Evaluation of the edaphic macrofauna in a silvopastoral system in Cauto Valley, Cuba

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The performance of the edaphic macrofauna was evaluated in a *Leucaena leucocephala-Cynodon nlemfuensis* silvopastoral system at the Cattle Breeding Enterprise "Manuel Fajardo", located in the municipality of Jiguaní, Granma province. An area of 6.71 ha distributed in six paddocks was used in a completely randomized design with six replications in a carbonated brown soil. The study was conducted in the litter strata, 0-10, 10-20 and 20-30 cm depth. The taxonomical composition, density and biomass of the macrofauna organisms were determined. The taxonomic composition consisted of 216 individuals, represented by three types, five classes and seven orders. From them, the most represented was the class Insecta. In the density of individuals there were differences ($P < 0.05$), from the litter of 8.08 individuals/m^2 to 1.83 individuals/m^2, at the 20-30 cm depth. For the biomass, there were differences ($P < 0.05$) and varied from 0.16 to 0.03 g/m^2 for the litter at 20-30 cm, respectively. Also, in total density there was growth, following tree incorporation (6.07 ind./m^2) and after total biomass grew by 0.18 g/m^2, thus proportional abundance increased with the appearance of Hymenopterous, Diplopodous and Lepidopterous. The silvopastoral system improved the macrofauna with advantages for their exploitation as time went by.

Key words: *edaphic macrofauna, silvopastoral system, Leucaena, star grass*

The high rate of deforestation in tropical countries not only has local effects on the degradation and productivity loss of soils, but also contributes with the fourth part of CO_2 emissions and other gases to the atmosphere, a process provoking global climatic changes. This favors the loss of biodiversity of natural forests and the unbalance of other land ecosystems (Pomareda and Steinfeld 2000, Ibrahim and Mora 2006 and Lok *et al*. 2012).

International programs and projects have been developed to study the communities of soil invertebrates and their relationships with the physicochemical and biological processes of this, with the objective of managing the edaphic populations for improving the field quality or to use them as bioindicators of the degree of conservation/disruption of the ecosystems, without provoking damages to the environment and for improving the man's quality of life in the planet Earth.

Soil macrofauna favors aeration and water infiltration through the gallery networks contributing in this way to the formation of macroaggregates that modify the physical structure of the field (Lavelle 2000). However, in Cauto valley, Granma province no deep study on the effect of trees on the increase of soil macrofauna has been realized, if considered that in it is settled an important part of livestock rearing. These aspects gain greater relevance due to the quality of the soils, high temperatures, and low rainfall as well as to the fragile and degraded agrosystems of this area (Vega 2012).

The objective of this experiment was to determine the influence of a silvopastoral system of *Leucaena leucocephala* (Lam) of Wit cv. Peru and *Cynodon nlemfuensis* in a carbonated brown soil of Cauto Valley, on the frequency of appearance and taxonomic composition of the soil macrofauna.

Materials and Methods

Location. The study was carried out for five years at the Basic Enterprise Unit "San José del Retiro" from the Genetic and Breeding Enterprise "Manuel Fajardo", in the municipality Jiguaní, Granma province, Cuba. It is located at 115 m.a.s.l., the soil is brown with carbonates (Hernández *et al*. 1999) and with slightly flat relief. Its chemical composition is pH (7.0), organic matter (6.7 %), P_2O_5 (0.36 mg.100 g^{-1}) and K_2O (65.6 mg.100 g^{-1}) (Vega 2012). Annual mean temperature is of 25.4 ºC, with means of 23.9 ºC and 26.8 ºC in the *dry* and rainy periods, respectively. During the development of the experiment, annual rainfall mean was of 939 mm, from this figure 225.7 mm corresponded to the *dry* period. The average relative humidity was of 81.7 % with values of 81 % and 82 % in the *dry* and rainy periods, respectively.

Treatment and design. A completely randomized design and six replications distributed in six paddocks, was applied. The treatment consisted of the *Leucaena leucocephala-Cynodon nlemfuensis* association.

Procedure. The experimental area used was of 6.71 ha and soil preparation was made with heavy equipment (DT-75). The field was ploughed in July and in order to take advantage of the soil humidity on August 31 Leucaena was sown manually after ploughing through

with oxen 5 m apart. Plant distance for guaranteeing the populations in the replications was 3 m. Leucaena was considered established on attaining 2 m height in all replications. Star grass sowing was carried out by the turnover ploughing method (Vega 2012).

For the study of the macrofauna communities, seven sampling were made in 2007, 2008, 2009 and 2010. The macrofauna was collected *in situ* manually and by soil strata: litter, 0-10, 10-20 and 20-30 cm depth (for a total of 160 samples), with the purpose of studying their vertical distribution. Sampling was carried out with a 50 x 50 cm frame. For that purpose walking was performed diagonally and counting was every 20 steps. The litter stratum was cleaned; samples were taken and placed in a glass container. Worms were preserved in formalin solution at 4 % and alcohol at 70 %. The rest of the fauna was conserved in alcohol 75 %, for biomass determination and classification. The same procedure was taken in the remaining strata. Macrofauna was identified according to Brusca and Brusca (1990) and Fuente (1994). The keys of Brinkhurst and Jamieson (1972) were utilized for Oligochaeta; Borror *et al*. (1976) for Insecta, Matic *et al*. (1977) for Chilopoda and Pérez-Asso (1995, 1996 and 1998) and Hoffman *et al*. (1996) for Diplopoda. The classification from the functional point of view (epigeous, anecics and endogeans) was carried out as per Lavelle (1997).

Statistical analysis. Results were analyzed according to the experimental design. The statistical package SPSS, version 11.5.2.1 (2003) was used. Mean values were compared by Duncan (1955).

Results and Discussion

Table 1 shows the taxonomic composition of the macrofauna collected from the soil. In total, were identified 216 individuals, represented by three types, five classes and seven orders. Classes with higher amount of organisms correspond to Insecta and Oligochaeta. Hymenoptera order outstands with 45 individuals, while in the second Haplotaxida predominated with 39 individuals. This latter annelid species was identified by Feijoo *et al*. (2007), as of frequent presence in grasslands without shade. Possibly the sowing frame used in this silvopastoral system was responsible for this performance.

Regarding the density (figure 1), in each studied stratum (litter, 0-10, 10-20 and 20-30 cm) the presence of individuals was significantly higher ($P < 0.001$) in the litter (8.08 individuals/m^2) and decreased to 1.83 individuals/m^2 at the 20-30 cm depth. This could be attributed to greater presence of feeds in the litter layer that gradually is formed on the soil with leaves fallen from the trees. This must increase the diversity of trophic resources on modifying the microhabitat. Also, it can be also due to the existence of greater amount of grass roots at the first soil strata, since these individuals are fed from the organic matter or the roots (alive or death).

The litter layer accumulated gradually throughout this time (17 months, approximately, that lasted the establishment, more than one year without exploitation) could have influenced on the population of organisms in this stratum (litter).

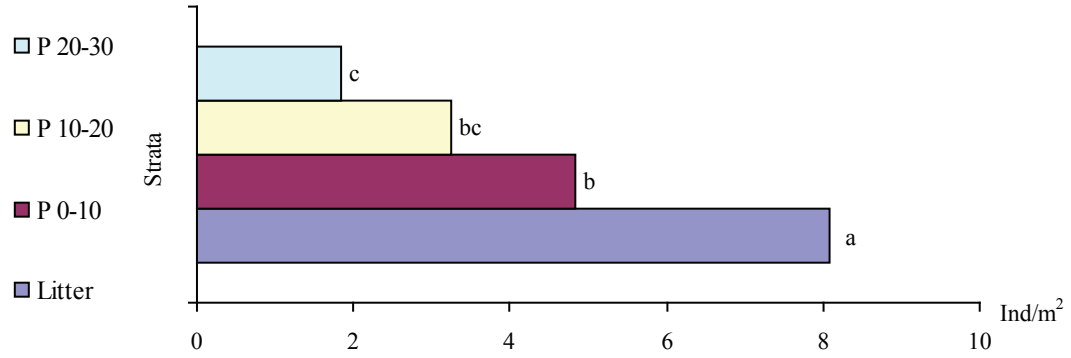
Macrofauna biomass (figure 2) differed ($P < 0.001$) between soil strata and varied from 0.16 g/m^2 in the litter layer to 0.03 g/m^2, at the 20-30 cm depth. This performance could be associated with the complex interactions of the factors that influenced during the decomposition process of the organic matter, among them the high values of mean temperature and greater number of rainfall days occurring in that period of time. There are populations that only come to the litter as nest or shelter, when humidity conditions and temperatures are perfect and others by preference for some specific feed of plant, animal or fungus type (Ayres *et al*. 2006). Thus, further characterization of the remaining organisms participating in the decomposition of the plant detritus is required.

Figure 3 shows that there is greater ($P < 0.001$) density of individuals after sowing and that is maintained invariable until the end of the experimental stage (two years after establishment) that could be determined by nutrient availability in the medium, due to litter

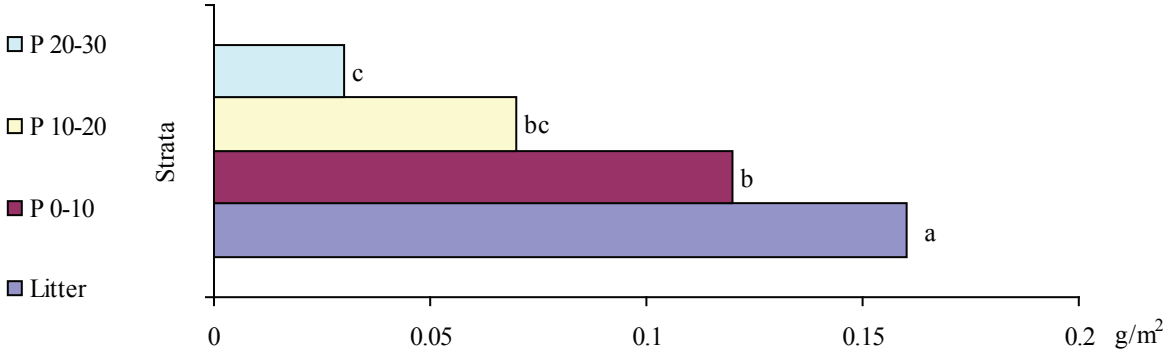
Table 1. Taxonomic composition of the collected soil macrofauna

Phylum Subphylum*	Class	Order Suborder*	No. of individuals
Arthropoda	Insecta	Coleoptera	38
		Orthoptera	32
		Lepidoptera	1
		Hymenoptera	45
	Diplopoda	-	5
	Aracnida	Araneae	29
Mollusca	Gastropoda	Stylommatophora	27
Annelida	Oligochaeta	Haplotaxida Lumbricina*	39
Total			216

(-) Not determined



[abc]Values with different superindices differ significantly at P < 0.05 (Duncan 1955)
SE = ± 0.028, P < 0.001
Figure 1. Density (individuals/m^2) of the soil macrofauna at each stratum studied.



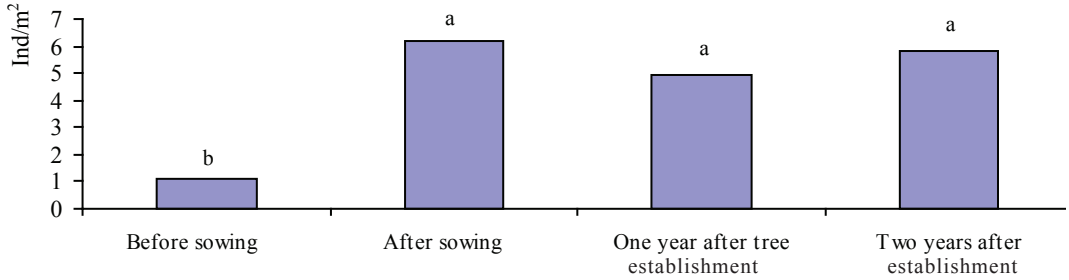
[abc]Values with different superindices differ significantly at P < 0.05 (Duncan 1955) SE ± 0.026, P < 0.001

Figure 2. Biomass (g/m^2) of the soil macrofauna at each stratum studied

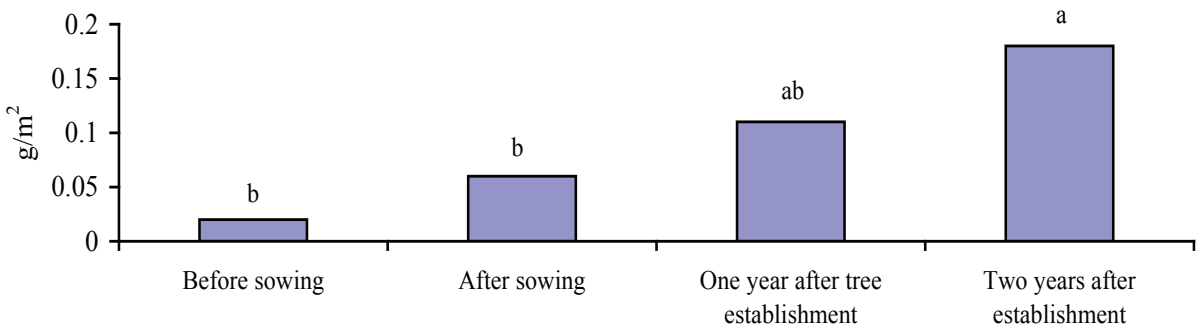
accumulation and to its decomposition, mainly that from the legume. This is decomposed faster than that of grasses, owing to the lower lignin content and best C/N relationship. The aforementioned coincide with the results of Sánchez (2007) in an area of the Experimental Station "Indio Hatuey", Cuba with similar arboreous area and *Panicum maximum*.

Total biomass of the macrofauna varied in upward order and attained the highest (P < 0.001) value two years after the establishment (figure 4). Values obtained could be considered as acceptable, if taking into account that the field before the establishment was covered in its great majority, by useless arvense species for animal production. Upward values of these indices are connected with the adequate management to which the silvopastoral system was submitted and to its favorable effect on the soil. In addition it must be borne in mind that during the whole experimental stage no chemical products (fertilizer, herbicides or pesticides) were applied. This influenced favorable on nutrient availability from the litter.

On considering the results, it was evidenced that the silvograzing increased the soil macrofauna by the arboreous inclusion (Leucaena). In this way diversity increased up to 8.08 ind/m^2 and the biomass with 0.16 g/m^2 in the soil layer at 0-10 cm depth. These conditions are mainly associated with the natural leaf fall of the legume that is known by effect of lower



[ab]Values with different superindices differ significantly at P < 0.05 (Duncan 1955)
SE = ± 0.35, P < 0.001
Figure 3. Total density (individuals/m^2) of the soil macrofauna, before and after sowing



[ab]Values with different superindices differ significantly at P < 0.05 (Duncan 1955) SE = ±0.18, P < 0.001

Figure 4. Total biomass (g/m^2) of the soil macrofauna throughout the time

temperatures and scarce humidity in the soil.

The above mentioned confirms the findings of Rodríguez *et al*. (2008) who in a study with a silvopastoral system of *Leucaena leucocephala*-Cynodon nlemfuensis in a commercial dairy production unit found that the highest number of individuals/m^2 and its biomass was in the soil stratum at 0-10 cm depth. Similar results found Lok *et al*. (2011) on studying the multiple legume mixtures.

Results from Lok and Fraga (2008) were also confirmed. These authors on comparing a silvopastoral system with *Leucaena leucocephala* to a *Panicum maximum* monoculture found that the number of individuals and its biomass was increased in time in the first system, while in the monoculture the opposite occurred.

Conclusions

In a general way, it is concluded that organisms with greater were of Insecta class, with 116 individuals while the highest values of density and biomass were concentrated after sowing. These indicate that the presence of Leucaena in the grass sward allows potentiating the biological activity of the soil and guaranteeing the stability of the system.

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