Scientific Paper

Variation of the components of the edaphic mesofauna in a farm with agroecological management

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ABSTRACT: In order to evaluate the variation of the groups of the edaphic mesofauna from the application of agroecological methods, a study was conducted in a farm with more than 20 years of establishment in the Artemisa province (Cuba). Previously the farm did not receive organic amendments and it was used as a grazing area for Zebu cattle with a low stocking rate. The area was transformed into three productive systems: 25 % of forage, 25 % of polycropping and 50 % of traditional pastureland, which was designated as control area. The forage area was established in mosaic form, with small plots of perennial crops, and had a periodical supply of organic fertilizers; while the polycropping area integrated a short-cycle crop rotation system, mainly, and compost was applied. The samplings were carried out in the dry and rainy seasons, six and eight years after the transformation. A total of 1 915 edaphic microinvertebrates was collected, belonging to the phylum Arthropoda, represented by two sub-phyla, three classes, two subclasses, six orders and two families. The dominance-diversity curves showed that in the pastureland and in the forage area the fauna communities were more abundant and diverse, and were distinguished by a high dominance of detritivore microarthropods. In the polycropping area no dominant taxa were present. It is concluded that the performance of the edaphic mesofauna was highly dependent on the type of soil management and the seasonality.

Keywords: biodiversity, exploitation system, soil management

INTRODUCTION

Sustainability has been traditionally developed by man, and rural cultures have created heterogeneous landscapes for the use and exploitation of natural resources. When man creates patches of different habitats, he offers more resources for the species he wants to increase, because each component has a different biomass renewal rate (Morais and Franklin, 2008).

The studies conducted by Funes-Monzote and Monzote (2000) showed that the integrated farming-agriculture systems, with an agroecological management based on the available natural resources, show sufficient capacity and potential to sustain intensive productions.

The application of agroecological methods in areas where farming and agricultural activities are combined includes the introduction of organic materials through the use of compost, plant wastes and animal excreta; the use of cover plants and crop rotation; which contributes to the improvement of the physical and chemical conditions of the soil and to a higher biological diversity (Robaina, 2010).

Biological diversity comprises the communities of soil organisms which are divided into three large sets: bacteria, fungi and different fauna groups, in which mesofauna is included. This edaphon category participates directly in the processes of fragmentation and redistribution of organic residues, which facilitates the decomposition of organic matter and the nutrient availability in the root zone, as well as the acceleration of nutrient recycling and phosphorus and nitrogen mineralization (Morais *et al*., 2010); this guarantees the maintenance of soil productivity. The mesofauna, on the other hand, is very sensitive to climate changes and to the anthropic disturbances of the edaphic medium, which cause variations in its density and diversity.

The objective of this study was to evaluate the variation of the groups of the soil mesofauna in different productive systems (forage and polycropping) with the application of agroecological methods, compared with a traditional pastureland.

MATERIALS AND METHODS

The study was conducted in a one-hectare agroecological farm, in the Cangrejeras locali-

ty (Artemisa province, Cuba), where the farming (75 %) and agricultural (25 %) activities were integrated. The soil is classified as typical Ferralitic Red (Hernández *et al*., 1999). Table 1 shows the physical and chemical characteristics of the soil for each one of the areas, which are described below:

Pastureland (P) with more than 20 years of establishment, without organic amendments (control area), in which Zebu cattle grazed with a low stocking rate. The prevailing plant community was integrated by *Megathyrsus maximus*, *Cynodon nlemfuensis* and *Teramnus uncinatus*.

Forage area (F) originated from the pasture area, subject to a cutting management regime, in which fertilization with compost of plant wastes and manure was applied. The prevailing forages were sugarcane (*Saccharum officinarum*), king grass (*Cenchrus purpureus*) and leucaena (*Leucaena leucocephala*).

Polycropping area (C), equally originated from the grazing area, in which, besides the organic treatment mentioned in F, short-cycle crop rotations were practiced, mainly cassava (*Manihot esculenta*), corn (*Zea mays*), banana (*Musa* spp.), beans (*Phaseolus vulgaris*), squash (*Cucurbita melopepo*), sweet potato (*Ipomea batatas*), tomato (*Lycopersicon esculentum*) and spinach (*Spinacia oleracea*). In this area organic fertilizer as compost and earthworm humus were used, at a rate of 4-6 t/ha according to their availability; and the harvest residues were incorporated. The areas F and C, at the moment of study, had been established since eight years ago.

In each area five soil samples were taken at a depth of 0-10 cm, with a cylinder of 5 cm of diameter and 10 cm of depth, following a completely randomized sampling design. The collections were carried out six and eight years after the transformation of the areas (forage and polycropping), three in the rainy season (May, July and October) and three in the dry season (December, February and March).

Tullgren funnels were used during seven days for the extraction of the edaphic fauna, without any artificial source of light and heat. The individuals were counted and separated through the stereoscopic microscope, were preserved in alcohol at 70 %, and then were identified, according to the classification proposed by Brusca and Brusca (2003) for insects and the one suggested by Krantz (2009) for mites. With these data the density (ind.m^{-2}) of each taxon was obtained in each period.

To characterize the structure, that is, the numerical arrangement of the orders that made up the mesofauna communities in each of the areas, the dominance-diversity curves were built from the decimal logarithms of abundance (Magurran, 1989). Non-parametric statistical methods were applied (Hammer *et al*., 2012) and the pack PAST, version 2.16, was used.

RESULTS AND DISCUSSION

Taxonomic composition of the soil mesofauna

A total of 1 915 individuals of the phylum Arthropoda, represented by two sub-phyla, three classes, two sub-classes, six orders and two families, was collected. In particular, the subclass Arachnida was represented by four orders: Oribatida, Astigmada, Mesostigmada and Prostigmada; on the other hand, the order Mesostigmada comprised the families Gamasidae and Uropodidae

Analysis of the dominance-diversity of the soil mesofauna

The range-abundance curves six years after the transformation started and in both seasons did not show an accentuated slope, which indicates that there was no marked dominance of groups of the edaphic pedofauna (fig. 1).

In general, in the dry season a slight dominance of the groups Oribatida and Gamasidae was observed in the three studied areas. In the case of Oribatida, it is reported in literature as the most abundant group of mites in the edaphic medium due to its high ecological plasticity (Chocobar,

Table 1.Physical and chemical characteristics of the first 10 cm of the soil (Izquierdo *et al*., 2003).

Area	pH (H_2O)	OM (%)	AD (g cm^{-3})	WHC (%)
Pasture (P)	6,0	3,65	1,34	50,0
Forage (F)	6,5	5,14	1,06	60,0
Crop (C)	6,4	4,14	1,16	54,0

OM: organic matter; AD: Apparent density; WHC:water holding capacity.

Table 2.Taxonomic and functional composition of the edaphic mesofauna.

Phylum	Sub-phylum	Class	Sub-class	Order	Family	Trophic group
Arthropoda	Hexapoda	Entognatha	-	Collembola		Detritivore
		Insecta	Pterygota	Psocoptera		Detritivore
	Cheliceriforme	Chelicerata	Arachnida	Oribatida		Detritivore
				Mesostigmada	Gamasidae Uropodidae	Predator Detritivore
				Astigmada		Fungivore
				Prostigmada		Predator

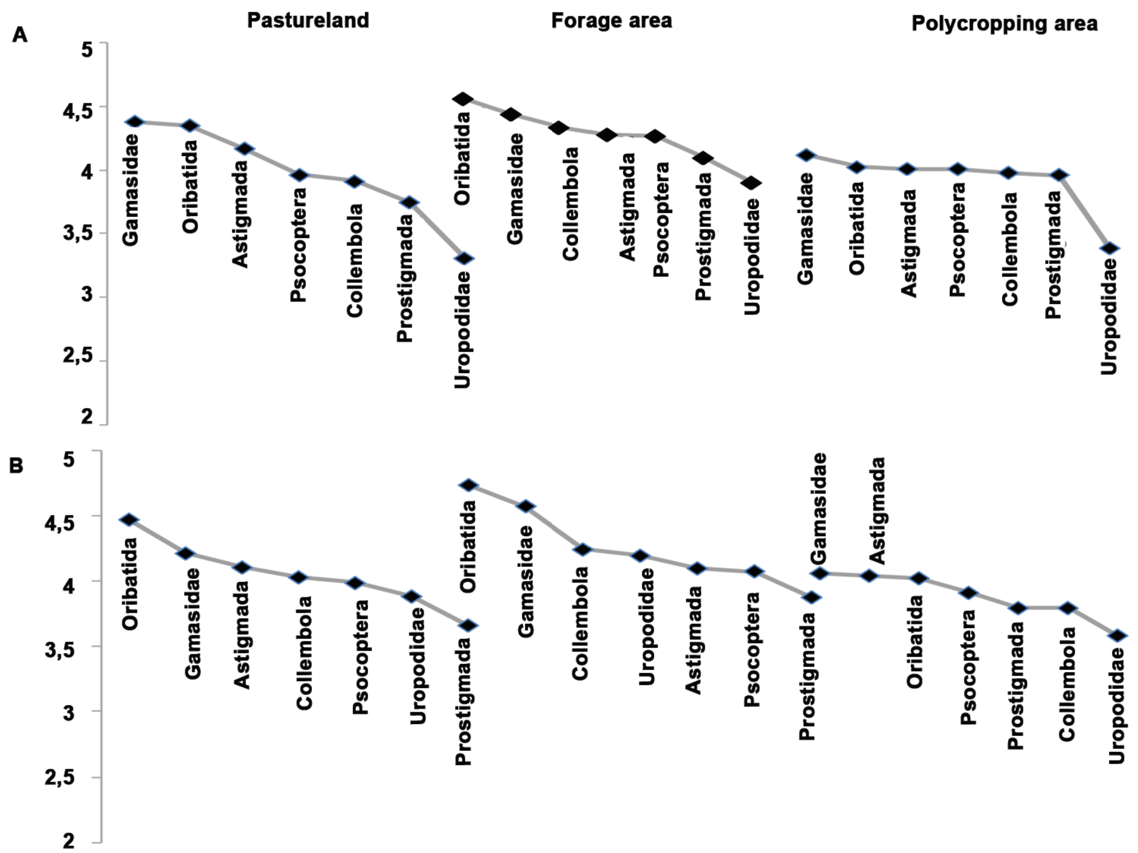

Figure 1. Range/abundance curves of the edaphic mesofauna in the studied areas six years after the transformation.
A. Dry season. B. Rainy season.

2010). Gamasidae occupied the second place, for its abundance; this taxon is predator of immature stages of Oribatida and Collembola, for which its abundance depends on the number of its preys (Salmane and Brumelis, 2010). In the same areas groups were found with moderate abundance, such as Astigmada, Collembola and Psocoptera; while Uropodidae and Prostigmada showed rare abundance. Uropodidae is a family of mites strictly depending on the stability of the edaphic medium, for which it constitutes an accurate criterion of the ecological status of the soils.

In the rainy season the performance of the taxa followed a similar trend to the one in the dry season

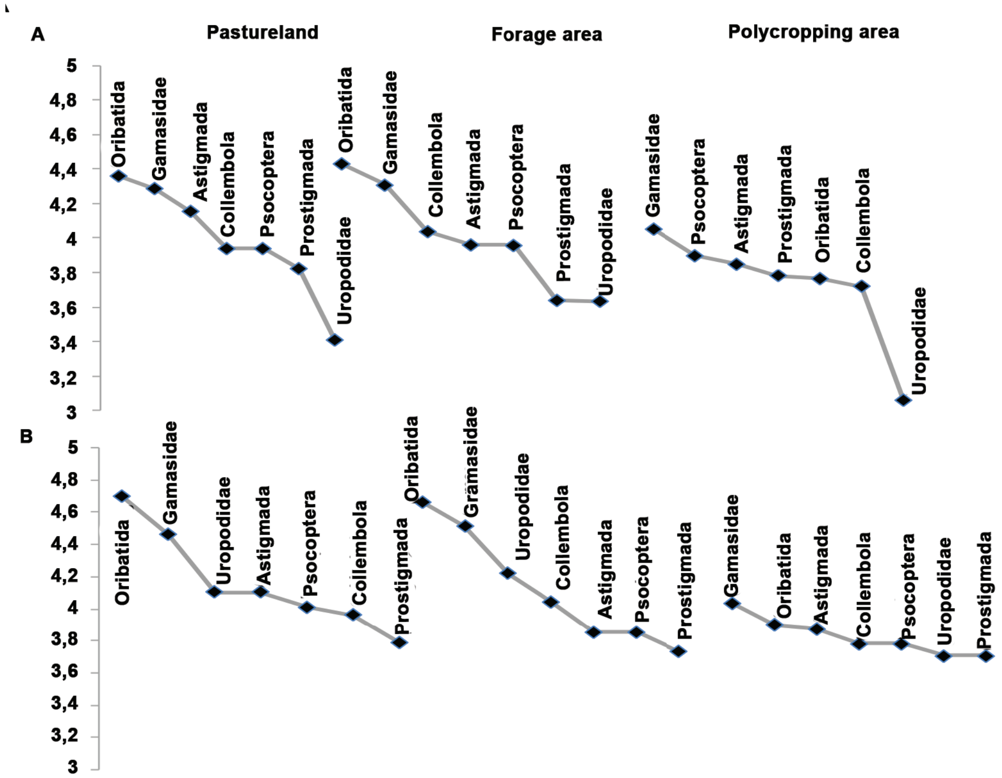

Figure 2.Range/abundance curves of the edaphic mesofauna in the studied areas eight years after the transformation.
A. Dry season. B. Rainy season.

(fig. 1). It is important to emphasize the increase of the values of Uropodidae in the forage area, being favored by the improvement in the edaphic conditions (humidity, soil cover and contribution of organic matter) and the appearance of Psocoptera and Prostigmata as rare groups. These last taxa are more abundant under conditions of hydric stress, for which in this season they are not favored. In the polycropping Astigmada increased its abundance, indicating that there was disturbance in the edaphic medium.

In the dry season, eight years after the modifications occurred, the curves were more abrupt and the dominance of the taxa Oribatida and Gamasidae was maintained (fig. 2). According to Magurran (1989), the groups with higher number of individuals occupy a large proportion of the niche, and make a higher utilization of the available resources. Uropodidae continued to appear as a rare taxon in the three studied areas; and it should be stated that the dry season does not favor the establishment of this zoological group.

In the polycropping a slight increase of the values of Psocoptera was observed, benefitted by the season and the disturbances caused by the agricultural practices applied in this area.

In the rainy season, in the forage and the pastureland areas mainly Oribatida and Gamasidae prevailed (fig. 2). The higher presence of Uropodidae in these uses should be emphasized, which indicates that a favorable change occurred in the edaphic conditions. In the pastureland, the taxon with the lowest number of individuals was Prostigmada; this order is abundant in oligotrophic areas with water deficit, which explains their presence as rare group. In the forage the accidental groups were Astigmada, Psocoptera and Prostigmada, which constitute indicators of disturbance and water deficit in the soil; such conditions should not have been shown in this area in the rainy season (fig. 2). In the polycropping area there was little abundance of the taxa present and little difference among them. Groups with moderate abundance, such as Oribatida, Astigmada, Psocoptera, Collembola and Gamasidae prevailed, with scarce numerical dominance. The ones with lower presence were Uropodidae and Prostigmada.

The performance of Astigmada suggests disturbance in the system due to the agricultural practices and the poor soil cover. Serrano (2010) and Cabrera *et al*. (2011) stated that, in ecosystems with higher human intervention, the abundance and more balanced distribution of the different groups of the soil fauna are conditioned by the scarce accumulation of resources, which brings about a decrease of the most sensitive groups and the proliferation of invading organisms or indicators of the edaphon disturbance.

According to the expression of the curves of abundance ranges it could be stated that the pastureland and the forage are more abundant and diverse fauna communities, with regards to the crop. Soil arthropods tend to prefer habitats characterized by a heterogeneous structure of the vegetation, and are even related to the increase of the variety of the resource to be decomposed (Wardle *et al*., 2006).

Trophic composition of the soil mesofauna groups

The communities of soil microarthropods were composed by four trophic categories in all the studied systems: detritivores, predators, fungivores and xylophagous insects (table 2). These categories play an important role in the ecological stability of the soil.

In both seasons and sampling years there was an increase in the number of detritivore individuals with regards to the other trophic groups in the three studied areas, with a peak in the rainy season and in the forage area (fig. 3). This last system was made up by sugarcane and king grass, species that guarantee a constant cover due to the contribution of litter to the soil, and also by leucaena, tree legume that improves the fertility conditions. In this area other agroecological managements were applied, such as mulching and incorporation of organic matter (feces and urine). The application of such sustainable practices in time favors the establishment of this trophic group (Gelvez-Pardo, 2009).

Predators stood out for their abundance in all the areas, seasons and sampling years. The representativeness of this group in the areas is due to a direct relation with their preys. In the study, the groups that made up this trophic category were predators of immature states of Oribatida and Collembola (detritivores), which are very abundant. Decaëns (2010) stated that detritivore arthropods and predators are the most dominant in terms of density.

In the pastureland, in the dry season and six years after the transformation a significant increase of detritivores and a non-significant increase of predators and fungivores was observed. In the forage area, in this same season the non-significant increase of fungivores and xylophagous insects was recorded (fig. 3). Fungivores were represented by Astigmada, group of mites indicative of soil disturbance. The xylophagous insects, represented by the order Psocoptera, prefer this season to express their maximum abundance, which was shown in the results.

With the passing of years (eight) the presence of predators in the pastureland was equal in both seasons, and the dry season favored fungivores; while in the rainy season only the populations of detritivores and xylophagous insects increased (fig. 3). This area, in spite of being established since more than 20 years ago, was subject to a grazing system with low stocking rate, which did not contribute large volumes of organic matter to the system; besides, it had little soil cover and low plant richness, and did not have external addition of organic matter. All these elements influence the uniform development of the communities of the edaphic mesofauna.

In the forage area, in the rainy season and eight years after the area was established, only detritivores increased significantly. This area had sufficient sources of organic material to be decomposed by such organisms. The other trophic groups decreased in this season (fig. 3). Predators and fungivores are constituted by microarthropods which are indicators of soil instability and infertility, conditions which were not expressed in this season and system. A similar performance of the detritivore, predator and fungivore groups was reported by Socarrás and Robaina (2011) in the same soil type, season and in different land uses in the Mayabeque and Artemisa provinces.

In the crop area a slight (non-significant) decrease of detritivores was observed with the increase of the establishment time of this area, in both seasons, although the number of individuals of this trophic group was below the reports for the other systems (fig. 3). Under the same conditions an increase of predators, xylophagous insects and fungivores was observed in the dry season with regards to the rainy season, which denotes disturbance and hydric stress by defect. The proportion of the different trophic groups in this area indicates that the applied methods did not guarantee the edaphic conditions that would propitiate a potential faunistic activity of

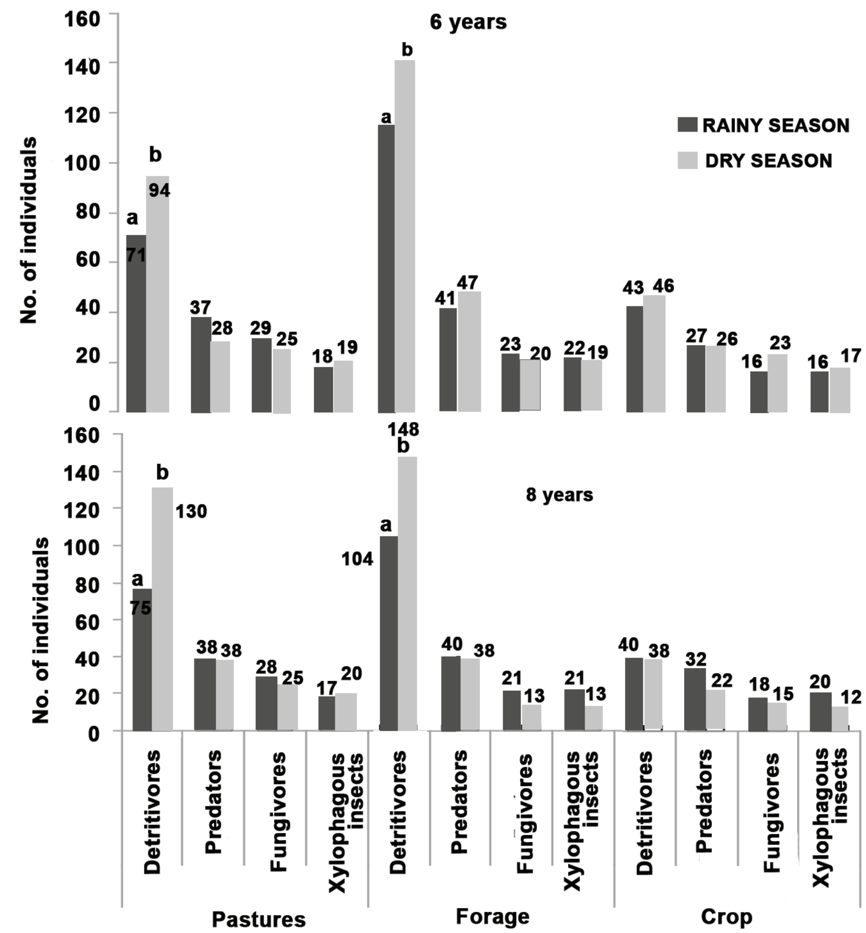

Figure 3. Variation of the functional groups of the edaphic mesofauna six and eight years after the transformations occurred.

the system. Robaina (2010) obtained similar results in a sugarcane area, this being the most disturbed system by the applied agricultural practices.

In general, the composition of the trophic groups of the edaphic mesofauna expresses different capacities in the regulation of the edaphic processes. In this study, the forage and pasture areas stood out due to a high dominance of the microarthropods responsible for the decomposition of organic matter (fertility and stability indicators) and a sudden drop of the abundance of the other trophic groups (disturbance and infertility indicators) of the edaphic medium. According to Zerbino *et al.* (2008), the richness of plant species, the changes in the soil properties and the management influence the wide availability of resources and the balance of the different edaphic groups.

In the case of the crop area, the proportion of the different trophic groups was not shown in the same way; a remarkable decrease of the abundance of detritivores was observed with regards to the other areas. On the other hand, the differences regarding the abundance among the trophic groups present in this use decreased, and no dominant taxa appeared. In this system the plant cover was very poor; in addition, the effect of tillage and exposure increase evaporation and cause higher soil desiccation and, as a consequence, alterations in the abundance and diversity of the detritivore groups of the edaphic mesofauna (Siddiky *et al.*, 2012).

It is concluded that the forage and pasture areas stood out for a high dominance of the microarthropods responsible for the decomposition of organic matter and for a decrease of the abundance of the other trophic groups of the edaphic medium.

The performance of the edaphic mesofauna in the areas was highly dependent on the type of soil management and the seasonality.

Likewise, in the forage area a qualitative leap and a trend to the recovery of the fertility and balance of the soil biota were observed.

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