Scientific Paper

Performance of the edaphic macrofauna in animal husbandry systems, in a productive entity of the Yaguajay municipality, Cuba

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Abstract

A study was conducted in areas of a basic unit of cooperative production, of the Yaguajay municipality –Sancti Spiritus province, Cuba–, in order to evaluate the edaphic macrofauna in two animal husbandry systems: natural pastureland and silvopastoral system, on a vertic Gleysol soil. The soil was sampled during two years in the rainy and dry seasons, in the litter and at the depths 0-10, 10-20 and 20-30 cm, according to the methodology of the Tropical Soil Biology and Fertility International Research Program. The macrofauna was identified to the taxonomic category of order. In both seasons and systems three phyla, seven classes and 11 orders were found. A total of 1 207 individuals were collected; from them, 840 corresponded to the silvopastoral system and 367 to the pastureland. In both systems coleopterans prevailed (36 and 37 % for the pastureland and the silvopastoral system, respectively), followed by Oligochaeta (21 and 17 %, respectively). A higher density of individuals was obtained in the silvopastoral system. It is concluded that the taxonomic composition of the edaphic macrofauna was similar in the evaluated systems, with differences regarding the diversity of the orders. The highest quantity and density of individuals were obtained in the silvopastoral system. The effect of depth on the macrofauna composition and the distribution of the collected individuals, as well as the preference for the shallowest layer of the soil, was proven.

Keywords: biota, natural pastureland, silvopastoral system

Introduction

The deterioration of soil quality is one of the most serious problems that animal husbandry systems have experienced in recent years, mainly due to inadequate agricultural practices.

The most significant problems in soil conservation at global scale, according to FAO (2016), are erosion, loss of organic carbon and nutrient unbalance. Animal husbandry utilizes those soils of lower productive value and, thus, in them the above-mentioned characteristics are increased (Lok, 2016).

Romanuk *et al.* (2014) sustain that the soil constitutes a unique biological system where there is a large diversity of organisms which play multiple key functions for the ecosystems. In this sense, Veresoglu *et al.* (2015) stated that soil biodiversity should also be considered as keeper of food security and of the ecosystem services in the face of climate change, because it propitiates a more complex and much more resistant structure.

The edaphic biota plays an important role in the biogeochemical processes of the soil in animal husbandry systems, and its functions include: litter decomposition, nutrient recycling, synthesis and mineralization of organic matter and modification of the soil structure, among others; this influences the system integrity and productivity (Sánchez *et al.*, 2011).

In animal husbandry ecosystems the knowledge of the edaphic biota has particular interest in Cuba, due to the functions it plays in the systems that are used for cattle feeding. In the case of the Yaguajay municipality, and specifically in the basic unit of cooperative production (UBPC) La Elvira, no reference was found about the macrofauna behavior, very important indicator for evaluating the soil quality. For such reason, the objective of this study was to evaluate the edaphic macrofauna composition and behavior in two systems: natural pastureland and silvopastoral system, in a vertic Gleysol soil.

Materials and Methods

Characterization of the study area. The research was conducted in areas of the UBPC La Elvira, belonging to the agricultural enterprise

Obdulio Morales, in the Yaguajay municipality –Sancti Spiritus province, Cuba–. This productive entity has a total area of 1 878 ha and from them 720 ha are aimed at animal husbandry.

Edaphoclimatic conditions. The soil where the experimental stage was conducted belongs to the grouping of Gleysols and to the genetic type vertic Gleysol, according to the classification proposed by Hernández-Jiménez *et al.* (2015), and shows clayey texture, effective depth of 0,90 m and deficient surface and internal drainage. Its apparent density is 1,26 g/cm^3, it shows a field capacity of 42,1 % and its topography is flat.

During the experimental period rainfall varied between 1 200 and 1 400 mm as annual average, with two well-differentiated seasons: a rainy season (May-October) in which 76 % of the rainfall occurred and a dry season (November-April). The mean annual temperature was 25,6 ºC.

Treatments. The treatments consisted in two systems, both with more than 10 years of exploitation:

- Silvopastoral system. In the tree composition the species *Leucaena leucocephala* (Lam.) de Wit, *Albizia niopoides (Spruce ex Benth.) Burkart* and *Talipariti elatum* (Swartz) Fryxell (blue mahoe) were present; and in the herbaceum stratum, natural pastures. The global stocking rate was 1,1 LAU/ha.
- Pastureland system. A pastureland system was evaluated mainly composed by the species *Bothriochloa pertusa* (L.) A. Camus and *Urochloa ruzziziensis* (R. Germ et Evrard). The area covered by the pastures in all the paddocks exceeded 90 %.

Experimental design. A completely randomized experimental design was used, with three replicas per treatment.

Experimental procedure. The macrofauna sampling was performed between 7:00 a.m. and 9:00 a.m. in the two systems, at the end of both seasons during two years, according to the methodology of the Tropical Soil Biology and Fertility International Research Program (Anderson and Ingram, 1993); it consists in the extraction of monoliths of 25 x 25 x 30 cm in a transept, whose point of origin is randomly and linearly determined. The following strata were evaluated: litter, 0-10 cm, 10-20 cm and 20-30 cm. The macrofauna was manually collected *in situ*. The earthworms were preserved in 4 % formaldehyde, and the other invertebrates, in 70 % alcohol, for their later identification in the laboratory.

The macrofauna was identified to the taxonomic category of order, according to the criterion expressed by Ruiz *et al.* (2008). The average density values (ind. m^{-2}) for the edaphic community, for each taxon and per stratum were determined, in each study system. The density was determined depending on the number of individuals.

Statistical analysis. For the analysis of the studied variable the fulfillment of the variance homogeneity (test of Levene, 1960) and normal distribution (Shapiro and Wilk, 1965) assumptions was tested; as the homogeneity requisite was not fulfilled, non-parametric analysis was performed. To determine the variations of the density of the edaphic macrofauna between the systems and strata, the Kruskal-Wallis test was used. The statistical processing was done with the software InfoStat, free version for Windows®.

Results and Discussion

Taxonomic composition of the soil macrofauna

The taxonomic composition of the soil macrofauna in the natural pasture system (NP) and in the silvopastoral system (SPS), for the rainy and the dry season, is shown in table 1.

In both seasons and systems three *Phylum*, seven classes and 11 orders were found; in general, in the silvopastoral system there was a higher presence of orders, which could be related to a higher soil cover in this system, propitiating better temperature and humidity conditions for the optimum development of the macrofauna (Cabrera-Dávila *et al.*, 2017).

Such results are higher than the ones found by Chávez-Suárez *et al.* (2016), who studied the macrofauna in mountain animal husbandry ecosystems in Guisa, Cuba, and only seven orders were reported in pasturelands; this could have been related with the drainage characteristics of the vertic Gleysol soil, present in the studied areas.

On the other hand, García *et al.* (2014) reported the presence of 14 orders in a silvopastoral system with *L. leucocephala* on a Ferralitic Red soil, which could have been due to the fact that their study was conducted in systems with cultivated grasses and on another soil type; these plants propitiate a higher biomass quantity and maintain the cover, which creates adequate conditions for the development of macrofauna biodiversity.

The fact that in the two seasons the same quantity of *Phylum*, classes and orders was found could have been related to the soil characteristics in the

Table 1. Taxonomic composition of the macrofauna.

Phylum	Class	Order	Natural pastures				Silvopastoral system			
			Year 1		Year 2		Year 1		Year 2	
			RS	DS	RS	DS	RS	DS	RS	DS
Arthropoda	Insecta	Coleoptera	X	X	X	X	X	X	X	X
		Lepidoptera		X	X	X	X	X	X	X
		Hemiptera	X	X		X	X	X	X	X
		Orthoptera	X	X	X	X	X	X	X	X
		Diptera	X	X		X	X	X	X	X
	Arachnida	Araneae	X	X	X	X	X	X	X	
	Chilopoda	Geophilomorpha		X	X	X	X	X	X	X
	Diplopoda	Spirobolida			X	X	X	X	X	X
	Malacostraca	Isopoda	X	X	X	X	X	X	X	X
Mollusca	Gastropoda	Archaeogastropoda		X	X	X	X	X	X	X
Annelida	Clitellata	Haplotaxida	X	X	X	X	X	X	X	X

X: presence, DS: dry season, RS: rainy season.

experimental areas; which is formed from clayey sediments, with predominance of smectites among the clayey minerals, and shows gley characteristics at less than 50 cm of depth and vertic horizon (Hernández-Jiménez *et al*., 2015). That is why throughout the year in this soil type humidity is maintained, which influences positively the development of the edaphic biota. According to Siqueira *et al*. (2016), the macrofauna community is affected by the hydrological regime in the different land uses.

The earthworms were present in the two systems and in both seasons, which coincides with the report by Chávez-Suárez *et al*. (2016) regarding the fact that, in animal husbandry systems –especially in the most humid ecosystems and in pasturelands–, there is a predominance of these macrofauna individuals. It is important to acknowledge the functionality of earthworms for the maintenance of the ecosystem services of the soil, due to their contribution as physical engineers, because they create channels and aerate the edaphic medium; in addition, they are considered biochemical engineers, for promoting organic matter decomposition and causing interactions with fungi and bacteria (Lavelle *et al*., 2016). These authors emphasize the services provided by earthworms in the formation of the edaphic medium through the mixture of organic and mineral components, and their bioturbation activities contribute to homogeneization; while the critical points of the drilosphere (soil zone influenced by earthworm action) increase spatial heterogeneity.

Figures 1 and 2 show the percentage distribution of the total number of individuals for each taxonomic group in the natural pasture and the silvopastoral system, respectively. As can be observed, the Coleoptera order was the one with the highest presence in both systems, because it was represented by 36 and 37 % of the total, respectively, followed by Haplotaxida (21-17 %) and Isopoda (14-14 %); similar results were reported by Cabrera *et al*. (2011) and García *et al*. (2014). The other orders did not exceed 5 %, except Orthoptera with 11 % in natural pastures, and Orthoptera and Geophilomorpha with 6 % in the silvopastoral system.

The higher presence of coleopterans in both systems is important, because due to their wide variety of feeding habits and biotic preferences they have ecological and economic repercussion on agroecosystems. In this sense, Cabrera-Dávila *et al*. (2017) stated that, according to their functionality, they can be detritivorous, predators and herbivorous; and they also show high abundance and diversity of species.

Density of the edaphic macrofauna

Figure 3 shows the average density values in litter for each season and system. The best performance was found in the silvopastoral systems for both seasons, in which there was higher density,

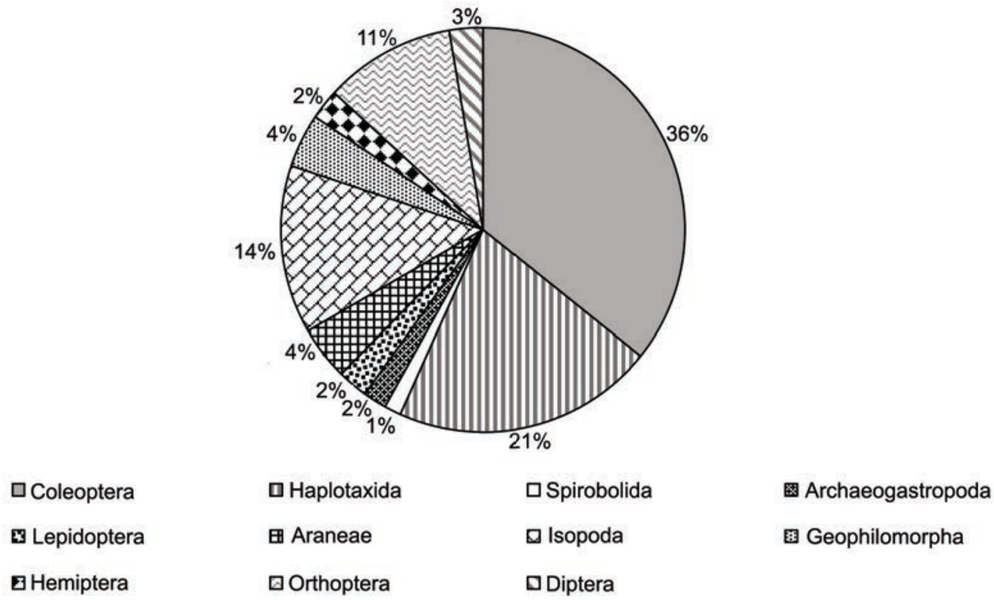


Figure 1. Percentage representation of the number of individuals in the natural pasture system.

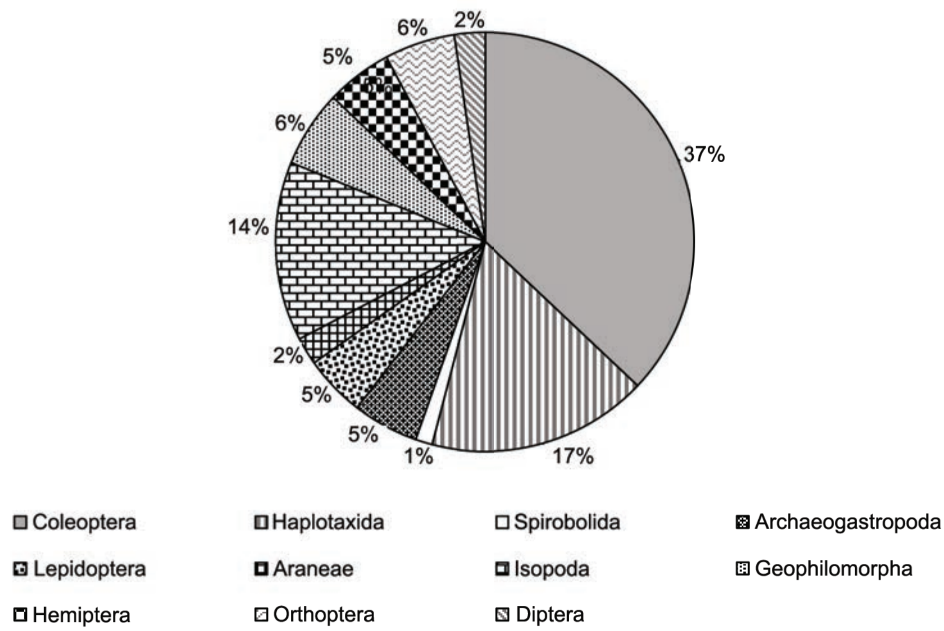
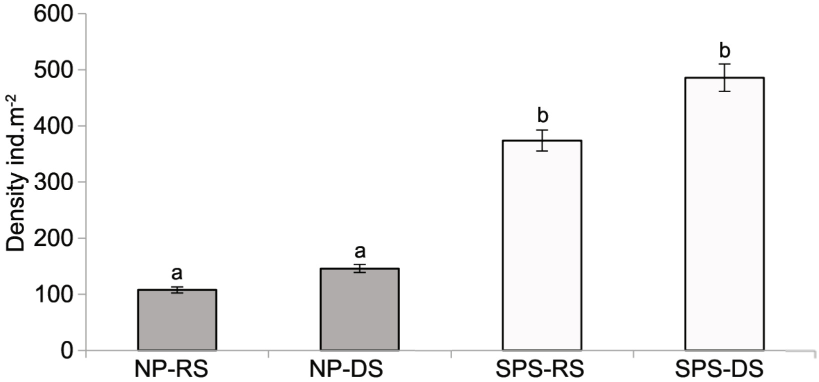


Figure 2. Percentage representation of the number of individuals in the silvopastoral system.

with significant difference from the natural pasture system.

These results coincide with the ones obtained by Cabrera-Dávila *et al*. (2017), who found higher abundance in agroforestry systems and forests, which was ascribed to a higher diversity of resources offered by these ecosystems, such as: shade, soil protection, high edaphic humidity and low temperatures, elements that contribute to the soil life subsistence.

In that sense, the values of this research could be ascribed to the higher presence of foodstuffs in the litter layer which, gradually, is formed on the soil with the fall of leaves from the trees, which



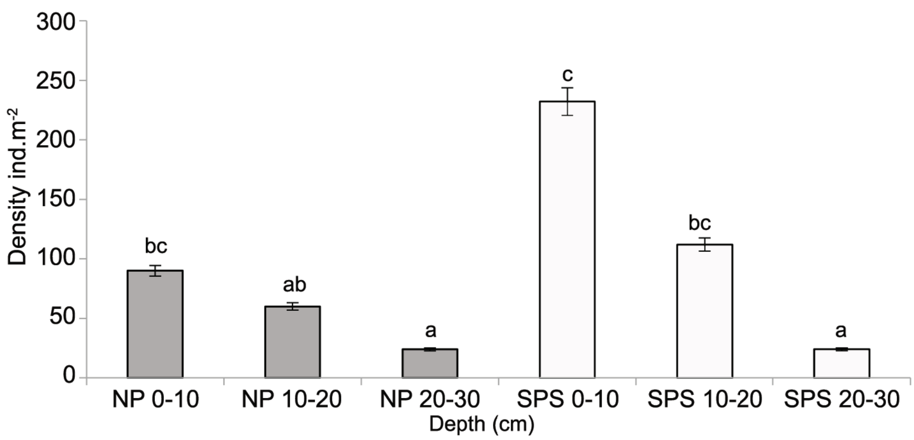
Different letters differ at p ≤ 0,05 (Kruskal-Wallis).
NP: natural pastures, SPS: silvopastoral system, RS: rainy season, DS: dry season.
Figure 3. Average density of macrofauna in the litter.

should increase the diversity of trophic resources by modifying the microhabitat. According to Vega *et al*. (2014), legume litter is decomposed faster than grass litter, due to the lower lignin content and a better C/N ratio.

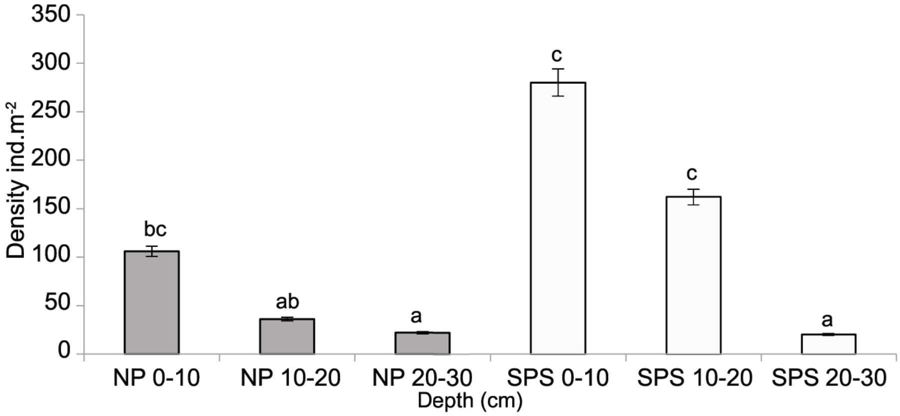
Regarding the average density of macrofauna in the rainy season in each of the systems and at the different depths (fig. 4), it was proven that in the silvopastoral system, at the 0-10 cm depth, there was higher abundance (232 ind. m^{-2}), with significant differences from the 20-30 cm depths in the silvopastoral system and 10-20 and 20-30 cm in natural pastures. On the other hand, the lowest density of individuals was found at the 20-30 cm depth for both systems (24 ind. m^{-2}).

For both systems the vertical distribution was concentrated in the 0-10 cm stratum, followed by 10-20 cm, without significant differences between both strata for the same system, which coincides with the results obtained by Yaros-Pardo (2014). The preference of macrofauna for the first centimeters of soil can be due to factors such as higher root density; from the 10-20 cm depth the higher compaction degree, caused by animal trampling (Medina, 2016), limits the existence of a higher quantity of porous spaces, which has repercussions on the density of individuals.

In the dry season (fig. 5) the performance was similar to that of the rainy season regarding the vertical distribution, with the best results for the silvopastoral system in the 0-10 cm depth. These results prove the importance of silvopastoral systems for the conservation of the soil macrofauna in animal husbandry systems.



Different letters differ at p ≤ 0,05 (Kruskal-Wallis).
NP: natural pastures, SPS: silvopastoral system.
Figure 4. Average density of the soil macrofauna. Rainy season.



Different letters differ at p ≤ 0,05 (Kruskal-Wallis).
NP: natural pastures, SPS: silvopastoral system.
Figure 5. Average density of the soil macrofauna. Dry season.

However, when comparing the density between seasons (figs. 4 and 5), in general it was higher in the dry season. This could have been due to the soil characteristics, which, because of having a deficient internal drainage in such season, retains humidity; causing flooding that limits the availability of the necessary oxygen for the development of the edaphic macrofauna.

The results of this study show the importance of silvopastoral systems for the conservation of the soil of animal husbandry soils, compared with grass monocrop which is a forage production model more susceptible to pest attack, to seasonality and to climate variability. Such conditions generate critical periods in the dry seasons, affecting milk and meat production and the reproductive indicators in cattle production systems (Navas-Panadero, 2017).

It is concluded that the taxonomic composition of the edaphic macrofauna was similar in the evaluated systems, with differences regarding the diversity of orders. The highest quantity and density of individuals were obtained in the silvopastoral system. The effect of depth on the macrofauna composition and on the distribution of the collected individuals, as well as the preference for the shallowest soil layer, was proven.

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