Biodiversity Journal, 2022, 13 (1): 115–121 https://doi.org/10.31396/Biodiv.Jour.2022.13.1.115.121

Study of relation between invertebrates community under *Allium sativum L.* crop in the semi-arid region in Algeria

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ABSTRACT A large number of organisms live in soil and perform various ecological functions there. This soil biodiversity of fauna community is particularly studied in the case of agrosystems because it has an impact on primary production. The garlic (*Allium sativum* L.) cultivation is one of gardening crops widely used above all in semi-arid regions in Algeria especially lately, given its economic and social interest. This vegetable constitutes the most important nutrient of a balanced diet due to their valuable nutritional component values and micronutrients essential for human health. The organic matter that is deposited in soil via aerial or root litter specific to garlic culture therefore constitutes particular energy and carbon sources for soil biodiversity, especially in rather distinct climatic conditions. The objective of this research was therefore to study the biodiversity relationship between edaphic invertebrates community under a garlic crop. Random soil sampling at six sites was carried out in the spring period in a plot at Chemora commune in Batna region, characterized by a semi-arid climate with cold winter. It was followed by an extraction and identification of invertebrates carried out with the naked eye, and by means of a Berlese trap with a soil volume of 30 cm^3 of about 8 at 10 kg of soil. The results allowed to identify eight varieties of invertebrates: Lombricidae of the genus *Aporrectodea*, *Allolobophora* and *Proctodrilus*, Coleoptera larvae, Tipulidae larvae; Dermaptera, Diptera larvae, Coleoptera larvae, mites and Carabidae. The correlation matrix revealed a negative correlation between the biomass of earthworms as well as their number and Tipulidae larvae Dermaptera and Carabidae. The principal component analysis gathers the variables in a first group of total earthworms, earthworm biomass and number of *Aporrectodea* and in the second group of Tipulidae larvae and Carabidae.

KEY WORDS Invertebrates community; Soil; Garlic crop; Berlese trap.

Received 04.12.2021; accepted 31.01.2022; published online 22.03.2022

INTRODUCTION

Biodiversity is the sum of all terrestrial, marine and other aquatic ecosystems, species and genetic diversity. It includes the variability within and among living organisms and the ecological complexes of which they are part (FAO, 2018). Soil represents one of the most important reservoirs of biodiversity. However, the evaluation of the regional distribution of soil biodiversity, as a function of climate, soil type, land use and management is scarce. However, there is every reason to believe that declines in soil biodiversity are following the general trend observed above ground. For these reasons, monitoring activities are necessary in order to protect soil biodiversity. Monitoring soil biodiversity will enable the detection of biodiversity hot spots as well as areas subject to change, and the implementation of ecosystem management successfully (Gardy et al., 2009). Wall et al. (2001) indicated that the majority of soil organisms are still unknown: it has been estimated that the currently described fauna of Nematoda, Acari and Protozoa represents less than 5% of the total number of species. Soil invertebrates are enormously diverse.

Soil invertebrates are key mediators of soil function for the diversity of ecosystem engineering processes in which they partake. The commination and incorporation of litter into soil, the building and maintenance of structural porosity and aggregation in soils through burrowing, casting and nesting activities, the control of microbial communities and activities, plant protection against some pests and diseases, acceleration of plant successions are among the many effects they have on other organisms through their activities (Bernier et al., 1994; Decaëns et al., 2003; Jouquet et al., 2006).

Moreover, Garlic (*Allium sativum* L.) is a horticultural plant of very high economic value. It is the 14th most important vegetable crop worldwide and the second most consumed plant of the *Allium* genus worldwide. It is a globally popular crop, which has a long history of planting, and plays an important role on people's dining tables (Rivlin, 2001).

Microorganisms play an important role in the soil ecosystem. Microorganisms in the soil are found in root (rhizosphere) and affect soil fertility because they play a role in the energy and nutrient cycles, act as decomposers, and determine soil health against diseases especially soil borne diseases. Microorganisms that inhabit the soil can be bacteria, fungi, algae, and protozoa (Adawiah, 2016). Garlic has distinct rhizosphere microbiota in different growth periods (Zhuang et al., 2020; Hidayah, 2021).

From these notions, this study therefore aims to extract the relation between the invertebrates community in the soil which is strongly influenced by garlic culture rhizospher in a region with a particular climate.

METHOD AND MATERIAL

Study area

This work was carried out in the commune of Chemora which is located about 58 km northeast of the city of Batna. It is limited by Lambert coordinates: 35°40'18" for latitude North and 6°38'57" for longitude East, and at an average altitude of 865 m (Fig. 1). The soils of the Chemora region are fundamentally silty-clay, characterized by a structure more or less fine to medium depending on the location. The silty-clay deposits are very recent; they come from a transport of earthy particles, by runoff from the neighboring mountains. These soils are shallow, on a continental Mio-Pliocene substrate of limestone nature. This region is characterized by arid Mediterranean climate type with cold winter. In period of 30 years (from 1990 to 2020), the most hot month is July, with an average maximal temperature of 34.52 °C, and coldest month is January with -0.32 °C. The temperatures fluctuate widely. For same period of 30 years, annual precipitation average is 295.31 mm with greater concentration in autumn and spring. The number of frost average is 40 days per year, usually between November and March.

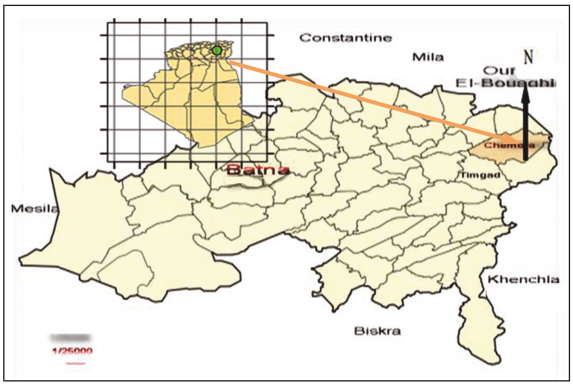

Figure 1. Study area.

Sampling method

The study was carried out in a traditional orchard of 1 ha of garlic crop in the spring (May 2021). This period coincides with the high activity and reproduction of earthworms.

Benkhelil & Doumandji (1992) and Dajoz (2002) explained that various capture methods can be used to capture insects according to the habitats where they live, in the air, on the trunks of trees, on low plants, in fruits, on the foliage on the ground, near roots, among rubbish, in nests or in bird shelters. Therefore, to be able to make a large number of observations in the field, sampling are made very close to the garlic plantations. Sampling places are chosen by the random method, and using a template of 30 cm on each side at a depth of 30 cm, a volume soil of 30×30×30 cm^3 from which a weight of about 8 at 10 kg, according to the bulk density of the soil, was extracted in buckets. Each sampling point consists of a single sample using a shovel. The entire volume of the extracted soil from each hole was first intended for manual sorting of invertebrates with naked eye, then for Berlese-Tullgren extraction.

Extraction, counting and determination method of soil invertebrate

Two methods have been adopted of extraction given the complication of representativeness of the individuals of invertebrates having a significant heterogeneity of dimensions and also to achieve the study objective. The two methods apply to a volume of soil of 30/30/30 cm which is the most adequate, from our point of view. The method used is manual sorting (Bouché, 1972; Lee, 1985). It is a physical method of extracting earthworms and visual invertebrates.

Manual method of extracting invertebrates visible by naked eye

In order to collect the macro-invertebrates visible by naked eye, the soil sample is spread on paper. Through a manual lens, a first extraction of invertebrates was performed from each soil sample. The invertebrates sample was taken by forceps for purpose of counting and identification. Collected specimens are stored properly in 70% alcohol.

Berlese-Tullgren trap method

The classical invertebrates' extraction method used was devised in 1905 by Berlese and later perfected by Tullgren, also use a leak reaction. A sample of soil is placed for three to four days on a sieve over a funnel and topped with a powerful lamp. Fleeing desiccation, Mites, Myriapods, Collembola and small insect larvae leave the sample at the bottom and fall into the funnel to a beaker containing 70% alcohol. Soil samples should be handled with care, so as not to compact them and prevent animals from escaping (Deprince, 2003). At the end of trapping, the alcohol collected is passed under a binocular magnifying glass for counting and identification of the extracted invertebrates.

Identification and taxonomy

In a laboratory, big specimens should be arranged so that important organs (wings, antennae, legs, etc.) are clearly visible for identification. However, the small specimens are removed from the alcohol and spread out on a white cardboard. Using magnifier binocular, taxonomic research is carried out as far as possible to order, family and genus and rarely to species. Samples were compared and identified for the majority specimens using guides for identification (Decamps, 1970; Brague-Bouragba, 2010; Dozière et al., 2017).

Data exploitation and statistical analysis

The Pearson matrix correlation and A.C.P., are calculated by using software XLSTAT 2015.

RESULTS AND DISCUSSION

Total number of specimens extracted from soil by naked eye and by Berlese trap, at six sites under garlic crop is 367 (166 by naked eye+201 by Berlese trap).

Invertebrates averages extracted by naked eye

After the extraction of the invertebrates, it was recorded a presence of 3 genus (*Allolobophora* Eisen, 1873, *Procdodrilus* Zicsi, 1985 and *Aporrec-*

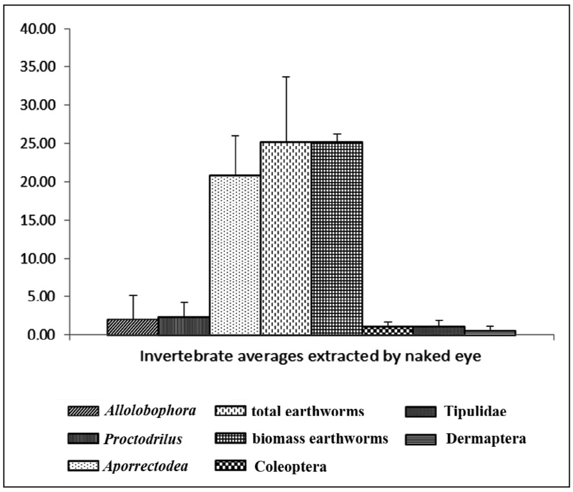

Figure 2. Invertebrates averages extracted by naked eye from soil at different site samples.

todea Orley, 1885). The genus *Aporrectodea* is the most dominant. Earthworms are the most dominant compared to Coleoptera larvae, Tipulidae larvae and Dermaptera in the sites under garlic crop (Fig. 2).

Invertebrate averages extracted by Berlese trap

By means of Berlese trap it was recorded a more important presence of Coleoptera larvae number compared to that of Diptera larvae, Mites, Hemiptera larvae and Carabidae (Fig. 3).

Total invertebrates

The total of invertebrates extracted from the soil under garlic crop has been illustrated by the diagram (Fig. 4). This graphic allows a comparison between the average total number of invertebrates and the total number as well as the total biomass of earthworms. The Coleoptera number is the second number of invertebrates after that of earthworms.

Correlation matrix

The correlation matrix of Pearson at 0.5% reveals a significantly negative relationship between total earthworms and Tipulidae larvae, Dermaptera and Carabidae. The genus *Aporrectodea* seems to influence the most the presence of the families mentioned (Table 1).

PCA analysis

Principal component analysis is explained by 77.95% of values. Axis 1 contains 52.11% of values. The PCA allowed gathering the variables in a first group of total earthworms, earthworm biomass and number of *Aporrectodea* and the second group of Tipulidae larvae and Carabidae (Fig. 5).

DISCUSSION

These results are very important to study invertebrate's community living in soil under a particular conditions of climate, variation of physic-chemical characteristic of soils, cultural practises and the earthworm abundance, being able to influence other communities such as the bacterial and fungal microorganisms. Moreover, different soil types possess different physical and chemical properties and rhizosphere microbiomes (Buyer et al., 1999; Latour et al., 1999; Marschner et al., 2004), and plant yields generally perform better in soil types that are suitable for plant growth. Adding beneficial microbes to the soil can increase crop yields and suppress plant disease (Zhuang et al., 2020).

Indeed, Brown (1995) notes that earthworms are usually a superior competitor at detritus consumption than other detritivore soil invertebrates, such as micro-arthropods. Migge-Kleian et al. (2006) explain that larger soil predators (macrofauna, such as

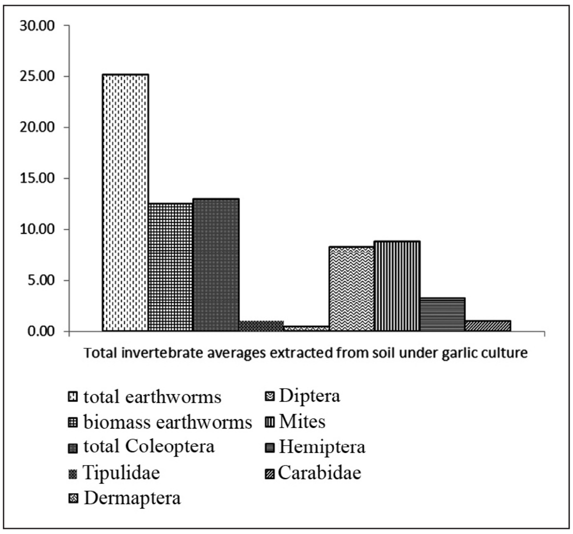

Figure 4. Total invertebrates averages extracted by Berlese trap from soil at different site samples.

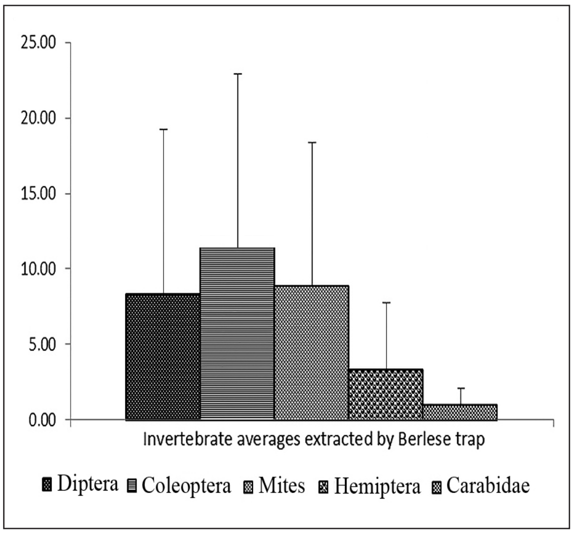

Figure 3. Invertebrates averages extracted by Berlese trap from soil at different site samples.

Variables	*Allolobophora*	*Proctodrilus*	*Aporrectodea*	Total earthworms	Biomass earthworms	Tipulidae	Dermaptera	Diptera	Mites	Hemiptera	Carabidae
Allolobophora	**1**										
Proctodrilus	0.41	**1**									
Aporrectodea	0.38	**0.82**	**1**								
Total earthworms	**0.69**	**0.86**	**0.92**	**1**							
Biomass earthworms	**0.77**	**0.84**	**0.79**	**0.95**	**1**						
Tipulidae	-0.42	**-0.72**	**-0.91**	**-0.86**	**-0.69**	**1**					
Dermaptera	-0.35	**-0.78**	**-0.67**	**-0.70**	**-0.82**	0.41	**1**				
Diptera	0.04	-0.47	0.02	-0.07	-0.16	-0.21	0.34	**1**			
Mites	0.49	0.00	0.5	0.48	0.35	**-0.61**	0.02	**0.78**	**1**		
Hemiptera	0.11	-0.40	0.1	0.01	-0.00	-0.15	0.08	**0.94**	**0.77**	**1**	
Carabidae	-0.17	**-0.69**	**-0.96**	**-0.79**	**-0.66**	**0.82**	**0.67**	-0.13	-0.5	-0.25	**1**
Total Coleoptera	**0.88**	0.02	-0.03	0.31	0.41	-0.15	0.07	0.19	0.42	0.16	0.24

Table 1. Pearson matrix correlation at 0.5% between total invertebrates extracted from soil under Garlic crop.

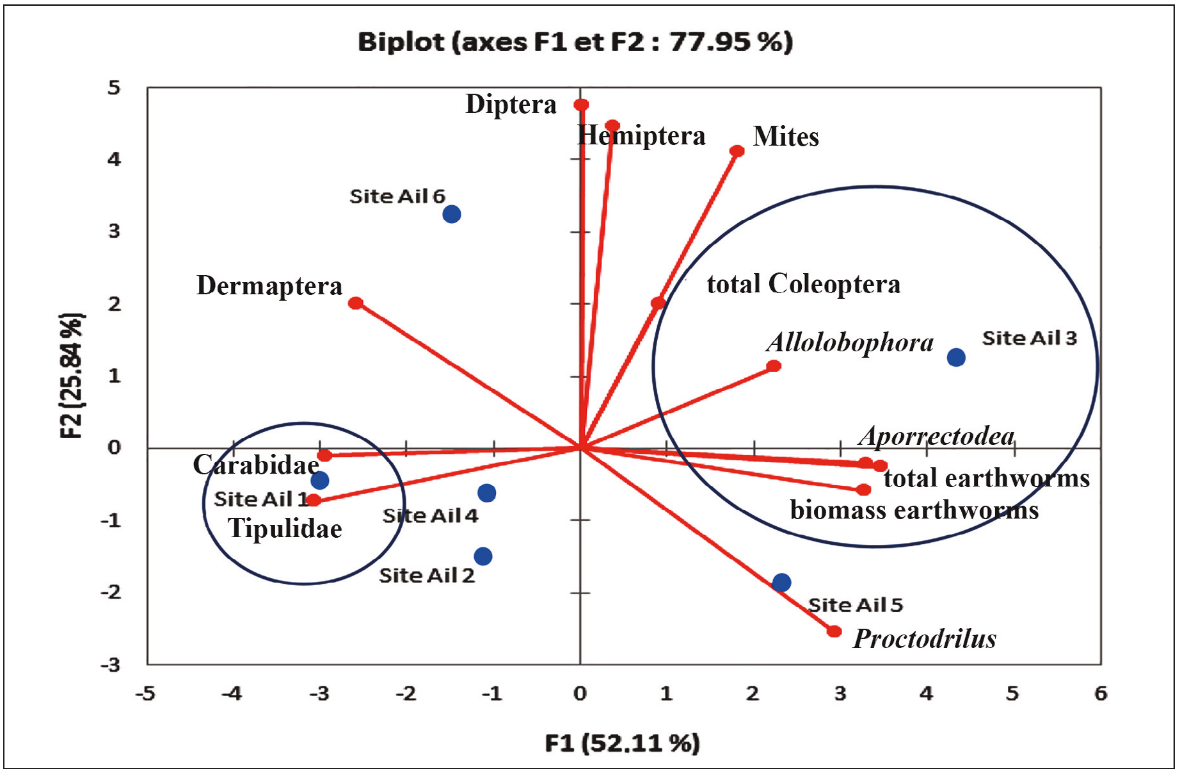

Figure 5. Principal component analysis of total extracted invertebrates from soil under Garlic crop.

soil beetles) benefit when they can feed on earthworms, but are negatively affected by earthworm-induced habitat modifications. The response of smaller body sized microbe-feeding soil invertebrates (mesofauna, such as Collembola or Oribatid mites) may depend on earthworm effects on microbial communities. In general, invasive earthworms are detrimental to litter-dwelling and feeding soil invertebrates due to habitat removal (Eisenhauer et al., 2007).

CONCLUSIONS

This research aims to study specific biodiversity by highlighting the relationship between the invertebrates community living in a soil cultivated by garlic in a semi-arid region of Algeria. From 6 sites, a soil volume of 30 cm^3 was randomly sampled. The extraction of macro-invertebrates was carried out by two methods; manually with naked eye, as well as by means of the Berlese trap. The results allowed recording a total of invertebrate specimen of 367. The greater number of *Aporrectodea* genus earthworms influences the presence of Tipulidae larvae, Dermaptera and Carabidae. This influence is probably related to peculiarity of root crop, climate, cultural practices as well as the abundant kind of earthworms. It is advisable to take a closer look at the fungal and microbial community of this rhizosphere in order to obtain even more information and explain these effects.

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