Caribbean Journal of Science, Vol. 42, No. 3, 311-314, 2006

Comparisons of Earthworm Community Structure between an Active Pasture and an Adjacent Tropical Wet Forest in Puerto Rico

XIAOMING ZOU[1,2,*], BÁRBARA ARANDES-PÉREZ[3], DAVID CAPÓ-RAMOS[3], JESSICA GUTIÉRREZ-SANTIAGO[3], AND MIRLA ROSARIO-SANTIAGO[3]

[1]*Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, 88 Xuefu Road, Kunming, Yunnan 650223, China*
[2]*Institute for Tropical Ecosystem Studies, University of Puerto Rico at Río Piedras, PO Box 21910 San Juan, PR 00931, USA*
[3]*Department of Biology, University of Puerto Rico at Río Piedras, San Juan, PR 00931, USA.*
**Corresponding author: xzou2000@yahoo.com*

ABSTRACT.—Earthworm populations have been recognized as indicators of soil fertility and health. To examine the influence of tropical land-use changes on earthworm community structure, we sampled earthworm populations in three plots in two adjacent sites: a tropical pasture and a forest both developed on an alluvial soil. We found that (1) the density of endogeic worm dominated by *Pontoscolex corethrurus* was greater in the pasture than in forest; and (2) there were no anecic worms present in the pasture. Our results support the findings from other studies that converting tropical wet forests to pasture may lead to the extinction or populations reduction of anecic earthworms in tropical soils.

KEYWORDS.—earthworms; pasture; tropical wet forest; tropical soil; Puerto Rico.

INTRODUCTION

An astonishing diversity of organisms spends all or part of their lives in soils. One group of these soil dwellers is the earthworms. Earthworm populations have been recognized as bio-indicators of soil fertility and health, because earthworm improves soil properties by playing an active role in the decomposition of organic materials, nutrient cycling, soil formation, and the improvement of soil structure by channeling and bioturbation (Fragoso and Lavelle 1992; Liu and Zou 2002).

It is known that earthworms contribute to a large portion of soil fauna biomass in the wet tropics (Lavelle 1988). Earthworms use a wide variety of organic materials as food sources. These materials include leaf litter, living and dead roots, microbial biomass, and animal wastes (Lavelle 1988; Cortez and Bouche 1992). However, earthworms have alimentary preferences, selectively consuming organic materials that differ in quality or chemical composition (González and Zou 1999). These differences in food preferences may affect the community structure of earthworms in sites altered by land-use changes (Zou and González 1997). In this sense, Skole and Tucker (1993) have demonstrated that food resources for earthworms differ considerably after tropical land-use changes at global scales. In a recent study Zou and González (1997) showed that earthworm abundance is higher in an active pasture than in a forest on a tropical Oxisol and that anecic earthworms occur only in mature forests. Sánchez et al. (2003) also found higher earthworm abundance in active pastures dominated by Ultisols than in forests, but *Amynthas gracilis*, an anecic, was also present in low density in pasture soils; suggesting that earthworm responses to tropical land-use changes may vary with soil types. Thus, we designed this study to examine the influence of tropical land-use changes on the community structure of earthworms on an alluvial Inceptisol by comparing the abundance and species composition of worms in two adjacent sites: a

ms. received December 20, 2005; accepted May 11, 2006.

tropical wet forest and a pasture located in Sabana, Puerto Rico.

Materials and Methods

The research sites were located at Sabana (18º18′N, 65º50′W) in the northeastern Luquillo Mountains of Puerto Rico. Soil in both study sites is an Inceptisol, developed from alluvial deposits from the Sabana River (Soil Survey Staff 1995; Zou and González 1997). Elevation is about 420 m above sea level, and the mean monthly temperatures vary from 22 to 26ºC. Annual precipitation is approximately 3500 mm (Scatena 1989). Two adjacent ecosystems were chosen: a pasture and a primary native wet forest. Native forest is described as a primary subtropical wet forest (Ewel and Whitmore 1973) dominated by tabonuco trees *Dacryodes excelsa*. The forest has never been cleared and large, old trees were present in air photos taken since 1936. The pasture was converted from tabonuco forest prior to 1936, and was dominated by grasses *Panicum laxum*, *Ipomoea setifera*, and *Hyptis lantanifolia* (Liu and Zou 2002).

We randomly established three plots of 25 cm × 25 cm for each site in March 2002. In each plot we collected all plant materials from the O horizon, and then sampled a soil monolith of 25 cm × 25 cm and up to 30 cm of depth. The earthworms were collected with the hand sorting method and classified as epigeic, anecic, and endogeic (Bouché 1977). Species identification was made in laboratory (González et al. 1999). Plant materials were oven dried at 65ºC until constant weights were reached. Differences in earthworm abundance were tested using one-way analysis of variance with site as the independent variable and a significance level at 0.10 due to the small sampling size.

Results

Total worm density was higher in the pasture than in the forest (Table 1). Endogeic worms were present in both sites, dominated by *Pontoscolex corethrurus*. The abundance of endogeic earthworms in the pasture was more than twice that in the forest (Table 1). The anecic earthworm, *Amynthas rodericensis*, was present only in the forest and had an average density of 16 ± 1.73 individuals per m^2, accounting for 8% of the total earthworm individuals (Fig. 1). Plant materials from the O horizon were over twenty times greater in the forest than in the active pasture (Table 1).

Discussion

Soil communities, the living component on the ground, are complex and very variable among ecosystems. Each grassland, forest, or pasture has an idiosyncratic soil food web with a particular proportion of earthworms, bacteria, fungi, and other groups of organisms, and a particular level or complexity within each group (Coleman and Crossley 1995). These differences might result from variation in climate, soil and vegetation factors, land-use history, and disturbances, as in the case of converting forests to pastures. Yet, some of the organisms of the food web (such as earthworms) may not be uniformly distributed through the soil. Each species and group exists where they might find appropriate shelter, carbon, nutrients, and/or moisture. Tropical land-use changes can alter many of these factors which in turn can affect the

TABLE 1. Mean (±standard deviation) earthworm density and soil surface plant litter in a tropical pasture adjacent to a wet forest on an alluvial Inceptisol in Puerto Rico

Site	Endogeic worms density (Ind./m^2)	Anecic worms density (Ind./m^2)	Total worms density (Ind./m^2)	Plant litter (g/m^2)
Pasture	480 ± 15.6 a	0 b	480 ± 15.6 a	14 ± 2 b
Forest	192 ± 11.1 b	16 ± 1.732 a	208 ± 11.53 b	335 ± 12 a

Ind. = individuals.
Different letter indicates significant difference between sites.

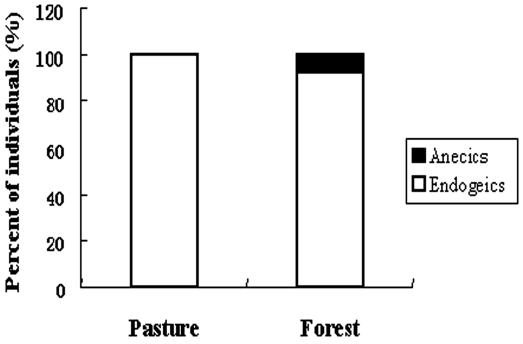

FIG. 1. Earthworm community structure in an active pasture and its adjacent tropical wet forest on an alluvial Inceptisol in Puerto Rico.

abundance and community structure of earthworms.

Converting tropical forests to pastures often result in the reduction of aboveground plant litter inputs, causing the disappearance of soil surface litter layer (Zou and González 1997; Paoletti 1999). Anecic earthworms can negatively be affected by the disappearance of soil surface litter that provides them with both shelter and food. Furthermore, the constant trampling of soil by horses and cows in active pastures may disrupt the life cycle (growth and reproduction) of earthworms that live in surface mineral soils and the litter layers. In our study, the decreased soil surface litter and cattle trampling were likely to cause the disappearance of anecic earthworms in the active pasture (declined from alluvial soils), resulting in the dominance of the endogeic species *Pontoscolex corethrurus*. *P. corethrurus* can borrow deep into mineral soil layers and regenerate rapidly even in nutrient poor soils (Lavelle et al. 1999). In short-term (less than one year) field experiments of manipulating plant litter input, both González and Zou (1999) and Sánchez and Zou (2004) found that reduction in plant litter input led to the decrease in the biomass of anecic earthworms.

Deforestation and the establishment of exotic grasses have been shown to lead to a dramatic fall in the diversity of earthworm communities in soils of Oxisols and Ultisols (Zou and González 1997; Sánchez et al. 2003). A greater quantity of the soil macrofauna of the original forest disappears and is replaced by a large population of *P. corethrurus* earthworms once forests are connected to pastures, partially due to the elimination of the soil surface litter (Lavelle and Chauvel 1999). The greater litter accumulation on the ground of forests can lead to a higher biodiversity of macrofauna likely due to the availability of territory space, food, and shelter protection from predation by other animals (Ruan et al. 2005).

One limitation of this study was the small sampling size without replications in other sites. Patterns revealed in this study that converting forests to pastures led to the disappearance of anecic earthworms need to be tested in other locations in different islands and continents across a wide range of soil types. Long-term experiments (greater than one year) for demonstrating earthworm responses to manipulated plant litter input are also needed to test if there is a causal relationship between the disappearance of anecic earthworms and soil surface plant litter.

Acknowledgments.—We thank the Department of Biology, University of Puerto Rico at Rio Piedras, for providing logistic support for us to work in the field and laboratories.

LITERATURE CITED

Abbott, I., and C. A. Parker. 1981. Interactions between earthworms and their soil environment. *Soil Biol. Biochem.* 13:191-197.

Bouché, M. B. 1977. Strategies lombriciens. *Ecol. Bull.* 25:122-132.

Coleman, C. D., and D. A. Crossley Jr. 1995. *Fundamentals of soil Ecology*. New York: Academic Press.

Cortez, J., and M. B. Bouché. 1992. Short communication: Do earthworms eat living roots? *Soil Biol. Biochem.* 24(9):913-915.

Fragoso, C. and P. Lavelle. 1992. Earthworm communities of tropical rain forests. *Soil Biol. Biochem.* 24(12):1397-1408.

González G., and X. Zou. 1999. Plant litter influences on earthworm abundance and community structure in a tropical wet forest. *Biotropica* 31(3):486-493.

González, G., X. Zou, A. Sabat, and N. Fetcher. 1999. Earthworm abundance and distribution pattern in contrasting plant communities within a tropical wet forest in Puerto Rico. *Caribb. J. Sci.* 35:93-100.

Lavelle, P. 1988. Earthworm activities and the soil systems. *Biol. Fertil. Soils* 6:237-251.

Lavelle, P., L. Brussard, and P. Hendreix. 1999. *Earthworm Management in Tropical Agroecosystems*. New York: CABI Publishing.

Lavelle, P., and A. Chauvel. 1999. Pasture damage by an Amazonian earthworm. *Nature* 398:32-33.

Liu, Z. G., and X. M. Zou. 2002. Exotic earthworms accelerate plant litter decomposition in a Puerto Rican pasture and wet forest. *Ecol. Appl.* 12:1406-1417.

Paoletti, M. G. 1999. The role of earthworms for assessment sustainability and as bioindicators. *Agriculture, Ecosystems and Environment* 74:137-155.

Ruan, H. H., Y. Q. Li, and X. M. Zou. 2005. Soil communities and plant litter decomposition as influenced by forest debris: Variation across tropical riparian and upland sites. *Pedobiologia* 49:529-538.

Sánchez, Y., X. M. Zou, S. Borges, and H. H. Ruan. 2003. Recovery of native earthworms in abandoned tropical pastures. *Conserv. Biol.* 17:999-1006.

Sánchez, Y., and X. M. Zou. 2004. Plant influences on native and exotic earthworms during secondary succession in old tropical pastures. *Pedobiologia* 48: 215-226.

Scatena, F. N. 1989. *An introduction to the physiograhy and history of the Bisley Experimental Watersheds in the Luquillo Mountains of Puerto Rico*. New Orleans, LA: USDA Forest Service General Technical Report, SO-72.

Skole, D., and C. Tucker. 1993. Tropical deforestation and habitat fragmentation in the amazon: satellite data from 1978 to 1983. *Science* 260:1905-1910.

Zou, X. M., and G. González. 1997. Changes in earthworm density and community structure during secondary succession in abandoned tropical pastures. *Soil Biol. Biochem.* 29:627-629.