Litter macro-fauna in two systems with different land use and husbandry in Cuba

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Abundance, richness and composition of the community of the litter macro-fauna were preliminarily characterized, with emphasis on the Coleoptera order, in an agro-forested system with a silvopastoral management and association of the tree leguminous *Leucaena leucocephala* and the grass *Megathyrsus maximus*, and in another system of grassland, only with *M. maximus*.Both were located in San José de las Lajas, Mayabeque province. The study was carried out during the rainy periods of 2009 and 2010, in June and October, respectively. The epigeous macro-fauna was collected with pitfall traps. Eight traps were examined per system during the first sampling and 16 during the second. Curves of richness and curves of range/abundance were built for data processing. Two indexes of similarity were calculated. A total of 7,818 macro-invertebrates belonging to 20 orders were collected from the litter. From them, 321 were adult Coleopterans, grouped into 18 families and 33 morpho-species. The macro-fauna had higher values of richness of orders and abundance in the silvopastoral system of leucaena, mainly in October, 2010. The predominant orders, in both systems and moments of study, were Coleoptera and Hymenoptera. From the last one, the Formicidae family was mainly the predominant. The analysis of the Coleoptera order, at the level of morpho-species, showed higher richness and abundance in the silvopastoral system of leucaena, and the dominant morpho-specie, in both systems, was *Scolytidae sp*. 1.

Key words: *macro-invertebrates, epigeous, Coleoptera, pitfall traps*

The macro-fauna of soil includes the arthropods from litter, also known as epigeous organisms. Their fundamental ecological function is the fragmentation of the litter, which influence on the processes of decomposition and mineralization of the organic matter in tropical ecosystems (Lavelle*et al*. 1992 and Barajas-Guzmán and Álvarez-Sánchez2003). The original community of the edaphic fauna undergoes changes in its composition and abundance, depending on the disturbances provoked by the soil management or the transformation of natural ecosystems into agro-ecosystems (Fragoso *et al*. 1997).

Among the communities of the soil macro-fauna, coleopterans are one of the most diverse groups, taxonomically and functionally speaking (Lavelle *et al*.1981 y Ruiz 2004). The specific coleopterans take part on the edaphic functions, like movement of excretions, necro-mass decomposition and regulation of the population of other invertebrates, which could be used as indicators of soil quality and its sustainability (Fávila and Halffter 1997, Lavelle and Spain 2001 and Fernández and Herrera 2004).

Numerous researches have been carried out in Cuba about the macro-fauna communities of soil in different land use systems (Rodríguez and Crespo 1999, Sánchez and Reyes 2003, Cabrera-Dávila *et al*. 2007, Sánchez *et al*. 2008 and Robaina 2010). The standard methodology proposed by the International Program "Tropical Soil Biology and Fertility" (Anderson e Ingram 1993) was applied. It consists on the extraction of soil monoliths of 25 x 25 x 30 cm. However, this methodology has disadvantages regarding the recollection of some epigeous organisms of great mobility, and an action range higher than 625 cm^2. Some authors propose the use of pitfall traps for the study of this type of macro-invertebrates. According toUetz and Unzicker (1976) y Lietti *et al*. (2008), the use of pitfall traps makes possible the continuous sampling of epigeous macro-invertebrates, although it depends on their movements and levels of activities. The method provides the recollection of a proper amount of arthropods, with relatively less time and effort, if it is compared with other absolute methods of sampling.

This study has the objective of characterizing, through the use of pitfall traps, the abundance, richness and composition of the community of the litter macro-fauna, with emphasis on the Coleoptera order, in a silvopastoral system of leucaena and a grassland with *M. maximus*. Besides, one of the goals is to evaluate the effect of the use of the land in these epigeous comunities.

Methods and materials

Research areas. The study was carried out in areas of the genetic dairy farm 3, from the Institute of Animal Science, San José de las Lajas, Mayabeque province. The dairy farm is located in a red ferrallitic soil (Anon 1999).

Two systems with different land use were evaluated, an agro-forested system with a silvopastoral management, characterized by an association of the tree leguminous *Leucaena leucocephala* (Lam.) Wit and the grass *Megathyrsus maximus* (Jacq.) B.K. Simon and S.W.L. Jacobs (Guinea grass), with a density of 9014 plants/ha, a mean height of 3m and a time of establishment superior to 16 years. The other system, of naturalized grassland with dominance of *M. maximus* represented the 75% of the botanical composition and it was under exploitation since more than 25 years. In both systems, a rotational

grazing was carried out with a mean stocking rate of 2.8 LAU/ha. The main cattle breed used were Holstein and Siboney.

Study of the litter macro-fauna. The samplings were carried out during the rainy periods of 2009 and 2010, in June and October, respectively. The litter macro-fauna was collected with pitfall traps. They consisted on plastic container of 450 mL, buried at the soil level, which were poured alcohol at 80 % and acetic acid at 5% as a preservative solution and they were maintained active for 48h. In 2009, four plots were defined, with 5 x 5 m in each system, separated at 50 m equally distant. Two traps were located in two of the diagonal extremes of each plot, and a total of eight per system. In 2010, eight plot were located, with the same characteristics and distance regarding the previous year, for a total of 16 traps per systems. The total area of sampling, for the two systems in study, was around 2.5 ha.

The identification of the macro-fauna was carried out until a taxonomical level of order and for adult coleopterans until the family level. Studies related to identification and taxonomical location of this fauna, were used for that purpose (Borror *et al*. 1976 and Brusca and Brusca 2003). Likewise, the adult coleopterans were separated in morpho-species or recognizable taxonomical units, according to Ricketts *et al*. (2001) and Hughes *et al*. (2002).

Data analysis. Only adults were considered in the curves of richness at the level of order in the macro-fauna and of the morpho-species in coleopterans. These curves allowed to know the observed and estimated richness of taxa and the effectiveness of the sampling.

The richness of taxa was valued through the non-parametric estimators Jacknife 1 and Bootstrap, for each system and study date, with the use of the program EstimateS 8.2.0 (Colwell 2006).

For supporting the analysis of dominance diversity, the range/abundance curves (RAC) were used starting from the decimal logarithms of the decimal abundances (Magurran 1989). Two similarity indicators were calculated, which compare the systems in each studied year, for measuring theβ-diversity, in other words, the replacement of taxa between two samples. The analysis was conducted at the level of order for macro-fauna and at the level of morpho-species for Coleoptera. The qualitative similarity was determined by the Community Coefficient (CC). This index may be $0 \leq CC \leq 1$, where CC=0 indicates samples that do not share any of their taxa and CC=1 represents samples that share all the taxa. For establishing the quantitative similarity, the index of Proportional Similarity (PS) was calculated that ranges between $0 \leq PS \leq 1$, being PS=0 two samples with no similarities, and PS=1 similarities in two identical samples. Both indexes were suggested by Feinsinger (2004). In both, values lower than 0.5 indicate low similarity and values higher than 0.5 represent a high similarity and medium similarity if 0.5 is the value.

Results

A total of 7,818 macro-invertebrates from the litter were collected, belonging to 20 orders, with a total effort of 48 pitfall traps and four days of sampling. Out of the total amount of macro-invertebrates found, 321 were adult coleopterans, grouped into 18 families and 33 morpho-species.

Richness of the epigeous macro-fauna. According to the curves of richness of the macro-fauna in 2010, the silvopastoral system of leucaena had higher richness, with 14 orders, regarding the grassland of Guinea grass, where 11 orders were found. However, in 2009, richness was slightly higher in the grassland system of Guinea grass regarding the one of leucaena. This resulted from the presence of an only individual, belonging to an undetermined order. Likewise, the values of estimators in the silvopastoral system of leucaena were higher than the values from the grassland of Guinea grass during the sampling of 2010 (figure 1). In the analysis of the total richness of macro-fauna in both systems in study per each moment of sampling, the number of orders collected in 2010 was higher than in 2009 (figure 2).

Nevertheless, the CC showed that both systems in study had similar taxon composition (table 1).This could have occurred due to the analysis of the macro-fauna that was carried out in the superior taxonomical order of order.

Richness of epigeous adult coleopterans. In coleopterans, the highest values of richness of morpho-species were in the silvopastoral system of leucaena. The values of the estimators were always superior in this system (figure 3). When analyzing the total richness of the coleopterans captured in each moment of sampling, there was a superior number of morpho-species of epigeous coleopterans in 2010 (figure 4).

The results of CC showed a low similarity in the morpho-species composition among the studied systems in both sampling moments (table 1).

Abundance of the epigeous macro-fauna. In the two samplings carried out, the total abundance was higher in the system of leucaena (2009= 360 individuals and 2010= 5,767 individuals). According to the range curves of abundance, the recollected epigeous macro-fauna was formed by 19 orders of invertebrates, and a group that was known as undetermined. Individuals belonging to an unidentified order were included in this group (figure 5).

In both systems and moments of sampling, the dominant orders of the litter macro-fauna were Hymenoptera and Coleopteran, excepting the second most abundant order of the sampling in the grassland during 2010, which was Spirobolida order (figure 5). However, it is necessary to point out the predominance of hymenopterans due to the high abundance of formicidae (ants), which were constituted by colonial insects. The invader specie known as little fire ants (*Wasmannia*

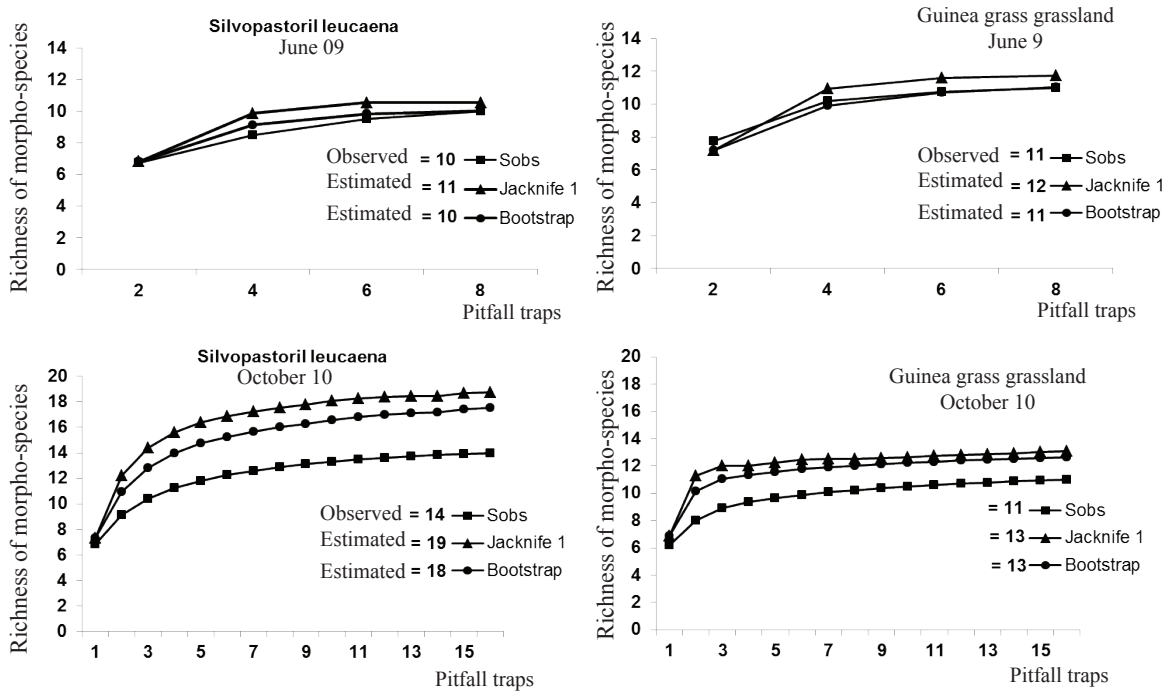

Figure 1. Accumulation curves of the richness of orders from the epigeous macro-fauna by sampling units in a silvopastoral system of leucaena and in a grassland of Guinea grass (Sobs: observed richness; Jacknife 1 and Bootstrap: estimated richness).

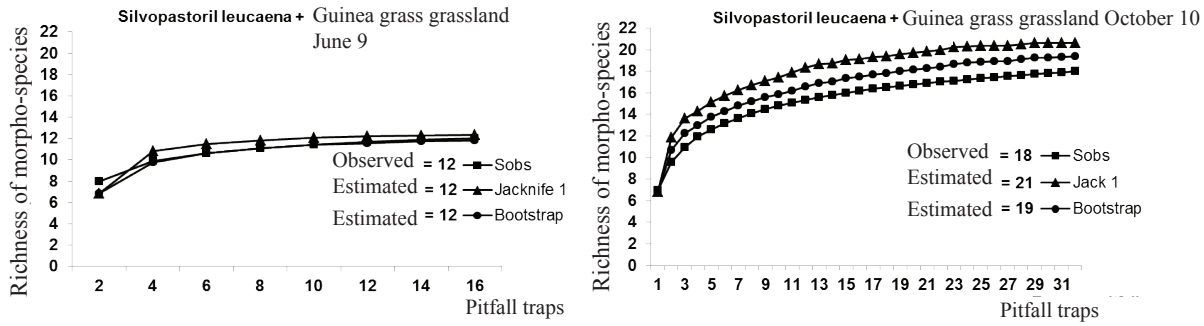

Figure 2. Accumulation curves of the richness of orders from the epigeous macro-fauna per sampling units, with the inclusion of both study systems during each sampling moment (Sobs: observed richness; Jacknife 1 and Bootstrap: estimated richness).

Table1. Indexes of coefficient of similarity, calculated between both studied systems: silvopastoral system (SPS) of leucaena and grassland of Guinea grass (GGG)

Group	Index	SPS leucaena	GGG
		2009	2010
Macrofauna	Community Coefficient	0.95	0.71
	Proportional Similarity	0.76	0.57
Coleóptera	Community Coefficient	0.35	0.56
	Proportional Similarity	0.63	0.70

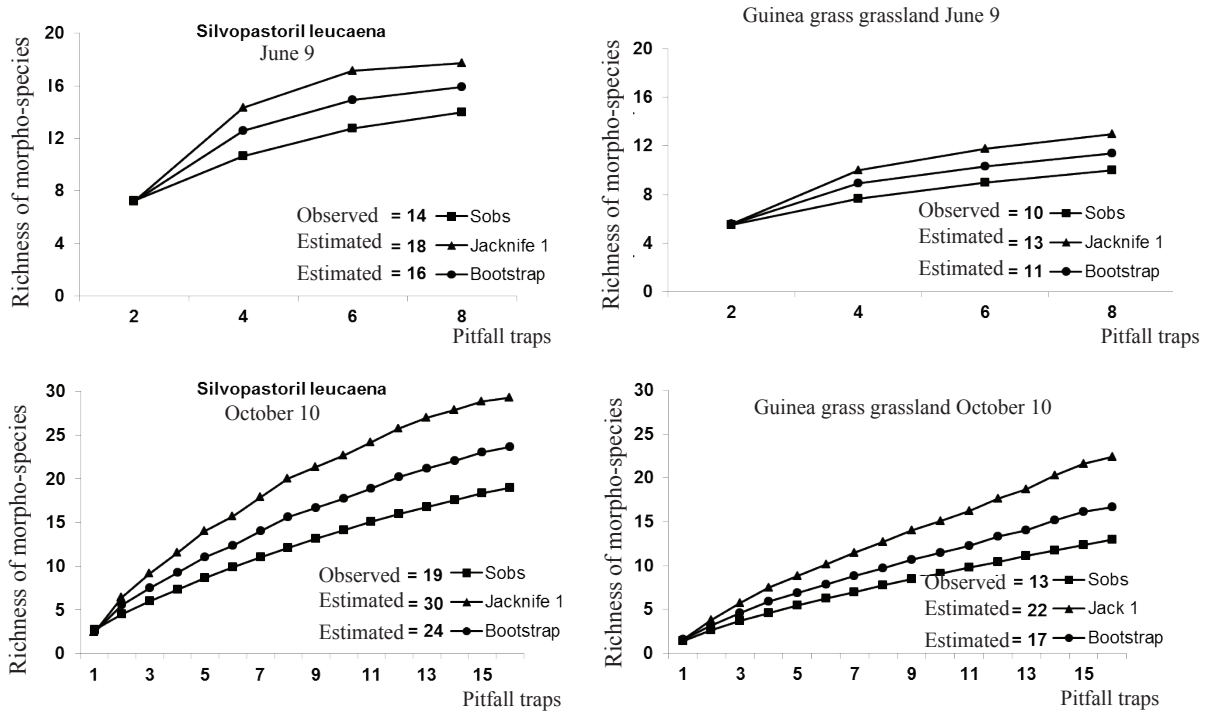

Figure 3. Accumulation curves of richness of morpho-species of epigeous coleopterans by sampling units in a silvopastoral system of leucaena and in a grassland of Guinea grass (Sobs: observed richness; Jacknife 1 and Bootstrap: estimated richness).

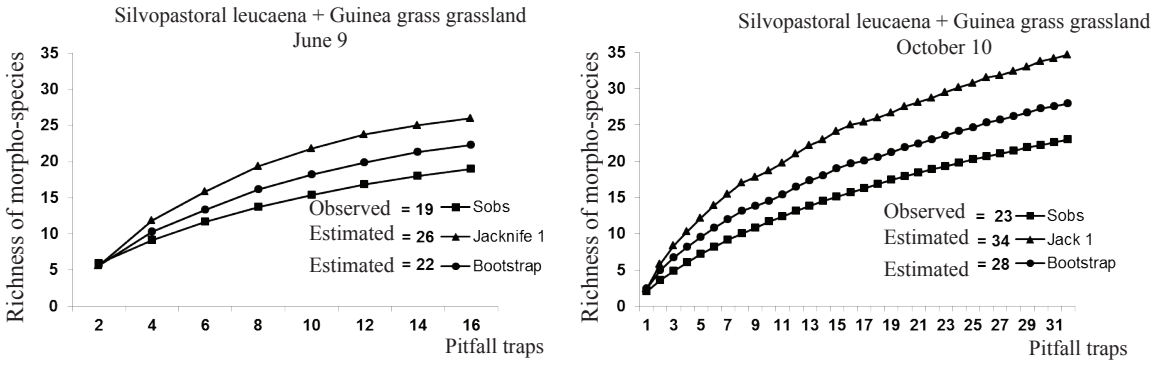

Figure 4. Accumulation curves of richness of morpho-species of epigeous coleopterans per sampling units, with the inclusion of both study systems during each sampling moment (Sobs: observed richness; Jacknife 1 and Bootstrap: estimated richness).

auropunctata) was the higher provider of its abundance.

The high and similar abundance values of ants in both study systems could influence on the results, according to quantitative similarity, which probably would explain a great resemblance between both samples. Therefore, the value of SP index shown excludes this group. Even in this condition, great similarity was obtained between the study systems in both sampling moments (table 1)

Abundance of epigeous adult coleopterans. The abundance values of epigeous coleopterans in the silvopastoral system of leucaena were also higher (2009= 127 individuals and 2010= 92 individuals) than in the grassland with Guinea grass (2009= 67 individuals and 2010= 35 individuals). The edaphic coleopterans communities was composed by 14 determined families and other undetermined four families (1, 2, 3 and 4), which were not identified. Out of these families, the main predominant were Scolytidae and Nitidulidae. Likewise, the dominant morpho-specie from both systems and sampling moments was *Scolytidae sp*.1 (figure 6). In this sense, the PS index showed a great quantitative similarity between both study systems

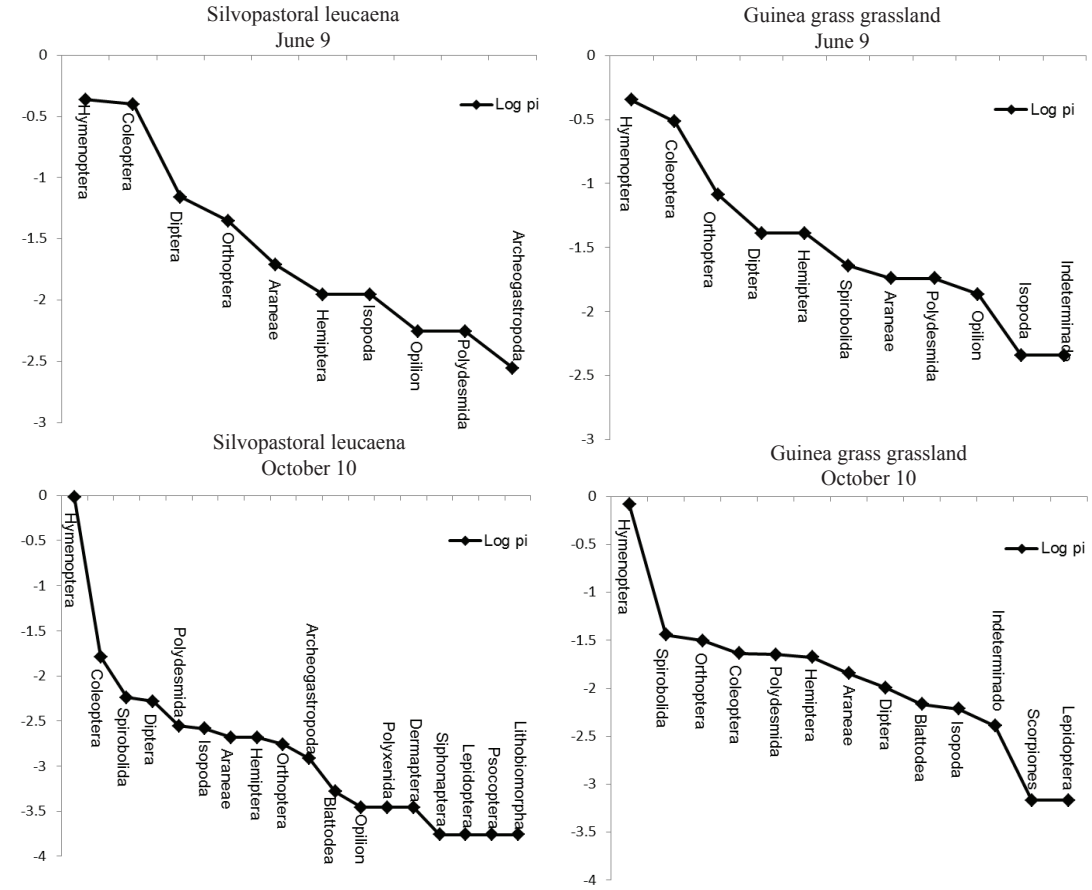

Figure 5. Range/abundance curves of the epigeous macro-fauna orders in a silvopastoral system of leucaena and a grassland of Guinea grass.

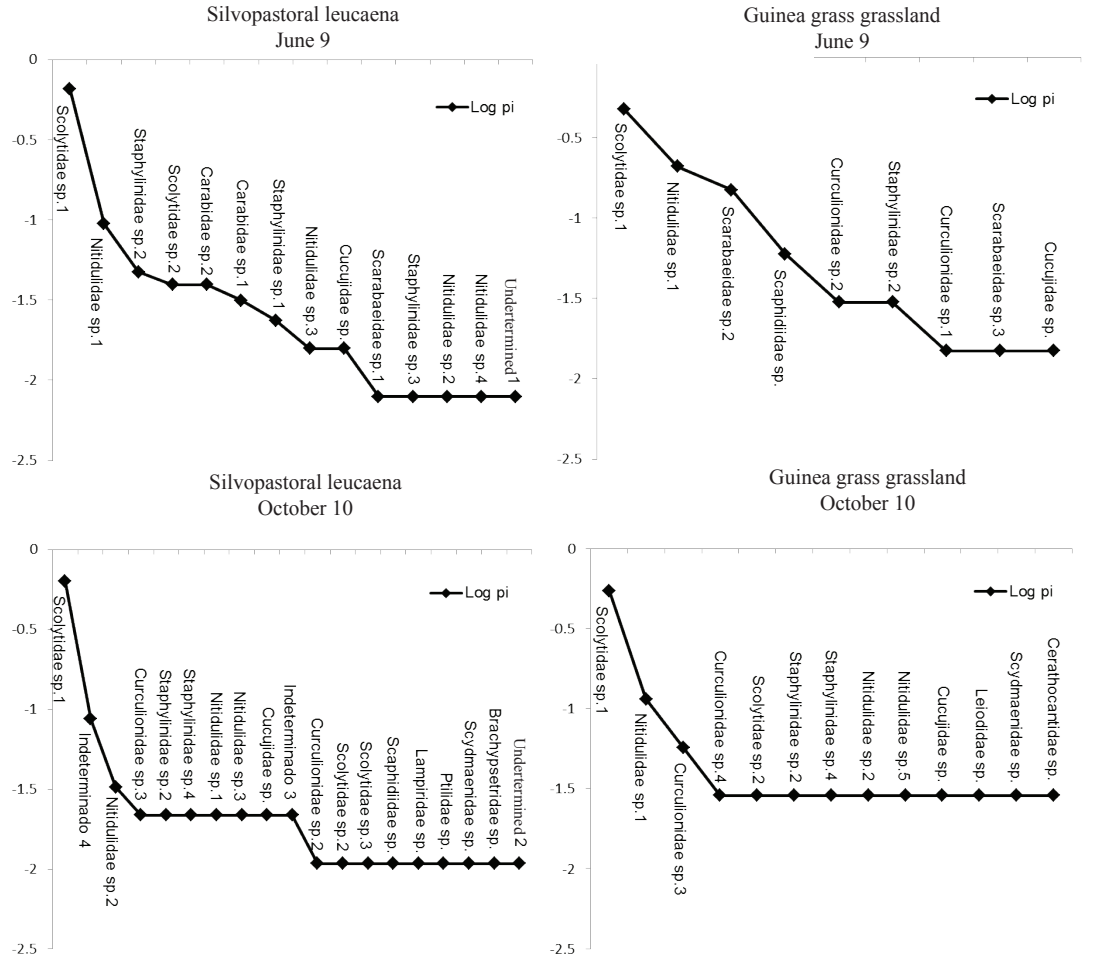

Figure 6. Range/abundance curves of the epigeous coleopterans morpho-species in a silvopastoral system of leucaena and a grassland of Guinea grass.

(table 1).

Discussion

When a slight comparison is carried out between the international results and the sampling effort used for the pitfall traps methodology, regarding the total abundance of macro-fauna, the results of this study are higher than those obtained by Goehring *et al*. (2002). These authors found 5,976 arthropods from 20 orders in two portions of wood and a plantation of coffee, growth under the sun, in Costa Rica. They applied a sampling of nine weeks and 36 pitfall traps placed in each ecosystem. Bautista *et al*. (2009) also obtained lower values of abundance and richness with the use of 50 traps, because they collected a total of 4,607 individuals, 15 taxa included, in a secondary wood, a silvopastoral system and in three grassland systems, with different time of establishment and management, in Yucatán, Mexico.

Álvarez-Duarte and Barrera-Cataño (2007) obtained higher results to those of this study, regarding the epigeous coleopteran communities. These authors found 857 individuals, belonging to 12 families and 72 morpho-species, when sampling different areas of a quarry that was out of exploitation in Bogotá, Colombia. However, it is important to consider that the sampling effort of that research was much higher than the one used in this study, in which a total of 176 pitfall traps were used in four month of sampling.

The accumulation curves (figures 1, 2, 3 and 4) reveal that the sampling intensity, that is the number of traps used, was not enough to collect all the taxa present in both study system. However, the phenomenon of non saturation of curves was more evident in the analysis of epigeous coleopterans, where an inferior taxonomical level was used, regarding the analysis carried out for the macro-fauna. This evidenced that only few orders of the macro-fauna were not collected in the studied systems, but several morpho-species of coleopteran could still be found in these areas.

The highest richness and abundance in the communities of epigeous macro-fauna and of the epigeous adult coleopterans from the silvopastoral system of leucaena, regarding the grassland system of Guinea grass, may be defined mainly by its tree nature. The presence of the tree stratum in this type of systems provides shadow that improves the microclimatic conditions of soil by decreasing the erosive action of wind and sun, preserving humidity and decreasing the edaphic temperature (Rodríguez *et al*.2000). Besides, it is known that silvopastoral systems associated with *L. leucocephala* and *M. maximus* have higher annual production and accumulation of litter than other systems with *M. maximus* only (Sánchez *et al*.2008). This litter layer, which is more developed, provides higher shelter possibilities for macro-invertebrates against drying and predation, and brings about great diversity in the epigeous macro-fauna because it undergoes a lower selective pressure from the environment. The composition of the litter of leucaena has great quality due to its high content of nitrogen, which makes possible to sustain more abundant and richer communities of macro-fauna. Rodríguez *et al*. (2002) and Sánchez and Crespo (2004) obtained this same pattern of environmental conditions and results in the macro-fauna of studies carried out in Cuba, with the use of a standard methodology of the TSBF. However, the richness values obtained in this study were higher than those informed by the quoted authors.

It is important to state that both sampling methodologies of edaphic macro-fauna (soil monoliths and pitfall traps) are recommended nowadays for obtaining a more complete inventory of this fauna. One methodology does not exclude or replace the other, they complement each other. The litter fauna, with higher mobility, whether with diurnal or nocturnal activities, is better collected through the use of pitfall traps. This is difficult to be obtained through the soil monoliths, which focus their action on less mobile organisms, mainly with higher permanence in the interior of soil and with a diurnal activity.

Generally, the superior values of richness and abundance of macro-invertebrate orders and morpho-species of epigeous adult coleopterans obtained in 2010, regarding those obtained in 2009, in both study systems. These values could be a result from the use of a higher amount of pitfall traps during the second collection moment (October 2010) and from the accumulative effect produced by precipitations during the last months of the rainy season. During these months, the environmental conditions are more favorable for growth and establishment of macro-fauna communities because the resources for food, shelter, humidity and temperature are higher and optimal regarding those from the first rainy months of the year. These results have been reported by many studies, where the highest values of diversity and density of macro-fauna populations are found during the end of the rainy season (Brown*et al*. 2001 and Bautista *et al*. 2008).

The CC results of the epigeous macro-fauna orders evidence that both systems share a great amount of macro-fauna orders, and only a few are exclusively from one system (figure 5). In 2009, 95% of the collected taxa were shared by both systems. In 2010, 71% had both values and similarities of macro-fauna orders over 50%. However, the CC analysis of adult coleopteran morpho-species showed that there is a great re-change of morpho-species between the silvopastoral system of leucaena and the grassland of Guinea grass (figure 6). This means that there are many native morpho-species s from each vegetable formation, which is possible maybe due to the habits developed by these morpho-species that have allowed them to seize the conditions from each ecosystem. Therefore, the possible competence decreases.

The values obtained from the PS, for macro-fauna and coleopterans, are determined not only by the taxa composition but by the abundance values that reach in the different systems. For instance, in 2009, the macro-fauna presented several common orders and similarity in the relative abundance of these taxa, which contributed to a high value of similarity between both uses of the studied lands during this sampling moment.

For the coleopteran, differences in the composition and abundance of morpho-species were observed in both years, which is shown in the lowest values of PS regarding the calculated for total macro-fauna in 2009.

The dominance of the Scolytidae and Nitidulidae families coincides with the international results and with those obtained in Cuba. Menéndez (2010) compared, in a study carried out in Cuba, the abundance of edaphic colepterans in two fragments of a semi-deciduous wood and a grassland with the use of pitfall traps. This author obtained the Nitidulidae as one of the dominant families. In the centre of Veracruz, Mexico, Deloya and Ordóñez-Resendiz (2008) found the Scolytidae among the three most abundant families in a mesophilous wood of mountain, three coffee plantations grown in the shadow and a coffee plantation cultivated under the sun.

A total of 7,818 macro-invertebrates from litter, belonging to 20 orders, were found in this study. The Himenoptera and Coleoptera orders were dominant in both land uses. There was a total of 321 adult coleopterans, grouped into 18 families and 33 morpho-species. The *Scolytidae sp*.1was the dominant morpho-specie in both studied systems.

It can be concluded that the use of silvopastoral systems with *Leucaena leucocephala* provides higher richness and abundance of edaphic macro-fauna communities and, specially, of coleopterans due to the resulting improvement of the edaphic conditions.

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