Journal of Research in Ecology

An International Scientific Research Journal

ISSN No: Print: 2319 –1546; Online: 2319– 1554

Journal of Research in Ecology

Short Communication

Effects of soil degradation on the distribution of soil macro-arthropods in the daya of the Algerian steppe

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ABSTRACT:

The main objective of this study is to assess the soil diversity, and temporal and spatial distribution of soil macro-arthropods, on different dayas in Algerian steppe. We have analyzed both Degraded Daya (DD) and Non Degraded Daya (NDD) (natural) with different soil physical and chemical characteristics. In our case, the main cause for degradation is the plowing and rainfed cropping. After two years (2012-2013), the results showed a degradation of the vegetation and deterioration of the soil environment during the degradation process with significant decreases in the vegetation cover, litter, clay and silt, soil organic carbon and soil. Also, soil degradation has adverse effects on the environment. Soil degradation results in a significant decrease in the richness and density of soil macro-arthropods and changes the seasonal distribution of the soil arthropod community. Desertification has greater effects on herbivores than on omnivores in the growth season and resulted in a significant change in the seasonal pattern of the trophic structure.

Keywords:

Daya degradation, Soil, Macro-arthropods, Vegetation cover, Density.

Article Citation:
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Effects of soil degradation on the distribution of soil macro-arthropods in the daya of the Algerian steppe
Journal of Research in Ecology (2018) 6(1): 1716-1722

Dates:
Received: 22 April 2018 **Accepted:** 16 May 2018 **Published:** 12 June 2018

Web Address:
http://ecologyresearch.info/documents/EC0569.pdf

INTRODUCTION

There are about 45.6 million km^2 of desertified land in the world, accounting for 35% of the terrestrial parts of the earth, occurring in more than 100 countries, and affecting 8.5×10^8 people (Zhao *et al*., 2006; Zhu and Chen, 1994). The Algerian steppe stretches over 20 million hectares on the edge of the northern desert. It is distributed over vast flat spaces slightly hilly, across which wadi beds run. It is divided by depressions and sometimes by high massifs. In arid regions, there are two types of depressions. Open as wadis and closed as dayas, in the second case water accumulates and gives rise to the alluvial soil. The dayas are the lowest point of closed basin, often of circular or oval shapes.

In Algeria, especially in the steppe, many researchers are interested in the phenomenon of desertification (Taibi, 1997; Bensaid, 2006; Guettouche and Guendouzi, 2007; Houyou *et al*., 2014). As desertification can not only result in the soil degradation and severe decreases in the land potential productivity (Zhao *et al*., 2009; Zhou *et al*., 2008), it also damage the eco-environment and economic development. It is one of the most serious environmental and socio-economic problems in many arid and semi-arid regions of the world (Gomes *et al*., 2003; Zhu and Chen, 1994).

There is a great deal of literature on the causes, processes, and mechanisms of desertification and its control. Research has confirmed that desertification is an important process that affects both the surface features and the biological potential of grassland soils (Houyou *et al*., 2014; Lal, 1998; Zhu and Chen, 1994). Through wind erosion and the accumulation of sand, desertification can lead to the loss of fine particles from soil, producing a more sandy texture (Zhao, 2006; Zhou *et al*., 2008). Such losses of fine particles can result in a noticeable decline in the soil organic matter and finally lead to partial or even complete destruction of soil productivity by increasing bulk density, reducing porosity, water infiltration rates, and damaging the soil structure and aggregate stability as well as the storage and availability of nutrients (Zhao *et al*., 2014; Zhou *et al*., 2008). Rainfed cropping in dry lands erosion causes severe soil degradation as a result of loss of soil, carbon and nutrients (Bielders *et al*., 2002; Hoffmann *et al*., 2011; Labiadh *et al*., 2013). Along with soil coarsening and impoverishment, the cover and height decrease and the species diversity and biomass are reduced in daya. Serious desertification can even lead to collapse of the daya ecosystem. However, studies have rarely considered the effect of daya desertification on the soil macro-arthropod community. In Algeria, some researchers have investigated the types of desertification and the causes and distribution of grasslands in this area. Others have studied wind erosion and airborne dust deposition in the grassland and characteristics of soil degradation in the grassland vegetation affected by desertification. However, there are few published studies on the effects of daya desertification on the temporal and spatial distribution of the soil macro-arthropod community in this area.

The objectives of this study are:

- To compare the differences in the soil macro-arthropod community between different seasons;
- To analyze changes in the temporal and spatial distribution patterns of soil macro-arthropods affected by daya degradation;
- To discuss the relationship between changes in the soil macro-arthropod properties and changes in the vegetation properties and soil environments.

MATERIALS AND METHODS

Laghouat called as dayas country, is located on the Southern Algeria steppe, 400Km south of capital. Covering a land area of 25,052km^2. Farming is the main activity of the population. The province of Laghouat comprises 1,531,125ha of grazing land, of which almost 89% is in a degraded state (DPWL, 2010).

Table 1. Changes in the soil texture (0-30cm)

S. No	Daya	Sand (%)	Silt (%)	Clay (%)
1	N.D.D	73.05 ± 4.83	16.75 ± 4.07	9.69 ± 3.06
2	D.D	92. 83 ± 2.62	4.88 ± 1.98	2.28 ± 1.16

Study site

The study area is located in the southern part of the dayas country (33°19'40''N, 3°5'23''E; 801m), The region is characterized by a typical desert climate with high temperatures and low rainfall. The mean annual precipitation is 162mm, and the mean annual temperature is 18.91°C. Soils were predominantly sandy top soil, easily mobilized by winds. On large dayas, soils are deep, sandy and fine-textured with ground surface covered by pebbles. Smaller dayas have a bare shallower coarse-textured soil with low clay content, covered with gravels of different sizes. The dominant plant species in the natural grasslands include *Pistacia atlantica* and *Ziziphus lotus.*

Methods

The study was conducted in summer and winter. The field sampling sites, which had a total area of 102 ha. The experimental dayas were divided into two desertification degrees or intensities: control Daya with No Degradation (NDD), and Degraded Daya (DD).

Two adjacent sites (20-50 ha in size) with similar topographies were selected for each desertification level. Within each site, three replicate 30m×30m plots were established. Three 1m×1m vegetation quadrats (n=27) and three 25cm×25cm×30cm soil quadrats (n= 27) were placed in each plot for the determination of vegetation and soil macro-arthropod community properties, respectively. The vegetation cover, aboveground biomass, and litter were measured in each vegetation quadrat in early June (summer) and January to February (winter). In each soil quadrat, all macro-arthropods (2-20mm, visible to the naked eye), by a standard hand-sorting method and preserved in a 75% alcohol solution before being brought back to the laboratory for identification and classification (Chen, 1983). Classification of the animal's trophic group is based on its main source of food, including predators, phytozoa, omnivores, scavengers, and parasites (Doblas-Miranda *et al*., 2007; Lü *et al*., 2007). Trophic group structure is a proportional relation of predators, phytozoa, omnivores, scavengers, and parasites in the community.

Soil samples were collected at 0–30 cm depth in each quadrat for soil physicochemical analyses. Soil particle size distribution was determined by the pipette method in a sedimentation cylinder using sodium hexametaphosphate as the dispersing agent. Soil pH and Electrolytic Conductivity (EC) were determined with a combination pH electrode. Soil organic matter was measured using the $K_2Cr_2O_7$-H_2SO_4 oxidation method, total nitrogen was analyzed by the Kjeldahl procedure, and the calcium carbonate ($CaCO_3$) is determined by the calcimeter (Bernard type).

Data analysis

All data were analyzed using the statistics 8 programme for windows version. Multiple-comparison and one-way analysis of variance (ANOVA) procedures were used to compare the differences among the treatments. Least Significant Difference (LSD) tests were performed to determine significant differences among the treatment means at $p<0.05$. A Pearson correlation

Table 2. Changes in the soil properties (0-30cm)

S. No	Daya	N (%)	OC (%)	pH	EC (mmhos/cm)	$CaCO_3$ (%)
1	N.D.D	0.69 ± 0.05	3.49 ± 0.33	7.85 ± 0.11	0.169 ± 0.026	7.39 ± 0.359
2	D.D	0.24 ± 0.05	0.97 ± 0.16	8.26 ± 0.28	0.079 ± 0.022	2.58 ± 0.328

OC: Organic Carbon; EC: Electrical Conductivity

Table 3. Changes in the cover properties

S. No	Daya	Cover (%)	B.S.S (%)	Biomass (g/m^2)	Mean richness (Species/m^2)
1	NDD	67.84 ± 3.48	32.16 ± 3.48	220.74 ± 12.03	14.9 ± 2.46
2	DD	22.61 ± 2.01	77.39 ± 2.01	67.23 ± 3.79	7.25 ± 1.48

BSS: Bare Soil Surface

Table 4. Changes in the vegetation cover

S. No	Daya	Litter (%)	Sand (%)	SC (%)	C.Elts (%)	PM (%)	B. Soil (%)
1	NDD	27.3 ± 2.67	46.65 ± 2.30	15.65 ± 2.00	2.95 ± 1.66	-	7.45 ± 2.62
2	DD	8.9 ± 1.74	44.20 ± 3.60	13.20 ± 2.73	10.75 ± 1.97	4.25 ± 2.91	18.20 ± 5. 11

SC: Slaking Crust; C.Elts: Coarse Elements of the soil; PM: Parent Material; B.Soil: Bare soil.

analysis was carried out to determine the strength of the relationship between two sequences of average values.

RESULTS

Changes in soil physical–chemical properties

As shown in Table 1 and 2, soil silt and clay content, soil organic carbon, total soil N, EC and $CaCO_3$ decreased significantly with daya desertification, while soil sand content increased significantly (P<0.05). Soil silt and clay content, soil organic carbon, total soil nitrogen, Electrical Conductivity (EC) and $CaCO_3$ decreased by 70.86, 76.47, 65.21, 72.20, 53.25 and 65.08%, respectively, in the DD compared to the NDD, while sand content and pH increased by 27.07 and 5.22%, respectively.

Changes in vegetation properties

As shown in Table 3, vegetation cover, above-ground biomass and mean richness, decreased significantly with desertification of daya, by 66.76, 69.54 and 51.34%, respectively, in the DD compared to the NDD, while bare soil surface increased by 140 %.

In the Table 4, litter, soil sand cover, SC (Slaking Crust) decreased significantly with desertification, by 67.39, 5.25 and 15.65% respectively. The coarse elements and bare soil increased significantly (P<0.05), by 264.40 and 144.29% respectively.

Changes in the richness and density

The richness in the NDD was at 02.65 and 06.33 orders in the summer and winter (Figure 1), respectively. The richness decreased significantly in two seasons with desertification (P<0.05). Compared to the DD the richness decreased by 100% in winter and summer. The change in density differed between seasons with the desertification effect. The density decreased by 58.13 and 30.89% in winter and summer, in the DD compared to the NDD.

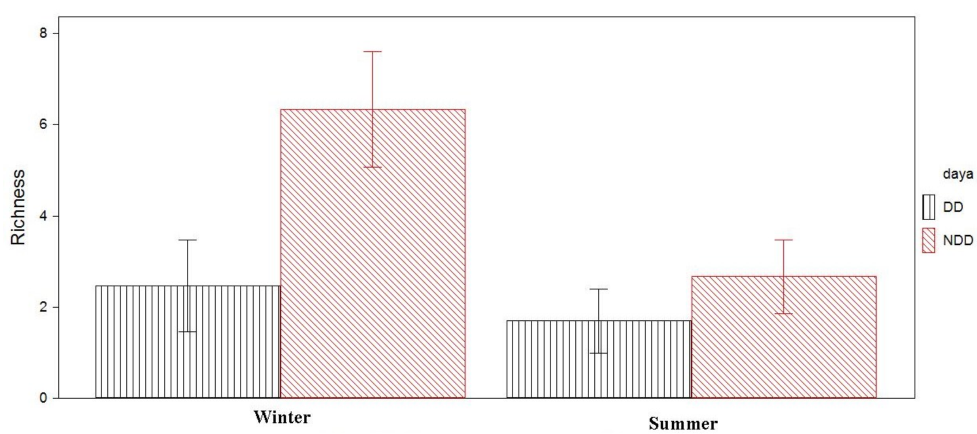

Figure 1. Seasonal changes in richness

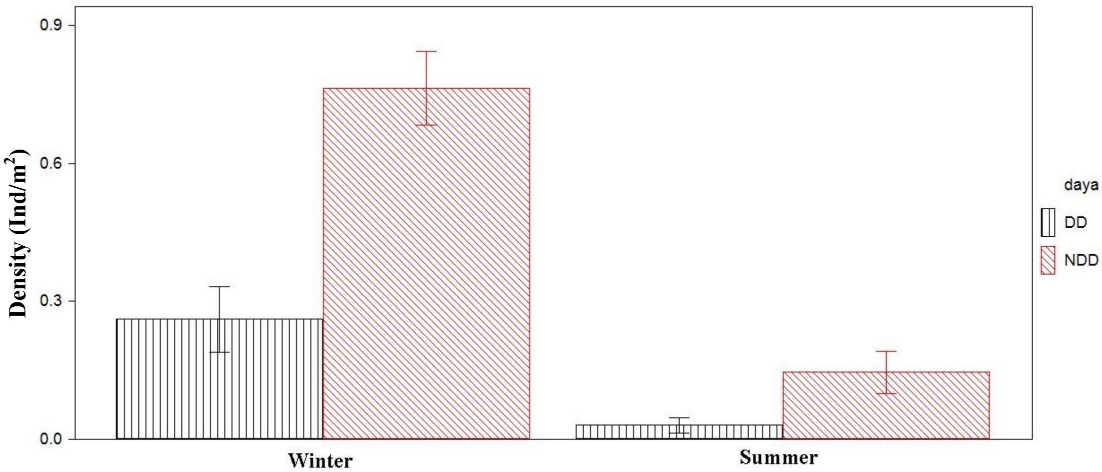

Figure 2. Seasonal changes in density

Seasonal changes in trophic group structure of the soil macro-arthropods

In the winter (Figure 2), the density of predators and omnivores decreased significantly (P<0.05) with desertification effect. From large to small, the order of density proportion in the community was omnivores>herbivores>predators>detritivores in the NDD, but changed to predators>omnivores from the DD. In the summer, the density of all trophic groups tended to decrease with desertification effect (P<0.05), but the magnitude of the decrease was greater for herbivores than for omnivores and predators, resulting in a decrease in the proportion of herbivores and an increase in the proportion of omnivores and predators in the community.

DISCUSSION

Normally, the soil macro-arthropod community changes regularly with seasonal changes (Frouz *et al*., 2004; Liu and Zhao, 2009). The present results showed that the richness and density of soil macro-arthropods in no desertified daya was winter>summer.

This result is in agreement with the results of Zhao *et al*. (2014) for the inner Mongolia grassland. The richness and density in the two seasons decreased significantly with daya desertification development, and the magnitude of the decrease was winter>summer. So the order of the richness and density from large to small changed to winter>summer in the DD. This is in agreement with the findings of Guan *et al*. (1999) for severely desertified grassland in Horqin sand land. The results suggested that daya desertification a serious damage to the soil macro-arthropod community, more serious in the summer than in winter and resulting in obvious change on seasonal distribution pattern of the soil macro -arthropod community. In addition, the present results also showed that the effects of desertification on the soil macro-arthropod community differed among desertification stages. These results are consistent with the findings of Zhao *et al*. (2014) on the effects of desertification on natural vegetation in Horqin sand land.

The dominant families and trophic functional group structure of the soil macro-arthropod community are important indicators of healthy ecosystem function (Liu and Zhao, 2009; Lü *et al*., 2007). The present results also showed that daya desertification had significant effects on the dominant families and trophic functional group structure of the soil macro-arthropod community. The dominant orders in the NDD were Hymenoptera.

In the DD, they were gradually replaced by Araneae and Pseudoscorpions in the summer and Coleoptera and Hymenoptera in the autumn. The density of predators, herbivores, and omnivores decreased significantly in the summer, while the complete opposite occurred in winter. These results suggested that the effects of desertification on the dominant families and trophic groups were greater in the summer, resulting in a significant change in the seasonal distribution of dominant families and the trophic group structure.

CONCLUSION

We conclude that

- Desertification results in a significant decrease in the richness and density of soil macro-arthropods and changes the seasonal distribution of the soil arthropod community;
- Desertification has greater effects on herbivores than on omnivores in the growth season and resulted in a significant change in the seasonal pattern of the trophic structure;
- Changes in the soil macro-arthropod community were attributed to the degradation of vegetation and deterioration of the soil environment during the desertification process, with notable decreases in vegetation cover, litter, soil clay and silt, soil organic carbon, and soil nitrogen and phosphorus.

ACKNOWLEDGEMENT

We thank, Dr. A. Adamou and Dr. M. Kouidri of the mechanical laboratory, University of Laghouat (Algeria) for their support during this study.

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