characterization

In order to determine the dominant species in the study area, the nests and ants of the site were quantified along with 10 strips of 200m transects in the study site. During the investigation and pickets in each nest, the specifications such as the nest code, the longitude and latitude of nests, the nest shape, the nest size, the date and name of the site were all marked down on the pickets. Along with the pickets, the ants of nests were collected and sampled by the direct sampling, and they were collected from each nest and put into vials with 85% of alcohol, and then, all the characteristics of pickets were recorded again in the notebook and put into the vials (Mahdavi & Ghobadi, 2014). Following the sampling, three genera of *Messor*, *Catygilyphis*, and *Formica* were identified, but the identification of all species could not be conducted meticulously because it was time-consuming and difficult. Then, the differentiation of species was simple and accurate due to differences in size and color of workers as well as different clearing and mound shapes among species (Table, 1). In the end, the effects of one species of harvester ants named *Messor spp.* were investigated because of their nest size (mean diameter of 2.3m). Their density proportionate to the area was (8.3 nests per ha) caused by their greater dominance relative to the other species and more noticeable effects on the plantation of the area (Fig.2 & Table 1).

Fig. 2. Mound of *Messor spp.* in Roodshoor

Table 1. Characteristic of Ant species in study site

Species	Function group	Typical habitat	Color	Size	Mound shape	Density (No/h)	Mound Diameter (m)	Material composition
Messor sp 1	Harvester	Dry region	Black	Small & medium	Flat	8.3	2.3	Seed, Plant, Soil
Messor sp.2	Harvester	Dry region	Black & Red	Medium	Dome	0.9	1.46	Seed, Plant, Soil
Messor sp. 3	Harvester	Dry region	Black	Small	Pore	0.1	-	Soil
Cataglyphis Bellicosus Karavaiev	Scavenger	Steppe & Desert	Black	Large	Pore	1.7	-	Soil
Cataglyphis sp.1	Scavenger	Steppe & Desert	Black & Red	Medium	Flat	0.5	0.95	Soil
Cataglyphis sp.2	Scavenger	Steppe & Desert	Orange	Small	Pore	0.2	-	Soil
Formica sp. 1	General forager	Unknown	Brown	Small	Pore	0.1	-	Soil

Soil physical and chemical measurements

Because of the variety of nest size to evaluate and measure the soil characteristics and the need for a comparison of the treatments, the diameter of all nests was measured by a measuring tape to determine a plot with a fixed size. After measuring the diameter, the most frequent size in the active and dead nests of the given ant species was estimated as the average value of 3.5m. Therefore, the circular plot with a diameter of 3.5m was determined to serve the sampling purpose in 18 active nests of *Messor spp.* in 3m away from each nest within 18 plots marked in the control area and 7 dead nests all of which had a diameter of 3.5m. In each plot, soil samples for chemical and physical analysis were taken from the different layers (0-10, 10-20, 20-30, and 30-40cm) placed separately in the labeled plastic bags. Ant bodies, stones, and other impurities in soil samples were removed; then, samples were dried to constant weight at 40°C, milled and sieved through a 2mm sieve for the elemental analysis. Such methods as hydrometer method for soil texture (Jacob and Clark, 2002), Kjeldahl method for total nitrogen (Bremner and Mulvaney, 1982), and the modified Walkley-Black wet oxidation procedure for organic carbon content were applied. Multiplying the soil organic carbon by 1.72 resulted in soil organic matter (Nelson and Sommers, 1982). Titration method with EDTA solution was used for measuring calcium and magnesium (Lanyon and Heald, 1982) and also, soil pH and electrical conductivity (EC) were measured in the saturated mud and saturated extract, respectively (McLean, 1982). Saturated moisture was determined from the saturated mud by the means of weighing method (McLean, 1982). The amount of phosphorus that exists in the extracts of soil was determined by a spectrophotometer (Olsen and Sommers, 1982). Absorbable K after extraction was measured using 1 N ammonium acetate (pH=7).

Soil hydrological measurements

Infiltration experiments were carried out by Double rings method in dry (July) and wet (January) seasons (Fig.3). Two metal rings were installed to measure the water infiltration rate in 5 nests of *Messor spp.* at 3m away from the nests as control sites all of which had a diameter of 3.5m. To have more exact results, samples were taken from four locations of nests and control site. The bigger ring was 50cm in diameter and 45cm in height, and smaller ring was 30cm in diameter and 20cm tin height placed into the soil to a depth of approximately 3cm. After that, water in the big ring became fixed at a depth of 5cm. Water was added to the smaller ring at a depth of 10cm. Then, the elevation of water infiltration in the soil with the fixed time (180min) over the experiment and durations of 1, 2, 4, 6, 10, 20, 30, 60, 120, and 180min in the small ring was measured by a ruler. All data were recorded in the field worksheet. Water was gently added to dry soils so that no splash effects would occur. A plastic surface was used for avoiding the soil deformation (Carol Nicolai, 2005; Sepahvand *et al.*, 2011).

Fig. 3. Double rings for soil infiltration measuring

Statistical analysis

Soil infiltration rate was measured by Infilt Excel Software (water & soil adviser engineers of Tehran, 1997). Among different models (Philip, Horton, Green-Ampt, Kostiakov and SCS) Kostiakov was the best model with the highest modeling efficiency (EF), and lower root mean square error (RMSE) so that this software was selected and used. Means and standard errors were calculated using the SPSS 14.0 software package. Comparisons of soil parameters in the active and non-active ant mounds and the control soil were also performed with one-way ANOVA. Duncan test was used to compare the treatment means.

Results

Soil chemical and physical properties

The mound soil was significantly different from the soil of control plots in all chemical and physical parameters except silt percent that did not differ between the treatments. There were higher concentrations of available organic matter, organic Carbon and N, P, K, Ca^{2+}, and Mg^{2+} in the mounds. In addition, the soil texture analysis showed higher sand percent and lower clay percent in the mound as compared to the control sites. In contrast, the soil from control plots only had higher pH and clay than the mounds (Table 2). On the other hand, after the mound abandonment, the only exceptions were pH and clay which were significantly increased after the abandonment whereas the other properties were decreased or did not differ between the dead mound and control site for all parameters (Table 2).

Table 2. Means comparison of physical and chemical properties of soils (Mean from 0 to 40 cm) from *Messor spp*. mounds, dead mounds and control sites in Roodshoor

Properties	Mound	Control site (n=18)	Dead mound (n= 7)
pH	7.47±0.01 b	8.30±0.03 a	8.40±0.04 a
Ec	3.05±0.03 a	1.43±0.06 b	1.30±0.06 b
%N	0.05±0.005 a	0.01±0.03 b	0.01±0.03 b
P (ppm)	15.7±0.70 a	4.01±0.03 b	4.08±0.10 b
K (ppm)	551.9±3.80 a	320.1±1.02 b	322.5±7.81 b
% OC	0.59±0.04 a	0.18±0.03 b	0.19±0.02 b
% OM	1.13±0.08 a	0.33±0.05 b	0.35±0.06 b
Mg (mg g^{-1})	110.5±0.2 a	90.2±0.25 a	91.3±0.01 a
Ca (mg g^{-1})	78.2±0.1 a	60.4±0.01 b	61.2±0.03 b
%Sand	80.5±0.19 a	77.9±0.18 b	78.0±0.15 b
%Silt	8.4±0.16 a	8.9±0.20 a	8.93±0.20 a
%Clay	11.06±0.2 b	13.13±0.25 a	13.00±0.21 a
Temperate (Dry season)	32±0.1 a	28.1±0.1 b	27.5±0.1 b
Temperate (Humid season)	25.2±0.01 a	22.0±0.2 b	23.4±0.03 b
Moisture (Dry season)	6.5±0.6 a	4.2±0.01 b	4.9±0.02 b
Moisture (Humid season)	9.3±0.3 a	7.4±0.05 b	7.8±0.01 b

*Means of rows with different letters are significantly different ($P < 0.05$)

Soil nutrient concentrations in relation to different depths

Nutrient concentrations were also significantly different between successive soil segments. Concentrations were systematically decreased along with the sampling depth (0-40cm). However, this pattern was typical for the soil from control plots and dead mound. In the mound soil, concentrations were similar between the soil layers (Fig. 4).

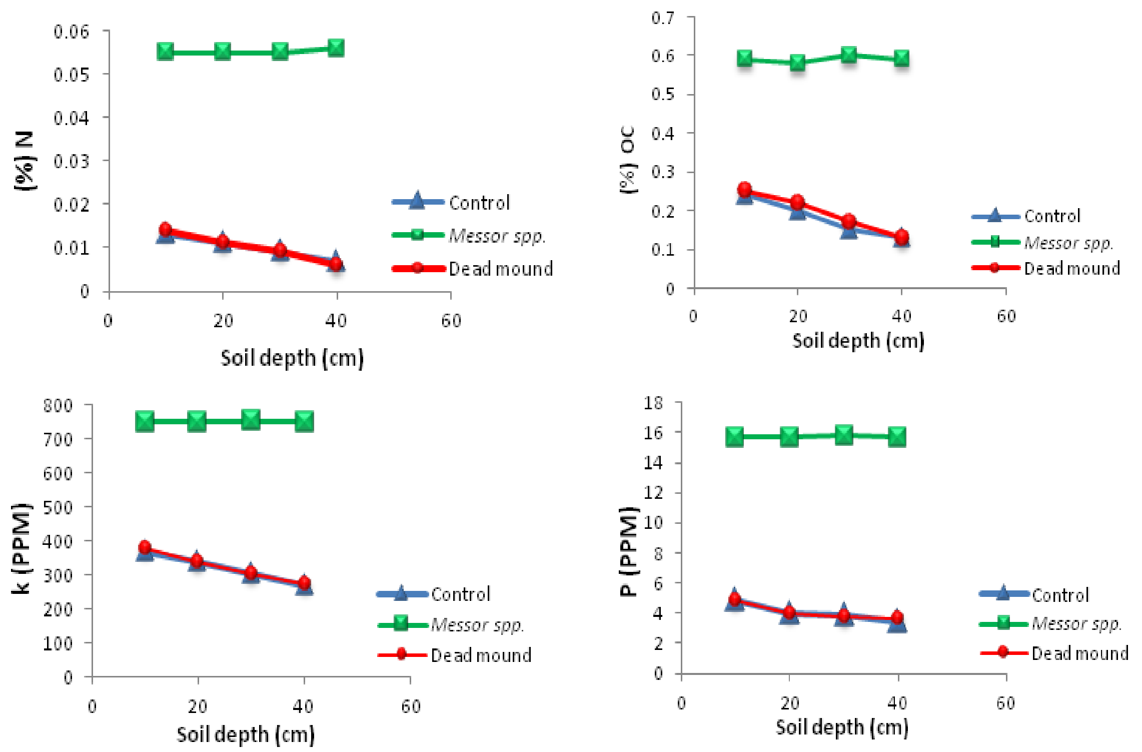


Fig. 4. Nutrient concentrations of soil in four layers (0 to 40 cm) in *Messor spp*. Mound, dead mounds and control sites (control & mound N=18, dead mound N= 7)

Soil infiltration properties

According to the results of Infilt Excel Software, Kostiakov model was selected as the best model with the highest modeling efficiency estimated as 98% and the coefficient of determination given as 97% in all the measurements. According to this model, the infiltration rates in both dry and wet seasons in *Messor spp.* nests were significantly greater than the control areas (Table 3). However, the infiltration rate was higher in wet season in comparison with dry season in mounds (Dry: 34/74 mm h^{-1}, wet: 40/32 mm h^{-1}; Fig. 5), but For control areas, there was no significant difference between dry and wet seasons (Dry: 21/66mm h^{-1}, wet: 22/84mm h^{-1}; Fig. 5).

Table 3. Results of soil infiltration measuring (+S.E) under conditions of high and low soil moisture contents by Double rings method

Replicate	Treatment	Time (min)	Total water applied (cm)	Final infiltration rate Dry season (mm h^{-1})	Final infiltration rate Humid season (mm h^{-1})
1	Control	180'	10	20.8 ± 0.03	23.5 ± 0.02
	Mound			30.7 ± 0.01	34.2 ± 0.20
2	Control	180'	10	20.0 ± 0.02	23.0 ± 0.06
	Mound			35.6 ± 0.04	45.6 ± 0.03
3	Control	180'	10	22.0 ± 0.01	24.8 ± 0.01
	Mound			36.2 ± 0.03	41.0 ± 0.20
4	Control	180'	10	22.3 ± 0.02	20.8 ± 0.02
	Mound			33.0 ±0.10	38.8 ± 0.04
5	Control	180'	10	23.2 ± 0.20	22.6 ±0.10
	Mound			38.2 ± 0.01	42.0 ±0.06

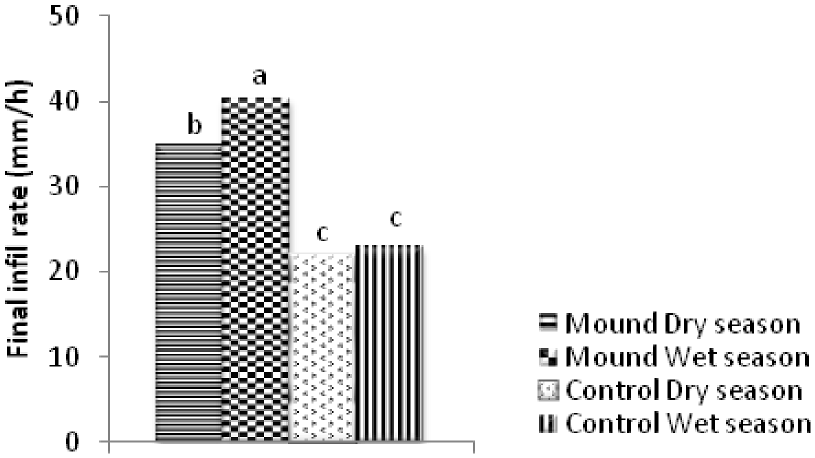


Fig. 5. Means comparison of infiltration rate in *Messor spp*. Mound & control site, N=5
*Means with different letters in each row are significantly different (P < 0.05)

Discussion

The purpose of this study was to evaluate the impact of harvester ants (*Messor spp*.) on the soil quality and properties and their comparison with the control area when the nests were abandoned in the rangeland steppe of Roodshoor in Saveh. Generally, *Messor spp.* nests were more fertile than control sites. The average concentrations of N, K, P, micro nutrient, OC, and OM were higher in the ant mounds than control soil. These results are in agreement with some similar reports from other previous studies on harvester ant mounds (Snyder *et al.*, 2002; Whitford *et al.*, 2007; Boulton *et al.*, 2003; Ginzburg & Steinberger., 2008).

Harvester ants such as *Messor spp*. increase soil nutrient and modify it by collecting and saving the plant seeds and also concentrations of litters, animal bodies, brood, and corpses in their nests while decomposing them. As discussed earlier, carbon and nutrient concentrations were probably influenced by the changes in soil processes such as respiration, decomposition, mineralization and denitrification. This creates both direct and indirect sources of food for other organisms, enhances soil microbial and enzyme activity, stimulates the growth of plants and creates good habitats for the other soil microorganisms (Ghobadi *et al.*, 2015). On the other hand, soil pH was lower in the ant nests than control sites. Jikova *et al.* (2011) claimed that pH changes are connected with the changes in organic matter content. Thus, pH is negatively correlated with organic matter content and a decrease in pH in the nest seems to be caused by increasing the organic matter content. Organic matter content is closely related to the content of Humic and Fulvic acids which acidify the soil and increase the decomposing. The ant nests are a place where they raise children and maintain and protect the Queen and stored food. Therefore, they select the best place with high temperature and suitable humidity for growing babies and the best soil for digging, making nests and changing the nest size easily (Anderson & Morrison, 1998; Johnson, 1998). Soil texture and sand play a major role in regulating the temperature and humidity in the colonies that would affect the survival of colonies. The harvesting of ants assists their nest by weeding plants for direct solar radiation and increases the temperature for the development and survival of queen (Wagner *et al.*, 1997 & 2004; Graham, 2009; Baraibar *et al.*, 2011). Thus, higher percentage of sand, temperature, and humidity can cause the ants' nest building and their activities. We also documented that a change in the concentration of nutrients along the vertical gradient was different in the mounds as compared to the control plots. In the ant nests, soil homogenization was also demonstrated by similar nutrient concentrations found between four consecutive layers down to a depth of 40cm. In contrast, soil nutrients in the control plots were decreased dramatically with respect to the sampling depth. Dostal *et al.* (2005) showed that in the soil surrounding the mounds, the concentrations of nutrients declined steeply with the depth whereas in the mounds, these parameters remained unchanged in consecutive soil layers. In conclusion, the ant mounds considerably increased the spatial homogeneity of chemical parameters and affected C/nutrient ratios and nutrient pools at the soil micro scale. However, Wu *et al.* (2010) claimed that soil nutrients in the nests of *Formica sanguinea* and *Lasius flavus* were dramatically decreased with regard to the sampling depth. The decline of these nutrients in the mounds is probably due to the removal of organic matter from the nests by the ants. In addition, this decline could be due to the replacement of upper horizon with mound subsoil which is usually poor in organic matter (Richards, 2009). Comparison of occupied and abandoned mounds confirmed that soil changes found in the mounds were due to ant activities during mound occupancy, not due to soil differences during colony establishment because of changes.

In total, carbon, nitrogen, and potassium concentrations were similar to the control sites after the abandonment, but they had significant differences with mounds. The soil infiltration rate was significantly higher on the nests than control areas in both dry and wet seasons. The research on the harvester ants conducted by Eldrige (1994) was adapted. Higher amounts of sand, Ec, and humidity as factors influencing permeability rate in the nests of ants *Messor spp* and their activity for creating holes and stomata pores in the soil for nests can cause soil weakness regarded as the reason for the increased rate of water movement in the soil of their nests (Jemes *et al*., 2008). Although the infiltration rate of nests in the wet season was higher than the dry season, the research conducted by Cammerat *et al.* (2002) only reported the increased infiltration rate in the harvester ants' nest in the wet season as compared to the control area. These studies showed the effects of ant nests on the infiltration depending on spatial and temporal patterns, amount of seeds, and vegetation in nest and measuring methods (Lobryde Bruyn & Conacher, 1994). In the wet season, rainfall causes moisture and more frailty. On the other hand, the accumulated seeds and other foods are washed into the nest holes with rainfall and they open these holes, but in the dry season, this amount is lower due to drought and soil compaction by more seed litter and various food outlets. In this regard, Wang *et al.* (1996) reported that the total infiltration rate in the nests of *Lasius neoniger* ants was lower than the control area because their holes were filled with different foods.

Conclusion

Finally, our results can be a reliable document for determining the relationship between soil fauna with soil processes and the ants' role as one of the ecosystem engineers in Iran. Over the time, they can affect the soil of whole area, modify different parts of an ecosystem, and increase its performance in poor and fragile areas by nest making, multi activities, competition and special bio-behavior. Low quality and fertility of soil are the key problems of desertification and surely, many ecosystems of Iran have different ant species in a large group for a long time that most of them remained unknown due to the lack of attention and research. Evaluating these effects in various sections in the future requires more attention, and it can use the ants as an important indicator to evaluate different parts of an ecosystem. In addition, it can be the prediction of next steps in soil science which emphasizes the importance of biota as an improving element for soil quality.

Acknowledgements

We would like to thank Professor Jonathan Majer, Dr. Omid Paknia, Dr. Helen Alipanah and Dr.Mohammad Hassan Jouri For their substantial number of comments and suggestions.

Literature Cite

Anderson, A. N., Morrison, S.C., 1998. Myrmecochory in Australia's seasonal tropics-effects of disturbance on distance dispersal. Ecology.5: 483-491.

Boulton, A. M., Jofee, B. A., Scow, K. M., 2003. Effects of a common Harvester Ant (Messor andrci) on richness & abundance of soil biota. Applied soil Ecology. 23: 257-265.

Bastin, G.N., Ludwig, J.A. Eager, R.W., Chewinys, V.H., Liedloff, A.C., 2002.Indicators of landscape function comparing patchiness metrics using remotely-sensed data from rangelands. Ecological indicators. 1: 247-260.

Baraibar, B., Torraa. l., Westerman, P.R., 2011. Harvester ant (Messor barbarus) density as related to soil properties, topography and management in semi-arid cereals. Applied Soil Ecology. 51: 60– 65

Bestelmeyer, B.T, Wiens, J.A., 2003. Scavenging Ant foraging behavior and variation in the scale of nutrient redistribution among semi-arid grasslands. Jour. Arid Environments. 53: 373-386.

Bremner, J. M., and Mulvaney, C. S., 1982. Nitrogen total. P. 595-624. In Page, A. L. (ed.), Methods of soil analysis. Agron. No. 9, Part 2: Chemical and microbiological properties, 2nd ed., Am. Soc. Agron., Madison, WI, USA.

Brown, G., Scherberb, C., Ramos Jr, P., Ebrahimde, E., 2012. The effects of harvester ant (Messor ebeninus Forel) nests on vegetation and soil properties in a desert dwarf shrub community in north-eastern Arabia. Flora. 207: 503-511.

Cammerat, L. H., Willott, S. J., Compton, S. G. & Incoll, L. D., 2002. The effects of ant's nests on the physical, chemical & hydrological properties of a rangeland soil in semi-arid Spain. Geoderma. 105: 1-20.

Carol Nicolai, N., 2005. Plant community dynamics governed by red harvester ant (Pogonomyrmex Barbatus) activities and their role as drought refuge in a semi-arid Savanna, Texas A&M University. PhD Theses.

Crawford, C.S., 1981. Biology of desert invertebrates. Springer. Berlin. 300pp.

Dahms, H., Lenoir, L., Lindborg, R., Wolters, V. & Douber, J., 2010. Restoration of semi natural grassland: what is the impact on ants? Restoration Ecology. 18:330-337.

Dostal., P., Breznova, M. Kozlı,Vladimıra, Kova, Herben,T., Kova, P., 2005. Ant-induced soil modification and its effect on plant below ground biomass. Pedobiologia 49: 127-137.

Eldrige, D.J., 1994. Nests of Ants and termites influence infiltration in a semi-arid woodland. Pedobiologia 38: 481-492.

Folgarait, P., 1998. Ant biodiversity and its relationship to ecosystem functioning: a review. Biodiversity Conservation. 7: 1221-1244.

Ghobadi, M., Agosti, D., Mahdavi, M., Jouri, M. H., 2015. Effects of harvester ant nest activity (Messor spp.) on structure and function of plant community in a steppe rangeland (Case Study: Roodshoor, Saveh, Iran). Jour. Rangeland Science, 5: 269-283.

Graham, J., 2009. Species richness, equitability and abundance of ants in disturbed landscape. Ecological Indicators. 9: 866-877.

Ginzburg, Orit W.G. & Steinberger, W., 2008. Effects of harvester ant (Messor spp.) activity on soil properties and microbial communities in a Negev desert ecosystem. Bio Fertile Soils. 45: 165-173

Herrick, J, E., Whitford, W.G., Desoyza, A.G., Vanzee, J.W., Hastad, K. M., Seybold. C.A., Walton, M., 2001. Field soil aggregate stability kit for soil quality & rangeland health evaluations. Catena. 44: 27-35

Jemes, A., Eldridge, D., Koen, T.B. & Whitford, W.G., 2008. Landscape position moderates how ant nests effect hydrology and soil chemistry across a Chihuahun desert watershed. Landscape Ecol. 23: 961-975.

Jikova,V., Maejicek, L., & Frouz, J., 2011. Changes in the pH and other soil chemical parameters in soil surrounding wood ant (Formica polyctena) nests. Soil biology 47: 72-76.

Jacob, H. and Clarke, G., 2002. Methods of Soil Analysis, Part 4, Physical Method, Soil Science Society of America, Inc, Madison, Wisconsin, USA, 1692 p.

Johnson, R.A., 1998. Foundress survival and brood production in the desert seed-harvester ants

Pogonomyrmex rugosus and P. barbatus (Hymenoptera Formicidae). Insect. Soc. 45: 255–266.

Lafleur, B., Hooperbui, L. M., Mumma, P., & Geaghan, J.P., 2005. Soil fertility & plant growth in soil from pine forests & plantations: effect of invasive red imported fire ants (Solenopsis invicta). Pedobiologia. 49: 415- 423.

Lanyon, L.E., and Heald, W.R., 1982. Magnesium,Calcium,Strontium and Barium. In: Methods of soil analysis. Part 2, Page, A.L., Miller R.H., Keeney D.R. (Eds). Agronomy No. 9. American Society of Agronomy, Madison WI, 247-262 pp.

Lei, S.A., 2000. Ecological impacts of seed harvester ants on soil attributes in a Larrea-dominated shrubland. WN Am Nat. 60: 439-444.

Lobryde Bruyn, L. A. and Conacher, A. J., 1990. The role of termites & ants in soil modification: a review. Soil Res. 28: 55-93

Lobryde Bruyn, L. A., Conacher, A. J., 1994. The bioturbation activity of ants in agricultural and naturally vegetated habitats in semi-arid environments. Aust. Soil. Res. 32: 555-570.

Machmahon, J. A, Mull, J. F., Crist, T. O. 2000. Harvester Ants (Pogonomyrmex Spp) their community and ecosystem influences. Annual review ecology systematic. 31:265-291.

Mahdavi, M., Arzani, H & Jouri, M. H., 2009. Analysis of rangeland conditions changes using of qualitative method of rangeland health. Rangeland. 3: 397-411. (In Persian).

Mahdavi, M. & Ghobadi, M., 2014. Persian translation of Ants book: Standard Methods for Measuring and Monitoring Biodiversity. Jahad Daneshgahi publishing. 528pp., Tehran, Iran (In Persian).

McLean, E.O., 1982. Soil pH and lime requirement. In Methods of soil analysis, part 2, In Page, A. L. (ed.), Madison, Wisconsin. ASA-SSSA.

Nelson, D. W. and Sommers, L. E., 1982. Total carbon and organic matter. In Methods of soil analysis, part 2, in Page, A. L. (ed.), Madison, Wisc. ASA-SSSA.

Olsen, S.R., and Sommers, L. E., 1982. Phosphorus. P.403- 430. In A.L. Page, Miller. R.H. (Eds).), Methods of soil analysis, Part 2: Chemical and microbiological properties, 2nd ed., Am. Soc. Agron., Madison, WI, USA.

Rezaei, S. A., Arzani, H., Tongway, D., 2006. Assessing rangeland capability in Iran using landscape function indices based on soil surface attributes. Arid Environments. 65: 460-473.

Richards, P., 2009. Aphaenogaster ants as bioturbators: impact on soil & slope process. Earth-science. 96: 92-106.

Robinson, E.J., Holcombet, M. & Ratnieks, F., 2008. The organization of soil disposal by ants. Animal Behavior. 75:1389-1399.

Snyder. S. R., Crist, T.O., Friese, C.F., 2002.Variability in soil chemistry and arbuscular mycorrhizal fungi in harvester ant nests: the influence of topography, grazing and region. Biol Fertil Soil, 35: 406-413.

Sepahvand, A. Taie Semiromi M., Mirnia S.K. & Moradi H.R., 2011.Assessing the Sensitivity of Infiltration Models to Variability of Soil Moisture. Jour. Water Soil. 25: 338-346. (In Persian).

Underwooda, E., Fisher, B.L., 2006. The role of ants in conservation monitoring: If, when, and how? Biological Conservation 132(2): 166-182.

Wagner, D., Brown, J. F., Gordon, D.M., 1997. Harvester ant nests, soil biota and soil chemistry. Oecologia. 112: 232-236.

Wagner, D., Jones, J. & Gordon, J., 2004. Development of harvester ant colonies alters soil chemistry. Soil Biology Biochemistry. 36: 797-804.

Wang, D., Lowery, B., Norman, J.M., & Mesweeny, K., 1996. Ant burrow effects on water flow and soil hydraulic properties of Sparta sand. Soil Tillage Res.37:83-93.

Water & soil adviser managers of Tehran province. 1997. Water infiltration in soil. Infilt software. (In Persian)

Whitford, W.G., Barness, G. & Steinberger,Y., 2007. Effects of three species of Chihuahuan desert ants on annual plants and soil properties. Arid Environments.72: 392-400.

Wu, H., Lu, X., Wu, D., Yin, X., 2010. Biogenic structures of two ant species Formica sanguinea and Lasius flavus altered soil C, N and P distribution in a meadow wetland of the Sanjiang Plain, China. Applied Soil Ecology. 46: 321–328.

بررسی تغییرات در خصوصیات خاک توسط فعالیت مورچه‌های دروگر (*Messor spp.*) در مراتع استپی رودشور ساوه، ایران

مهسا قبادی[الف]، محمد مهدوی[ب] ، دونات آگوستی[ج]

[الف] کارشناسی ارشد رشته مرتعداری، دانشگاه آزاد اسلامی، واحد نور ، نگارنده مسئول، پست الکترونیک:
Email:Ghobadi.Mahsa@gmail.com

[ب] عضو هیئت علمی گروه منابع طبیعی، دانشگاه آزاد اسلامی، واحد نور

[ج] استاد پژوهش گروه جانورشناسی بی مهرگان آمریکا، موزه تاریخ طبیعی، نیویورک

تاریخ دریافت: ۱۳۹۴/۱۰/۰۹

تاریخ پذیرش: ۱۳۹۵/۰۱/۲۹

چکیده. مورچه‌های دروگر بعنوان یکی از مهم‌ترین مهندسان خرد اکوسیستم‌های خاکی بویژه در مناطق گرم و بیابانی شناخته می‌شوند که به دلیل حضور و فعالیتشان در خاک بواسطه ساخت لانه می‌توانند تاثیرات مهمی در تغییرات سطحی و زیر سطحی خاک به جای بگذارند این تحقیق با هدف بررسی تاثیرات مورچه دروگر *Messor spp.* بر برخی خصوصیات خاک مرتع استپی رود شور ساوه انجام شد. نمونه‌های خاک در چهار عمق (۰-۱۰، ۱۰-۲۰، ۲۰-۳۰، ۳۰-۴۰ سانتی‌متر) از لانه‌های فعال و غیرفعال این گونه و منطقه کنترل (فاقد لانه) جمع‌آوری گردید. سرعت نفوذپذیری خاک نیز در دو فصل خشک و مرطوب به روش استوانه مضاعف در لانه‌ها و منطقه کنترل اندازه‌گیری شد. نتایج نشان داد که خاک لانه‌های *Messor spp.* در مقایسه با خاک منطقه کنترل بطور معنی‌داری دارای مقدار اسیدیته پایین‌تر و تمرکز بیشتر مواد آلی، کربن آلی، نیتروژن، فسفر، پتاسیم، مواد میکرو، رطوبت، دما، هدایت الکتریکی و درصد شن بوده است. سرعت نفوذپذیری خاک نیز در دو فصل خشک و مرطوب در لانه‌ها بیشتر از منطقه کنترل بود. مقدار مواد مغذی خاک در منطقه کنترل با افزایش عمق کاهش یافت اما در لانه‌های *Messor spp.* این مقادیر با افزایش عمق تغییر معنی‌داری نداشتند که نتیجتا بیانگر یکسان سازی لایه‌های مختلف خاک توسط فعالیت این مورچه‌ها بوده است. از طرفی مقایسه خصوصیات شیمیایی و فیزیکی خاک لانه‌های غیرفعال و منطقه کنترل نشان دهنده تفاوت معنی‌داری نبود. این امر می‌تواند بیان کننده تاثیراتی باشد که در نتیجه حضور و فعالیت مورچه‌ها در تغییر و اصلاح خاک در لانه‌های فعال به وجود می‌آید و بعد از ترک آن‌ها با گذشت زمان این اثرات از بین می‌رود. بنابراین نقشی که مورچه‌ها در تغییر و دگرگونی خاک ایفا می‌کنند می‌بایست مورد توجه بگیرد، خصوصا در مناطق خشک و نیمه خشک که غالبا خاک از کیفیت مطلوبی برخوردار نیست، حضور کلنی‌های مورچه و فعالیت آن‌ها در این اقلیم می‌تواند موجب بهبود وضعیت خاک و افزایش حاصلخیزی در غالب قطعات دوایر مانند مجزا در سطح زمین شود.

کلمات کلیدی: مورچه های دروگر، خصوصیات خاک، نفوذپذیری خاک، مرتع استپی، *Messor*