Research article

Melolonthidae (Coleoptera: Scarabaeoidea) assembly associated to pastures in Caqueta (Colombia) and its possible relationship with soil health

Ensamblaje de escarabajos Melolonthidae (Coleoptera: Scarabaeoidea) asociados con pasturas en el departamento del Caquetá y su posible relación con la salubridad edáfica

Luis Carlos Pardo-Locarno[1], Bertha Ramírez-Pava[2], Harold Villota[3], Oscar Villanueva[2], and Wilmar Bahamón[3]*

[1]Environmental Consultant, Fondation Center for Research on Sustainable Systems for Agricultural Production (CIPAV), Cali, Valle del Cauca, Colombia.[2]Professors Universidad del Amazonas, [3]Project Research Assitants.
*Corresponding author: pardolc@gmail.com

Rec.: 06.05.11 Acept.: 01.12.11

Abstract

The Caquetá hillside zone is a part of the Colombian Amazon region (mean pluvial precipitation 3600 mm; 260 m.a.s.l., 26ºC). It shows a mega diverse environment, ecologically fragile as the soils have been increasingly degraded. This research had the purpose of monitoring biological aspects of degraded soils resulting from extensive livestock production systems. A comparative sampling of richness and abundance variation of edaphic scarabs on cattle ranches of five municipalities (San Vicente del Caguán, El Doncello, Belén de los Andaquíes, Albania y Valparaíso) was used. Adults were sampled using light traps and larvae by excavation of soil quadrants on pasture and forest relict plots during dry and rainy seasons. 26 Melolonthidae species were documented, a moderate diversity assemblage including 16 and 2 new records for the Department of Caquetá and Colombia, respectively. 475 larvae and 11 morphospecies were collected, their distribution and abundance varied significantly depending on management, seasons and localities, highlighting the low beta diversity of the region (11 species) and the low alpha diversity by municipalities (five species), including just 33% saprophagous (*Cyclocephala, Euetheola*), while the other ones (*Phyllophaga, Plectris, Barybas, Bolax*) are rhizophagous. This balance showed increasing soil degradation, presumably due to the reduction on soil organic matter and deterioration of soil physical properties as a consequence of extensive livestock production systems. It is recommended to extend these studies to a large geographical scale in order to detail the diagnosis and to redefine the soil management strategy to focus on sylvopastoral systems with improved grasses, herbaceous and shrubby legumes and arboreal strata.

Key words: *Barybas*, Beetles, *Bolax*, Caquetá, Coleoptera, Colombia, *Cyclocephala*, *Euetheola*, *Phyllophaga*, *Plectris*, Scarabaeidae.

Resumen

La zona de Piedemonte caqueteño (Colombia) forma parte de la región amazónica (3600 mm de precipitación anual, 260 m.s.n.m., 26 °C) y presenta un ambiente megadiverso ecológicamente frágil cuyos suelos están siendo afectados de manera creciente por la ganadería de tipo extensivo. En el presente trabajo se hizo un monitoreo de la biología y abundancia de escarabajos edafícolas en fincas ganaderas con pasturas degradadas, localizadas en los municipios de San Vicente del Caguán, El Doncello, Belén de los Andaquíes,

Albania y Valparaíso del departamento del Caquetá. Para el estudio se hicieron muestreos de adultos utilizando trampas de luz y de larvas en cuadrantes de suelo en parcelas de pasturas y relictos de selva durante épocas seca y húmeda. Se registraron 26 especies de Melolonthidae, ensamblaje de diversidad moderada, que incluye 16 nuevos registros para el departamento de Caquetá y dos nuevos registros para el país. Se recolectaron 475 ejemplares y 11 morfoespecies especies, cuya distribución y abundancia variaron significativamente según usos del suelo, épocas y localidades. Resalta la poca diversidad beta de la región (11especies) y alfa por municipios (cinco especies), de las cuales solo 33% fueron saprófagas (*Cyclocephala, Euetheola*), mientras que el resto (*Phyllophaga, Plectris, Barybas, Bolax*) son rizófagas, lo que significa un balance expresivo del deterioro edáfico, presumiblemente causado por la declinación de la materia orgánica y afectación de las condiciones físicas del suelo como consecuencia de la ganadería extensiva. Se sugiere realizar estudios a mayor escala geográfica y reenfocar el uso del suelo hacia sistemas multiestratificados.

Palabras clave: *Barybas*, *Bolax,* Caquetá, Coleoptera, Colombia, *Cyclocephala*, escarabajo, *Euetheola*, *Phyllophaga*, *Plectris*, Scarabaeidae.

Introduction

Deforestation or transformation of the primary forest in tropical regions is one of the biggest environmental impacts with main consequences on biodiversity and environmental damage (Martino, 2007; Smith *et al.*, 1997). During the last decades, Colombia has been one of the countries with the highest deforestation rate, especially in the amazon region where it has lost 6002 km^2 during the last five years. (Correa, 2010; Domínguez, 1985; González, 2000). The amazon region of Colombia consists of 483,164 km^2 (42.3% continental area), and it is considered as the less populated region of the country and one with highest biodiversity (Correa, 2010; Murcia *et al.*, 2009), these conditions are being altered by severe deforestation, due to the expansion of the agricultural frontier for livestock and cultivation of illicit crops (González, 2000).

The Department of Caqueta is at the southeast of Colombia and has a diverse biophysics environment, plenty of natural resources and forestry potential, attractive to settlers which from early times in the last century, established themselves to develop their life projects (Amézquita, 1985) and for extensive livestock (Andrade, 1988; CID, 1987). In 1998, agricultural and livestock activities represented 8,895,600 ha, pastures (31.22%) feed 1,692,900 cattle in an extensive system with double purpose. It has Zebu x Holstein and Zebu x Brown Swiss cattle characterized by their low productivity index (21/cattle per day and average daily weight gain of 300g/day). This system is characterized by a misuse of the forest resources, accelerated edaphic damage, infertility, farm desertion, ecological simplification, and other impacts originated on the low efficiency of the productive system, which surpasses the recovery capacity of the ecosystem keeping its productivity (Andrade, 1988; Cipagauta and Pulido, 1998; IGAC, 1988, 1995; Ramírez, 2010).

In this scenario, clearly opposite to a sustainable production (IGAC, 1993), is required to implement environmental monitoring, like soil organisms, which provide early alerts for deterioration(Anderson e Ingram, 1993; Pardo-Locarno *et al.*, 2006; Sevilla, 2002; Sevilla *et al.*, 2002). This approach, together with an evaluation of chemical and physical properties, can deliver a better comprehensive analysis of the soil (Anderson and Ingram, 1993; Pardo-Locarno, 2009).

This work was performed as part of the project on degraded pastures reconversion and generation of ecosystem services as instrument for the improvement and sustainability of the livestock competence in Caqueta, with the aim of studying the variability on composition and abundance of soil scarabs' assembly and, their impact on ecosystem degradation. With the soil biological analysis, we aimed to identify sustainable productivity proposals adjusted to the local biophysics.

Materials and methods

Location and sampling

The Department of Caquetá, Colombia, belongs to the amazon region, which is located

at the western side of the Eastern range in the Caquetá river left side, 2° 58'N and 0° 40' S and 71° 30' and 76° 15' W, average temperature 26 °C and a super-humid tropical rainforest life zone (Holdridge, 1978). It has a complex physiography which includes denudation areas (hillsides), alternating with medium terraces and lowlands near rivers. It has a yearly rainfall of 3600 mm with a rainy season from April till July and a dry season between December and March. The region has land use types or biophysics units of agriculture, livestock and forest (IGAC, 1993; Ramírez, 2010). Agricultural activities generate damages and important constrains for vegetation development. Livestock generates losses in tree cover and biodiversity, and soil compaction with low infiltration, poor root penetration, soil structure loss, reduction in aeration, which are accentuated by runoff (Domínguez, 1985; Fujisaka, 1997; IGAC, 1988, 1993, 2003).

For this work, sampling in each town was done in Ultisols soils, with a moderate to poor drainage, clay, highly acidic (pH < 4.5), low organic matter content and cationic interchange capacity, high aluminum saturation (90%) and low nutrient content –Phosphorus 2-6 ppm, 0.4, 0.12 and 0.14 meq/100 g Ca, Mg and K, respectively-, which are normal conditions for a soil in the Colombian Amazon (Escobar and Liriatti, 1992; IGAC, 1995; Ramírez, 2010).

Sampling was done in livestock farms with jungle relics in El Doncello, San Vicente del Caguán, Belén de los Andaquíes, Albania and Valparaíso towns (250 - 260 m.a. s. l.), which predominantly have dense thickets , and *Paspalum* sp., *Homolepsis aturensis, Hiparrhenia rufa*, *Brachiaria decumbens*, *B. dyctioneuray*, *B. humidicola* pastures, surrounded by small plantain and cassava crops (Figure 1).

Beetle sampling included adults and larvae. Due to transport constrains and poor energy supply, adult sampling using light traps was performed only during the rainy season on a farm in Belén de Andaquies town (Bustillo, 1989). Adults were identified using collection samples and bibliographical sources (Endrödi, 1985; Frey, 1967, 1975; Morón and Vallejo, 2007; King, 1996).

Beetle larvae sampling compared the abundance by seasons, locations and land use, for that purpose in each farm and in each town plots were randomly selected in the degraded pastures and jungle relics. In each location with degraded pastures, three plots (aprox. 0.5 ha) were drawn and three samples were extracted from each of them, these were

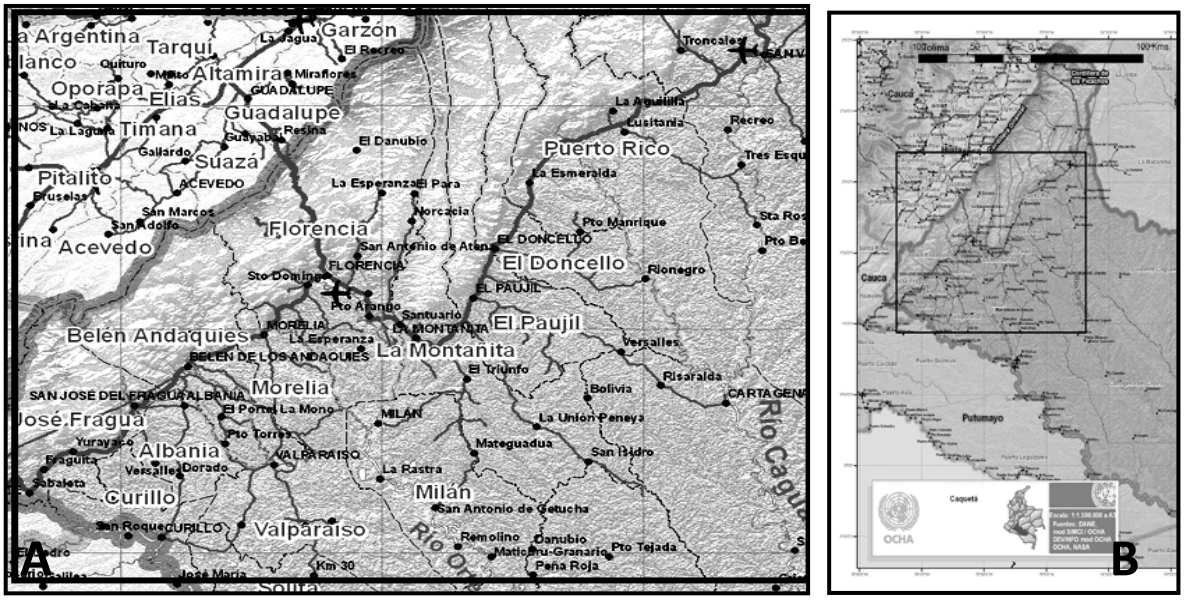

Figure 1. Caqueta, Colombia. **A**: Close up to the Caqueta foothills showing the studied towns. **B**: Western region of Caqueta.
Source: Modify from DANE (OCHA-NASA).

soil quadrants (Pardo-Locarno, 2002; Swift and Bignell, 2001) with 1 m^{-2} x 30 cm depth. Recollected samples were stored in plastic containers, with water and low concentration of soap to break superficial tension and speed up drowning. Subsequently, they were placed on a container with formol solution (10%) (Pardo-Locarno, 2002) and the larvae were identified by comparison with a reference collection (CFPL-COL) and literature searching (Ritcher, 1966; Böving, 1942; Morón, 1995; Vallejo *et al.*, 1998; Pardo-Locarno *et al.*, 2009; Stehr, 1987, 1991).

Result analysis

Results were processed by one-way analysis of variance (SPSS) to compare species abundance by seasons (2), towns (5) and land use types (2). Dry and rainy season were compared taking into account that for the rainy season samplings were only done in El Doncello and Belen (Table 1).

Results and discussion

Beetle assembly

In Belen de los Andaquies, scarab sampling of Melolonthidae adults with light traps and manual capture yield 174 samples, which belong to 26 species: *Cyclocephala mannheinsi* Endrödi**, *C. amazona* L.*, *C. lunulata* Burm.*, *C. epistomalis* Bates**, *C. gravis* Bates*, *C. stictica* Burm.*, *Dyscinetus* aff. *dubius* Oliv., *Stenocrates bicarinatus* Robinson*, *Aspidolea fuliginea* Burm.*, *Euetheola bidentata* Burm., *Ligyrus ebenus* (DeGeer)*, *L. bituberculatus* Beauv*, *Strategus aloeus* L., *Podischnus agenor* (Oliv.), *Phileurus didymus* L.*, *Anomala* sp. 1, *Pelidnota* aff. *prasina* Burm., *P.* aff. s*umptuosa* Vigors, *Macraspis* aff. *nazareti* Soula*, *Rutela lineola* L.*, *Bolax* sp., *Leucothyreus* sp., *Phyllophaga* aff. *chiriquina* Bates*, *Plectris* spp. (2 species) and *Barybas* aff. *curta* Burm*. In the same manner, scarab larvae sampling in soil quadrants of jungle relics and pastures yield 475 samples of 11 species: *Cyclocephala* aff. *mannheinsi* Endr., *Cyclocephala* sp. 2, *Eue-*

Table 1. Analysis of variance (SPSS) for beetle larvae in soil quadrants (1 m^2). Caquetá, Colombia.

Specie	Analysis	Square sum	G.l.	Quadratic mean	F	P < 0.05
			Anova 1. Rainy and dry seasons			
Euetheola bidentata	Inter-grupos	92.011	1	92.011	7.626	0.007**
			Anova 2. Location (towns)			
Plectris sp. 1	Inter-groups	11.736	4	2.934	3.337	0.015*
Phyllophaga sp.	Inter-groups	1.333	4	0.333	3.865	0.007*
Cyclocephala sp. 1	Inter-groups	146.556	4	36.639	6.646	0.000*
Cyclocephala sp. 2	Inter-groups	2.500	4	0.625	2.792	0.033*
Leucothyreus sp. 1	Inter-groups	11.500	4	2.875	2.787	0.033*
Euetheola bidentata	Inter-groups	152.889	4	38.222	3.268	0.017*
			Anova 3. Land use (pasture, jungle relict)			
Plectris sp. 1	Inter-groups	0.304	1	0.304	8.264	0.005*
Plectris sp. 1	Inter-groups	5.700	1	5.700	6.143	0.016*
Barybas sp.	Inter-groups	3.373	1	3.373	11.117	0.001*
Phyllophaga sp.	Inter-groups	0.904	1	0.904	10.193	0.002*
Cyclocephala sp. 1	Inter-groups	56.213	1	56.213	8.559	0.005*
Cyclocephala sp. 2	Inter-groups	1.214	1	1.214	5.219	0.025*
Euetheola bidentata	Inter-groups	79.631	1	79.631	6.504	0.013*

theo labidentata Burm., *Phyllophaga* sp., *Plectris* sp. 1, *Plectris* sp. 2, *Leucothyreus* sp. 1, *Leucothyreus* sp. 2 y *Bolax* sp. (Table 2). Both samplings form a list considered preliminary and with moderate diversity, but includes 16 new departamental records (*) and two new records for Colombia (**) (Restrepo *et al.*, 2003; Figueroa, 1977). This confirms that the group is poorly studied in the region in despite of its importance in agricultural production.

Although, little is known about scarabs in the extensive Colombian amazon and the clear need to expand the sampling in the foothills of Caqueta, the data of this assembly regarding the adult and larvae capture exhibit distinctive features. These include a structure that is smaller than what is expected for a region on a jungle biophysical context, and a composition that is similar to the one registered for scarab assembly in humid warm regions at the east side of Colombia (Pardo-Locarno *et al.*, 2007), which includes unique records to highlight *Cyclocephala mannheinsi*, the most common specie, described for Ecuador and Bolivia (Endrödi, 1985) and registered for the first time for Colombia; *Cyclocephala epistomalis*, registered for Guatemala, Costa Rica, Panamá, Venezuela, Brazil, Bolivia and Paraguay (Endrödi, 1985; Ratcliffe, 2003) which will be the first registry for Colombia; *Bolax* sp., genus that is registered for the first time for Caqueta and which abundance surpasses all the samplings previously described (Table 2) (Pardo-Locarno *et al.*, 2007) and *Phyllophaga* aff. *chiriquina*, registered for Central America and in Bolivar, Colombia (Restrepo *et al.*, 2003).

This assembly presents similar features to what is registered for Orinoquia (Meta) and Amazon (Putumayo and Vaupes) regions, where samplings of 40 Melolonthidae species were studied, with some of high agricultural importance (Table 3). The information gathered shows a complex Melolonthidae assembly in soil, with notorious diversity and abundance of Dynastinae scarabs from Cyclocephalini and Pentodontini tribes. From the latest group, the known 'cucarro' (*Euetheolabi dentata*) scarab is highlighted for its economic impact, it is a scarab with a reproductive phase dependent on the rainy season (march, april) and whose adults had been registered as a limiting plague on pastures and cereal crops in the region.

There are other coincidences to highlight in other groups of Pentodontini genus *Ligyrus* (=*Tomarus*) and Rutelinae-Geniatini, specifica–lly *Leucothyreus* sp and *Bolax* (Pardo-Locarno *et al.*, 2007). Even though this information is preliminary, we can declare that the registered assembly presents enough affinities with those regions according to available information from the collection of the first

Table 2. Species and abundance of soil beetles on soil quadrants in five towns in the Caquetá foothills.

Genus/specie	**Towns**					
	San Vicente del Caguán	**Doncello**	**Valparaíso**	**Belén de los Andaquíes**	**Albania**	**Total**
Dynastinae						
Cyclocephala aff. *mannheinsi*	11	19	2	18	55	105
Cyclocephala sp. 2	—	—	6	—	—	6
Euetheola bidentata	7	4	10	27	27	75
Melolonthinae						
Phyllophaga sp.	—	2	3	—	—	5
Plectris sp. 1	—	—	13	—	1	14
Plectris sp. 2	—	1	—	1	—	2
Rutelinae						
Leucothyreus sp. 1	14	2	2	—	6	24
Leucothyreus sp. 2	—	—	—	6	6	12
Bolax sp.	1	223	—	3	5	232
Total	33	251	36	55	100	475

author of this work and the national collections reviewed: sharing around 50% of the indicated assembly in Vi–llavicencio (Meta), 30% with what is registered for Puerto Leguizamo (Putumayo) and in lower degree with Mitu and Vaupes (Pardo-Locarno *et al.*, 2007; Pardo-Locarno *et al.*, 2003). In relation to other agricultural pest, damage to some Oryctini species has been seen. Its adults feed on palms stipe (*Strategus aloeus* beetle) or sugarcane stems (*Podischnus oberthuri* Sternberg rhinoceros beetle) (ICA NNE: 1972-1994; Pardo-Locarno, 1994, 2000; Pardo-Locarno et al., 2009; Posada 1989; Restrepo 1998).

Agroecological aspects

Beetle species showed variation in abundance according to the season, location and land use, possibly due to specific bioecological requirements. This coincides with what is observed in other physiographic regions and partially evidences the local assemblies that depend on land use (Pardo-Locarno, 2002, 2009). When comparing beetle abundance in both seasons in El Doncello and Belen de los Andaquies, differences were observed ($P < 0.05$) in *Euetheola bidentata* (F: 7,626; S: 0.007), which higher abundance was in the wet season, with a mean of 4.17 individuals, however a sharp difference was also noted for *Bolax* sp. in both seasons (dry, mean = 3.70; wet, mean = 0.83).

When comparing the species abundance variation in the locations studied differences were observed ($P < 0.05$) in *Plectris*s sp. 1 (Valparaíso), *Phyllophaga* sp. (Doncello y Valparaíso), *Cyclocephala* sp. 1 (Albania), *Cyclocephala* sp. 2 (Valparaíso), *Leucothyreus* sp. 1 (Albania, El Doncello y Valparaíso) and *Euetheo labidentata* (was similar in Albania, San Vicente del Caguán and Valparaíso).

In the same manner, abundance differences ($P < 0.05$) in some species were found according to land use (pasture vs. jungle), among them were, *Plectris* sp. 1, *Phyllophaga* sp., *Barybas* sp., *Cyclocephala* sp. 1, *Cyclocephala* sp. 2, and *E. bidentata*. The difference is notorious in some rhizophagous species, e.g, *E. bidentata* (pasture, mean = 2.31, jungle 1 , mean = 0), in *Bolax* sp. (pasture, mean = 3.88, jungle, mean = 1.62) and it is less notorious in saprophagous like *Cyclocephala* sp. 1 (pasture, mean = 2.04, jungle, mean = 0.1).

The abundance variation by seasons, locations and land uses evidences preferences or success of a specie under a particular cir–cumstance or management type. In larvae, only the 33% of species are included in the saprophagous group (*Cyclocephala*, *Euetheola*), whereas the rest (*Phyllophaga*, *Plectris*, *Barybas*, *Bolax* and possibly *Leucothyreus*) are rhizophagous. This situation shows a trophic balance in favor of rhizophagous and phyto–phagous groups, since saprophagous were only abundant in Albania (Table 2), this tendency could be associated to a decline in organic matter (litter, and decomposing branches and stems) as a consequence of non-forestry agricultural systems that have low offer, accelerated mineralization and possibly lixiviation of organic matter products (Pardo-Locarno, 2009).

This region exhibited another structural and population feature: focalized abundance of Geniatini in the genus Bolax and Leucothyreus; particularly on non-determined Bolax specie which presented a remarkable abundance in quadrants of scarce presence in Belen and Albania (Table 2). This constitutes the first record in which abundance of a Rutelinae-Geniatini is highlighted on Colombian agroecosystem soils, and especially in pastures of degraded zones in the low trophic.

The 'cucarro' *E. bidentata* was the third most abundant specie in the quadrant sampling, and presented the highest picks in the plots from Belen de los Andaquies and Albania, which is in contrast with the registries annotated on Table 3, that show that two decades ago this specie was the most abundant plague in the amazon agroecosystems, Caribbean coast and Llanos Orientales. The rhizophagous larvae from the genus Phyllophaga have been recorded in Colombia in Andean zones over 500 m.a.s.l (Pardo-Locarno *et al.*, 2007; Vallejo y Morón, 2007); as such,

1 Here we reference jungle as described by Cuatrecasas (1958) who defined as a representative vegetal formation in the country, being this primary, highly intervened or secondary.

the adult registry in light tramps and larvae in soil P. aff. chiriquina Bates quadrants in pastures of El Doncello and Valparaiso, 260 m.a.s.l, is an event of both, biological and economic importance due to the group zoogeography (Nearctic and Mexican transition zone) and of Andean highlands (Vallejo and Morón, 2007). This finding coincides with recent records that pointed out a Phyllophaga specie that highly populated crops in El Paujil (Caquetá) (ICA NNE: 1972-1994).

The assembly analyzes could be framed in the preliminary national evaluations, which approximately record 75 Melolonthidae beetle species associated with representative agroecosystems from warm to cold regions (Caribe, Andes, Pacific, Orinoquia and Amazon) which composition, structure and abundance exhibited specificity and distinctive features in agreement with the biophysics and soil management (Pardo-Locarno *et al.*, 2007). These results, besides giving guidelines for management programs, are considered valuables to learn about edaphic health (Pardo-Locarno, 2009).

The soil damage can be expressed in the declination of the assembly structures or in the functional group (in this case sapro–phagous) declination (diversity, abundance), or, in the contrary, with the population success of some species considered agricultural plagues, among them, the known 'chisas' or Melolonthidae beetle larvae (Table 3) (Restrepo and López-Ávila, 2000). In this sense, the samples (475) and species (11) obtained in the beetle larvae sampling in relic forestry and pasture soil quadrants (Table 2) with degraded soils, show low beta and alpha diversities (mean of five species per location) in the Melo–lonthidae beetles on soil when comparing with other agricultural locations (Pardo-Locarno *et al.*, 2007). This is contradictory with the recent agricultural story of the region which was jungle till few decades ago, that favors a higher local and structural biodiversity of the soil scarabs' assembly (Pardo-Locarno, 2009).

The low biodiversity found on Melolonthidae scarabs collected on soil differs from the adults found on light tramps, which show a high diversity (26 species) with low abundance in most cases. These results, till now, suggest that the actual land use may be affecting both, diversity and abundance, of soil beetles, because there are more feeding opportunities and as such, more abundance of phytophagous species (rhizophagous of the genus *Euetheola*, *Strategus*, *Podischnus*, *Plectris*, *Phyllophaga*, *Bolax*, *Leucothyreus*) in comparison to saprophagous species (*Cyclocephala*) (Table 2).

Preliminary, it is possible to infer that land use had affected and simplify the soil beetle population structure in the Melolonthidae (Coleoptera:Scarabaeoidea) family, and it has declined the presence of innocuous beetles that belong to the macroinvertebrates group, which degrade decomposed organic matter, and are associated with humus formation, therefore are considered organisms involved in pedogenesis, like Cyclocephalini-*Cyclocephala* (Stechauner-Rohringer and Pardo-Locarno, 2010).

Conclusions

According to the study results, we can conclude that:

- The beetle assembly in five representative towns in the Caqueta foothills (Colombia), possibly reflects the ecosystem deterioration; before megadiverse and fragile (weather, topography), and now, ecologically collapsed due to extensive livestock that deteriorates the soil.
- The edaphic fauna showed a detriment in organic matter, basic food for saprophagous beetles; compaction or reduced soil porosity; loss of water and thermic regulation in the soil, among other chemical and physical factors that can affect beetles and other macroinvertebrates (Pardo-Locarno, 2009; Villani and Wright, 1990; Vitousek and Sanford, 1986).
- Since the obtained results could be related to the edaphic offer (amount and type of available organic matter and root diversity) and the consequence in the trophic levels (saprophagous, rhizophagous), it would be suitable to improve land use by changing extensive livestock which offers low organic matter and is environmentally costly, to diverse silvopastoral multilayer systems. These systems can have an effect which is "beneficial to the natural resources, agricultural production, economy and regional wellness", since they allow optimization of

Table 3. Melolonthidae studies and entomological data in different regions of Colombia.

Genus/specie	**Location and crop**	**Observations**	**Ref.**
Cucarro, *Euetheola bidentata* Burm.	Córdoba	Life cycle.	Caraballo y Salgado, 1987.
Cucarro, *Euetheola bidentata* Burm.	Urabá (Antioquia)	Biology and ecology.	Casas, 1990.
Multiple species of Melolonthidae	Villavicencio (Meta)	23 genus of Melolonthidae	López y Pardo-Locarno, 1997.
Cucarro, *Euetheola bidentata* Burm.	Caquetá	Most important plague in corn and sorghum roots in Caquetá	Sánchez y Vásquez, 1993.
Cucarro, *Euetheola bidentata* Burm.	Caquetá	Important plague. Biocontrol with *Hexamermis* sp., *Metarhizium anisopliae*	Sánchez y Vásquez, 1993.
Cucarro, *Euetheola bidentata* Burm.	Caquetá	Recorded on semestral crops and pastures, highlighted as most important plague.	Vásquez y Sánchez, 1994.
Diverse species of the genus *Cyclocephala, Dyscinetus, Ligyrus, Euetheola, Strategus, Stenocrates, Surutu, Phyllophaga, Plectris, Macrodactylus*	Villavicencio (Meta)	More than 25 genus, groups of highest economic impacto on pastures, rice and other crops.	Pardo-Locarno, 2000.
Euetheola bidentata and diverse species of the genus *Cyclocephala, Liogenys, Phyllophaga,* etc.	Caucasia (Antioquia) and Tierralta (Córdoba)	20 species (aprox.) of Melolonthidae plagues on lowland rice, corn and sorgum.	Pardo-Locarno, 2000.
More than a dozen of Melolonthidae plagues *Euetheola bidentata* and other Pentodontini from the genus *Ligyrus, Oxyligyrus*, etc.	Puerto Leguízamo (Putumayo)	Cucarro is the main specie but, a complex dominated by others Pentodontini is observed. These species affect corn, cassava and pasture crops .	Pardo-Locarno et al., 2003; Pardo-Locarno et al., 2007.

Source: Modified from Pardo-Locarno (2002).

solar energy, temperature and humidity use in order to produce at low cost and high quality (Nieto, 1995; Gaviria 1995, cited by Ramírez, 2010). In that sense, golden buttom [*Tithonia diversifolia* (Hemsl.) Gray, Asteraceae] is highlighted because it has been implemented for animal feeding due to, among others, its high nutritional balance (protein 18.9 to 28.8%; high digestibility), wildness (highly adaptable to acidic and low fertile soils), and other desirable agronomical traits (Calle and Murgueitio, 2008).

- Finally, from an integral point of view, since soil health goes further than a physical and chemical condition and includes biological aspects, the obtained results deserve an extension of this study to macroinvertebrates sampling in a higher geographical scale (taking the amazon part of Caqueta), with other land uses and weather conditions (rainy, transition and dry seasons), to precise in high detail the diagnosis in soil biology and in consequence direct the soil management plans (Stork and Eggleton, 1992).

Acknowledgments

This investigation was done in a framework between Universidad de Amazonas and CIPAV,
No 900189 de 2009. Thanks to Enrique Murgueitio from CIPAV, for his academic and administrative support; to Carlos Molina from CIPAV and to the student´s group in charge of the field phase (Ana Cristina Medina, Karina Cifuentes and Martha Arboleda); to the Professor Gamaliel Rodríguez and the secretary Magnolia Saldarriaga from the Universidad de la Amazonia, Florencia, thanks for your institucional support; and to Elena Gómez to support the lab phase and report.

References

Anderson, J. M. and Ingram, J. S. 1993. Tropical soil biology and fertility. A handbook of methods. (2ed.) Wallingford. Reino Unido. CAB International.

Amézquita, C. E. 1985. Aspectos de la colonización del Caquetá y la Amazonía en los últimos 15 años. Tesis MS. Universidad Surcolombiana, Neiva. 85 p.

Andrade, G. I. 1988. Amazonia colombiana, aproximación ecológica y social de la colonización del bosque tropical. Tercer Mundo Editores.Bogotá. 86 p.

Böving, A. G. 1942. A classification of larvae and adults of the genus *Phyllophaga* (Coleoptera: Scarabaeidae). Memoirs of the Entomological Society of Washington. No. 2. 96 p.

Bustillo, A. E. 1989. El uso de trampas de luz en el manejo de poblaciones de insectos. Actualidades ICA 35:1 - 8.

Calle, Z. and Murgueitio, E. 2008.Flora amiga del ganado. El botón de oro: arbusto de gran utilidad para sistemas ganaderos de tierra caliente y de montaña. Carta Fedegan 108:54 - 60.

Caraballo, U. and Salgado, M. 1987. Ciclo de vida y biología de *Euetheola bidentata* Burmeister. Tesis Ingeniero Agrónomo. Universidad de Córdoba. Montería. 32 p.

Casas, H. 1990. Aspectos preliminares de la biología y ecología del cucarro *Euetheola bidentata* en el Urabá antioqueño. En: Instituto Colombiano Agropecuario-(ICA). Seminario nacional de investigación y control del insecto cucarro *Euetheola bidentata*. Caquetá. p. 1 - 28.

CID (Centro de Investigaciones para el Desarrollo), Universidad Nacional de Colombia. 1987. Evaluación socioeconómica de la colonización del Caquetá y su impacto sobre el medio natural. Informe a Inderena. Bogotá. 14 p.

Cipagauta, M. y Pulido, J.1998. Producción de leche en tres pasturas del piedemonte amazónico del Caquetá, Colombia. Rev. Pasturas Tropicales 20(3):10 p.

Correa, P. 2010. Colombia ha perdido el 8,65% de su Amazonía. Primeras cifras de deforestación. El Espectador. 30 Abril de 2010. (Edición On Line revisada en abril 17-2011).

Cuatrecasas, J. 1958. Aspectos de la vegetación natural en Colombia. Rev. Academia Colombiana de Ciencias Exactas, Físicas y Naturales. 10 (40):221 - 264.

Domínguez, C. 1985. Amazonía colombiana. Biblioteca Banco Popular. Textos Universitários. 274 p.

Endrödi, S. 1985. The dynastinae of the world. Akadémiaikiadó. Budapest. 800 p.

Escobar, C and Liriatti, J. L. 1992. Características químicas de un Ultisol del piedemonte amazónico (Caquetá-Colombia). Rev. ICA 27(2):155 - 164.

Figueroa, P. A. 1977. Insectos y acarinos de Colombia. Facultad de Ciencias Agropecuarias Palmira. 685 p.

Frey, G. 1967. Die gattung*Plectris* (*Philochlaenia*) (Coleóptera: Melolonthinae)Beistimmungstabelle und Beschcreibungneuer Arten. Ent. Arbeiten Mus. Frey Band 18, 1967 316 p.

Frey, G. 1975. Bestimmunstabelle der sudamerikan ischenarten der gattung *Phyllophaga* Harris unihreruntergamrng *Phytalus* Er. (Col. Melolonthidae). Entomologische. Arbeiten. Mus. Frey. 26: 201 - 226.

Fujisaka, S. 1997. Metodología para caracterizar sistemas de uso de tierras: Acre, Rondonia y Pucalpa en la Amazonía. En: Lazcano, C.E. y Holmann, F. Conceptos y metodologías de la investigación en fincas con sistemas de producción animal de doble propósito. Centro Internacional de Agricultura Tropical (CIAT). Santiago de Cali, Colombia. p. 174-190.

González, D. 2000. La coca, la deforestación y la seguridad alimentaria en la Amazonía Colombiana 5 pp.(http://www.fao.org/NEWS/2000 /000 307-e.htm)

Holdridge, L. R. 1978. Ecología basada en zonas de vida. IICA. Serie de libros y materiales educativos. No. 34. 276 p.

ICA (Instituto Colombiano Agropecuario). 1972 - 1994. Boletín notas y noticias entomológicas. Programa de Entomología. I.C.A.

IGAC (Instituto Geográfico Agustín Codazzi). 1988. Suelos y bosques de Colombia. Subdirección agrológica. Bogotá, Colombia.

IGAC (Instituto Geográfico Agustín Codazzi). 1993. Aspectos ambientales para el ordenamiento territorial del Occidente del Departamento del Caquetá. Proyecto Investigaciones para la Amazonía – INPA: Estudios en la Amazonía Colombiana VI. 3 Tomos. Tercer Mundo Editores. Santafé de Bogotá, D.C.

IGAC (Instituto Geográfico Agustín Codazzi). 1995. Suelos de Colombia origen, evolución, clasificación, distribución y uso. Subdirección de Agrología. Bogotá. 632 p.

IGAC (Instituto Geográfico Agustín Codazzi). 2003. Atlas de Colombia. Quinta Edición. Imprenta Nacional. Bogotá. 342 p.

King, A. B. 1996. Biología, identificación y distribución de *Phyllophaga* spp. de importancia económica en América Central. En: Memorias seminario taller sobre la biología y control de *Phyllophaga* spp. Informe técnico No. 277. CATIE. Turrialba, Costa Rica. p: 50 - 61.

López, C. E. and Pardo-Locarno, L. C. 1997. Estudio de los escarabajos (Coleoptera:Scarabaeoidae) de Villavicencio, Meta. I. Avances en el estudio de Melolonthidae. Resúmenes. XXVI Congreso Socolen. Pereira. p: 72.

Martino, D. 2007. Deforestación en la Amazonía. Principales factores de presión y perspectivas. Revista del Sur 169 (1):3 - 20.

Morón, M. A. 1995. La diversidad de coleópteros Scarabaeoide o Lamellicornia en Colombia y su repercusión en el complejo plagas subterráneas. En: Memorias II Reunión Latinoamericana de Scarabaeidología. Bogotá. Pontificia Universidad Javeriana. p: 1 - 3.

Morón, M. A. and Vallejo, L. F. 2007. El género *Phyllophaga* Harris (Coleóptera: Melolonthidae) en Colombia. Nuevos avances para el conocimiento de su diversidad y distribución. En: Memorias Diplomado en Biología, Ecología y Taxonomía de Scarabaeoidea. En: Pardo-Locarno, L. C; Gallego, M. C. y Montoya, J. (eds.). Taller Editorial. Facultad de Ciencias. Universidad del Valle. Cali-Colombia. p: 69 - 91.

Murcia, U.;Castellanos, H.; Fonseca, D.;Ceontescu, N.; Rodríguez, J. and Huertas, C. 2009. Monitoreo de los bosques y otras coberturas de la Amazonía colombiana. Instituto Amazónico de Investigaciones Científicas –Sinchi. Bogotá. 242 p.

Nieto, O. A. 1995. Sistemas pecuarios sostenibles para montañas tropicales. Las reservas naturales de la Sociedad Civil. En: Sistemas pecuarios sostenibles para las montañas tropicales. CIPAV. Santiago de Cali. p. 41.

Pardo-Locarno, L. C. 1994. Escarabajos (Coleóptera: Melolonthidae) de importancia agrícola en Colombia. En: Memorias XXI Congreso Sociedad Colombiana de Entomología, Medellín, Colombia. p: 159 - 176.

Pardo-Locarno, L. C. 2000. Avances en el estudio de chisas rizófagas (Coleóptera: Melolonthidae) en Colombia. Observaciones sobre los complejos regionales y nuevos patrones morfológicos de larvas. En: Memorias del XXVII Congreso Sociedad Colombiana de Entomología-Socolen. Medellín. Colombia. p: 285 - 306.

Pardo-Locarno, L. C. 2002. Aspectos sistemáticos y bioecológicos del complejo chisa (Col, Melolonthidae) de Caldono, Norte del Cauca, Colombia. Tesis Maestria. Universidad del Valle. 139 p.

Pardo-Locarno, L. C.; Morón, M. A.; Gaigl, A.; and Bellotti, A. C. 2003. Los complejos regionales de Melolonthidae (Coleoptera) rizófagos en Colombia. En: Estudios sobre coleópteros del suelo en América. Aragón, G. A.; M. A. Morón & A. Marín J. (Eds.). Publicación especial de la Benemérita Universidad Autónoma de Puebla, México. Pp. 45-63.

Pardo-Locarno, L. C.; Velez, C; Sevilla, F.;and Madrid, O. 2006. Abundancia y biomasa de macroinvertebrados edáficos en la temporada lluviosa, en tres usos de la tierra en los Andes Colombianos. Acta Agronómica 55(1):43 - 54.

Pardo-Locarno, L. C; Morón, M. A; Montoya, J.; Yepes, F; Pérez, C. R. and Galeano, P. 2007. Escarabajos (Coleoptera: Melolonthidae) de importancia agrícola en Colombia: aproximación a los complejos regionales fisiográficos. En: Pardo-Locarno, L.C; Gallego, M. C. y Montoya, J. (eds.). Memorias Diplomado en Biología, Ecología y Taxonomía de Scarabaeoidea. Taller Editorial. Facultad de Ciencias. Universidad del Valle. Cali-Colombia. Pp: 10-33.

Pardo-Locarno, L. C. 2009. Macroinvertebradosedafícolas en agroecosistemas del municipio de El Cerrito (Valle), con énfasis en la comunidad de escarabajos Melolonthidae (Coleoptera: Scarabaeoidea). Tesis Doctorado en Ciencias Biología. Facultad de Ciencias Naturales y Exactas. Universidad del Valle. 195 pp.

Pardo-Locarno, L.C; Stechauner-Rohringer, R. and Morón, M.A. 2009. Descripción de larva y pupa, ciclo de vida y distribución del escarabajo rinoceronte *Podischnusagenor* Olivier (Coleoptera: Melolonthidae) en Colombia, con una clave para larvas de tercer estadio de *Dynastinae neotropicales*. Kempffiana 5(2):20-42.

Posada, L. 1989. Lista de insectos dañinos y otras plagas en Colombia. Bogotá. Instituto Colombiano Agropecuario (ICA). Bol. Téc. 43. p. 662.

Ramírez, B. L. 2010. Caracterización del sistema ganadero de doble propósito en la Amazonía intervenida del departamento del Caquetá, en el marco del desarrollo sostenible. Proyecto Universidad de la Amazonia. 13 p.Disponible en:http://www.rimisp.org/FCKeditor/UserFiles/File/documentos/docs/pdf/propuesta3_colombia.pdf (consultado en Abril-2011)

Ratcliffe, B. C. 2003. The dynastinae scarab beetles of Costa Rica and Panamá (Coleoptera:Scarabaeidae: Dynastinae). Bull. University of Nebraska State Museum 16:1 - 506.

Restrepo, G., H. 1998. Aproximación al conocimiento de los escarabajos fitófagos (Coleóptera: Melolonthidae) en Colombia. Tesis de Grado. Universidad Nacional de Colombia. Bogotá. 144 p.

Restrepo, G., H.; y López-Ávila,A. 2000. Especies de chisas (Coleoptera: Melolonthidae) de importancia agrícola en Colombia. Corporación Colombiana de Investigación Agropecuaria (Corpoica). 62 p.

Restrepo, H.; Morón, M. A.; Vallejo, F.; Pardo-Locarno, L. C.; and López-Ávila, A. 2003. Catálogo de Coleoptera Melolonthidae (Scarabaeidae Pleurosticti) de Colombia. Folia Entomol. Mex. 42(2):239 - 263.

Ritcher, P. O. 1966. White grubs and their allies. Oregon State University Press, Corvallis. 219 pp.

Sánchez, G. G.;y Vásquez, N. C. 1993. El cucarro *Euetheolabidentata*Burm. (Col: Scarabeidae) plaga de la raíz de maíz y sorgo. En: Memorias del seminario in-

ternacional sobre los cultivos de sorgo y maíz, sus principales plagas y enfermedades. C. I. Tibaitatá-ICA. p: 25-30.

Sevilla, F. 2002. Distribución y abundancia de la macrofauna asociada con unidades locales de clasificación de suelos en la microcuenca Potrerillo, Cauca, Colombia. Tesis de Pregrado Ingeniería Agronómica. Universidad Nacional de Colombia – Centro Internacional de Agricultura Tropical (CIAT). 129 p.

Sevilla, F.; Oberthür, T.; Usma, H.; Escobar, G.; Pardo-Locarno, L. C.; and Narváez, G. C. 2002. Exploración de la presencia y abundancia de la coleopterofauna edáfica en diferentes usos de la tierra en una microcuenca del Departamento del Cauca. En: XXXVII Congreso Nacional de Ciencias Biológicas. Ponencias. San Juan de Pasto. Universidad de Nariño. p: 274.

Stechauner-Rohringer, R.; and Pardo-Locarno, L. C. 2010. Descripción de larva y pupa, ciclo de vida y distribución del escarabajo rinoceronte *Cyclocephala lunulata* (Coleoptera:Melolonthidae) en Colombia, con una clave para larvas de tercer estadio de Dynastinaeneotropicales. Boletín Científico Museo de Historia Natural 14 (1):203 - 220.

Stehr, F. W. 1987. ImmatureInsects. Kendall/Hunt Publishing Company. USA. 754 p.

Stehr, F. W. 1991. Immature Insects.Volume 2. Kendall/Hunt Publishing Company. USA. 974 p.

Smith, J.; Sabogal, C; De Jong, W.;and Kaimowitz, D. 1997. Bosques secundarios como recurso para el desarrollo rural y la conservación ambiental en los trópicos de América Latina. CIFOR. Occasional Paper no. 13:1-31.

Stork, N. E. and Eggleton, P. 1992. Invertebrates as determinants and indicator of soil quality. Am. J. Altern. Agric. 7:38 - 55.

Swift, M.;and Bignell, D. 2001. Standard methods for assessment of soil biodiversity and land use practice. En: International Center for Research in Agroforestry. Lecture Note 6b. Bagor, Indonesia. 34 p.

Vallejo, F.; Morón, M. A.; and Orduz, S. 1998. First report and description of immature stages of *Phyllophagaobsoleta* (Blanchard) (Coleoptera: Melolonthidae) in Colombia. ColeopteristBull. 52(2):108 - 117.

Vallejo, L.; and Morón, M. A.2007. El género *Phyllophaga* Harris (Coleoptera:Melolonthidae) en Colombia. Nuevos avances para el conocimiento de su diversidad y distribución. En: Pardo-Locarno, L.C; Gallego, M. C. y Montoya, J. (eds.). Memorias Diplomado en Biología, Ecología y Taxonomía de Scarabaeoidea.. Taller Editorial. Facultad de Ciencias. Universidad del Valle. Cali-Colombia. p: 68 - 90.

Vásquez, N.; and Sánchez, G. 1994. El cucarro, la plaga más Importante en el Caquetá. ICA – SENA. Creced Caquetá. Bol. Div. no. 89. 12 p.

Villani, M. G.; and Wright, R. J. 1990.Enviromental influences on soil macro arthropods behavior in agricultural systems. Ann. Rev. Entom. 35:249 - 269.

Vitousek, P. M. and Sanford, R. L. 1986.Nutrient cycling in moist tropical forest.Ann. Rev. Ecol. Syst. 17:137-167.