CLIMATE IMPACT ON THE ABUNDANCE OF SOIL MACROINVERTEBRATES IN ALGERIAN OLIVE ORCHARDS

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Abstract

The current study gathers new data on soil macroinvertebrates in Algerian groves. Data were collected in three sites from sub-humid, semi-arid to arid regions of Algeria. We have particularly investigated the effects of soil properties and climate. Olive trees are very important socioeconomically for many Mediterranean countries like Algeria. Climatic and pedological characteristics of this region favor soil erosion and salinity that threaten soil biodiversity. These factors also constraint soil community dynamics and recognized as important drivers for soil fauna. The objectives were to determine levels of soil macrofauna abundance and to hierarchize the factors controlling their distribution.We particularly investigated the effects of soil properties and climate. We collected 24 taxa, of which 33% were coleopterans , 25% ants and 7% gasteropods. The factors site and climate as well as their interaction influenced total soil macrofauna abundance. Particularly, earthworms and spiders were highly sensitive to aridity, which was not true for ants.

Keywords: *algerian groves, soil, macrofauna, olea europeae l., climate*

1. INTRODUCTION

Although soil fauna is known to influence soil behaviour (Lavelle and Spain 2001), invertebrate communities in Algeria soils are still poorly described. In Mediterranean soil ecosystem, climatic conditions play a major role for soil macrofauna that is sensitive to temperature (Sharon et al., 2001), precipitations (Morón-Ríos et al., 2010) and soil humidity (El-Sharabasy et al., 2008). Climatic and soil characteristics of this region favor soil erosion and salinity that threat soil biodiversity (Pueyos and Alados, 2007).

In Algeria, olive groves are widespread due to their socioeconomic importance and their rusticity (Ruano et al., 2004). However, since several decades these groves have been progressively neglected in profit of more yielding cultures. Such policies led to a deterioration of agroecosystems for which currently attempting to restore function (Santos et al., 2007).

The aim of the present work was to hierachize factors recognized to as important drivers for soil invertebrate community: the climate (sub-humid, semi-arid *and* arid) and soil properties. We hypothesized that macroinvertebrates are controlled by interactions between these factors.

2. MATERIAL AND METHODS

2.1. Study sites

Three sites have been selected on a 70km North-South transect in Northern Algeria: Oued Aissi Tizi Ouzou (36°42’30N ; 4°04’17.77” E), Oued El Berdi Bouira (36°15'38.22"N ; 3°53'11.94"E) and Melaga Djelfa (35°16’48.5”N ; 4°22’96”E).

Some characteristics of these sites are given in Table 1. Climate is sub-humid in Oued Aissi, semi-arid in Oued El Bardi and arid in Melaga, presenting Martonne indices of 26.6, 19.3 and 5.53 respectively.

In each site mean density was about 100-120 trees per hectare. The productivity of these groves was irregular. Management was very low, without amendments, fertilization nor irrigation. Fructification and thinning cuts were done during the harvest, but not systematically.

2.2. Soil sampling and characterization

Soil characteristics were determined on three replicates from the composite samples according to standard methods proposed in Jackson (1967). Particle size distribution was measured according to the Robinson pipette method (*i.e.* organic matter oxidation by H_2O_2, shaking in a sodium hexametaphosphate solution). Soil pH was measured in a 1/5 soil distilled water suspension. The $CaCO_3$ content was determined using the HCl 1M volumetric method. Organic C was determined by sulfochromic oxidation. Bioavailable phosphorus was determined (Olsen, 1967)by colorometry. Exchangeable-K was extracted (Quemener, 1979) determined by flame spectrometry.

Table 1. Characteristics of the studied sites.

Orchard	Oued Aissi	Oued El Bardi	Melaga
Altitude (m)	100	678	815
Mean annual precip. (mm)*	826	560	291
Mean annual temp. range (°C)*	5.7 - 37.7	4.2-39	1-52
Orchards age (yr**)**	30	30	20
Slope	5%	5%	5%
Type (WRB)	Cambisol(Calcaric)	Calcisol	Aridosol

2.3. Invertebrate sampling and identification

Invertebrate samplings were done during summer (June 2012) following the methodology of Coineau (1974). In each selected grove, six sampling zones of 25x 25 cm, distant by at least 10 m each from the other, have been located. Two depths were sampled (0-10 and 10-20 cm). At laboratory, large invertebrates were handsorted. Afterward, remaining invertebrates were extracted from soil by Berlese-Tullgren method. After extraction, all invertebrates were preserved in 70° alcohol for identification. Giving the low taxonomic expertise on Algerian soil fauna, invertebrates were indentified at order level in most cases.

2.4. Statistical analyses

Kruskal-Wallis rank sum test were used for testing soil differences between sites and groves. Afterward, multiple comparisons were done to identify groups that differed (Siegel and Castellan, 1998). We also tested the influence of the factors ‘site’ and ‘climate’ and their interactions on the density and the diversity of invertebrates. For this, analyses of variance were performed on log-transformed data. Tukey's ‘Honest Significant Difference’ method was used to test for means multiple comparisons.

3. RESULTS

Soil characteristics are detailed in Table 2. Differences were recorded between sites. A total of 958 individuals have been collected and 24 taxa identified. Coleopterans and ants dominated the communities, representing 33% and 25% of total individuals, respectively.

Table 2. Mean (standard error) soil characteristics of the studied groves.

	Oued Aissi	Oued El Bardi	Melaga
pH water	7.00 (0.15) *, B	8.1 (0.11)*, A	8.20 (0.03) *, AB
Org C (%)	1.06 (0.08) *, B	2.17 (0. 9) *, A	0.55 (0.12) *, AB
CaCO3 (%)	2.4 (0.12) *, B	25.0 (1.15) ns, A	18.19 (0.66)*, AB
P assi	1.9 (0.17) *, A	1.3 (0.15)*, B	1.1 (0.04) *, A
K assi	26.13 (1.92) *, A	26.70 (7.33) *, A	21.73 (0.76) ns, A
Clay (%)	12.53 (0.9) *, AB	12.60 (0.8) *, B	6.4 (0.6) ns, A

Total macro-invertebrate density was highly influenced by the factors ‘site’, ‘climate’ and their interaction. Invertebrates other than coleopterans and ants were found at lower densities. Nevertheless, some groups represented up to 10% of the community. Finally, Spiders were present only in Oued El Berdi although in low density. Among the factors investigated, soil characteristics and climate significantly influenced the taxonomic richness of macro-invertebrates.

4. DISCUSSION

Our results showed that olive trees have different effects on soil characteristics. Highly Significant differences were observed with soil characteristics, probably related to the nature of the calcareous parent material. The main result of this work lies on the hierarchization of factors driving invertebrate communities in Algerian soils. It clearly appeared that the factors climate and soil characteristics profoundly affected the total density of soil invertebrates. These results agreed with Sharon et al. (2001). These authors showed that climate was the main factor influencing abondance and diversity of soil macrofauna in Middle East Mediterranean forests. Similar results have been reported for woodlice by Warburg et al. (1984) and Huerta and van der Wal (2012).

However, the simplified structure of vegetation in groves acts negatively on abundance and diversity of soil arthropods (Van der Wal et al., 2009; Martins da Silva et al., 2011). The tree species can also influence soil biota by root effect, such effect being more important as soil organic matter content is low (Eo and Nakamoto, 2008). Our results also showed that densities of soil invertebrates separated Oued Aissi and Oued El Berdi from Melaga. Differences can be ascribed to climate rather than to soil type. They presented different soil characteristics in terms of pH, organic C, $CaCO_3$, available P and K contents.

Soil characteristics can be evoked to explain this result (Lavelle and Spain, 2001), specially organic C content is 7-fold lesser in Melaga than in other soils. Finally, in addition to the warm summers of these regions, soil invertebrates in Oued El Bardi and Melaga orchards and were also exposed to cold winters, with, for instance, 25 to 34 days of frost during winters.

Among the studied communities, taxa exhibited different responses. For instance, coleopterans were significantly numerous in arid and semi arid soils during summer 2012, while other taxas density picked whatever the soil. In the future, the work must be discussed taxon by taxon. Coleopterans in groves have been demonstrated to be influenced by year-round climate variations and management

regimes (Ruano et al., 2004) or by landscape (Martins da Silva et al., 2011). Coleopterans play important roles in groves (Ruano et al., 2004) . In particular, they are recognized as regulators since some soil larvae are rhizophagous and other species are predators either at larval or imaginal stage. Therefore, they are well documented and established as indicative bioindicators (Shanas et al., 2011).

Hymenoptera, particularly ants, communities varied significantly. The aridity does not reduce their abundance (Delsinne et al., 2010). Ants have very important densities in Melaga, but less abundant in Oued Aissi. Their number is very weak compared to the results of Santos et al. (2007) (1182-3120 ind.m^{-2}). Studies showed that ants play an important roles in groves (Castro et al., 1996; Garrido-Jurado et al., 2011).

Several authors suggested their importance as bioindicators agroecosystems (Lobry de Bruyn, 1999), under olive trees with a very heterogeneous distribution and variable (Pereira et al., 2004 ; Santos et al., 2007). These invertebrates are still badly known in the Mediterranean ecosystems (Ottonetti et al., 2008). Gastropods were collected in very low number Oued Aissi but in low number in Melaga. These invertebrates are very sensitive to the fluctuations of aridity (Pokryszko et al., 2011). This group is related on the soil properties and the vegetation (Omodeo et al., 2003; Cameron et al., 2010).

This study allowed us to hierarchize the factors controlling the abundance of macroinvertebrates in Algerian orchards. It appears that they are influenced by climate and Soil. Moreover, it provides reference values for soil macroinvertebrates under olive groves. However the results presented here were valid only for this region.

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