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# Earthworms in central Amazonian primary and secondary forests and a polyculture forestry plantation

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## ABSTRACT

Species composition, abundance and biomass of these earthworms were determined in a polyculture forestry plantation (POA/C) and in plots of nearby secondary (SEC) and primary (FLO) forests in Amazonia. The earthworms were collected using the formol extraction method. In five collections between July 1997 and June 1998, only seven species were found (mainly Glossoscolecidae). One peregrine species (*Pontoscolex corethrurus*) was found in the polyculture plot and another (*Dichogaster bolau*i, Octochaetidae) nearby. The abundance of earthworms in the three plots is low for tropical rain forest sites ( $< 1 - 5.5 \text{ ind m}^{-2}$  compared to  $1 - 189 \text{ ind m}^{-2}$ ) but biomass (up to 20 g fresh weight per square meter) is among the highest numbers ever found in rain forests.

## RESUMO

Composição de espécies, abundância e biomassa de minhocas foram determinadas num policultivo (POA/C) e em áreas adjacentes de floresta secundária (SEC) e primária (FLO) na Amazônia. As minhocas foram coletadas usando o método de extração com formol. Em cinco coletas entre julho de 1997 e junho de 1998, apenas sete espécies foram encontradas (sobretudo Glossoscolecidae). Uma espécie peregrina (*Pontoscolex corethrurus*) foi encontrada numa área de policultivo e uma outra (*Dichogaster bolau*i, Octochaetidae) na vizinhança. A abundância de minhocas nas tres áreas é baixa ( $< 1 - 5,5 \text{ ind m}^{-2}$  em comparação com  $1 - 189 \text{ ind m}^{-2}$ ), mas a biomassa (até 20 g peso fresco por metro quadrado) está entre as maiores encontradas em florestas tropicais.

## ZUSAMMENFASSUNG

Artenzusammensetzung, Abundanz und Biomasse von Regenwürmern wurden auf drei Versuchsflächen (einer Polykulturplantage (POA/C) und zwei nahebei gelegenen Sekundär- (SEC) bzw. Primär- (FLO) Waldflächen im Amazonasgebiet) untersucht. Die Regenwürmer wurden mit der Formol-Extraktionsmethode gesammelt. In fünf Aufsammlungen zwischen Juli 1997 und Juni 1998 wurden nur sieben Arten gefunden (primär Glossoscolecidae). Eine peregrine Spezies (*Pontoscolex corethrurus*) wurde in der Polykultur und eine weitere (*Dichogaster bolau*i, Octochaetidae) nahebei gefunden. Die Abundanz der Regenwürmer auf den drei Flächen für tropische Regenwälder sind niedrig ( $< 1 - 5,5 \text{ ind m}^{-2}$  im Vergleich zu  $1 - 189 \text{ ind m}^{-2}$ ), aber die Biomassen (bis 20 g Frischgewicht pro Quadratmeter) liegen im Vergleich zu anderen Regenwaldstandorten sehr hoch.

## INTRODUCTION

Earthworms are known to be the most important group of soil animals in temperate regions of the world but their contribution to ecosystematic soil functions, especially litter decomposition, in the humid tropics remains largely unexplored. Therefore, the species composition, abundance and biomass of these organisms have been determined in a polyculture forestry plantation and in plots of nearby secondary and primary forest as part of the SHIFT ("Studies on Human Impact on Floodplains and Forests in the Tropics") project since 1997. The aim of the project is to study the regeneration and better use of already degraded areas, to diminish the human impact on primary rain forest in Amazonia (Beck et al. 1998a, b). The basic hypothesis of all investigations within this project is that soil fauna (e.g. earthworms) and microorganisms are extremely important for the maintenance of „healthy“ (functional) nutrient cycles (Fragoso and Lavelle 1995).

## MATERIAL AND METHODS

The study area belongs to the agroforestry research station EMBRAPA - CPAA (altitude 44 m), which is located close to the city of Manaus, Amazonas, Brazil. The investigations took place on an abandoned plantation of rubber trees (Seringueira) which were used (since 1992) as a polyculture forestry research area. The plantation is divided in 90 experimental plots of 32 \* 48 m each. Two of these plots (called POA and POC (= POA/C)) were sampled together with two sites in a secondary (SEC) and primary (FLO) forest within a distance of less than 200 m. In 1997, the mean annual air temperature was 27.9 °C (maximum 56 °C in POA) and soil temperatures usually range between 21.5 and 23.8 °C. The annual precipitation was 2585 mm. The soil is an acid clay (Ferrasol) according to the FAO classification. Its properties are practically the same at all plots (Table 1), but the vegetation cover differs greatly since POA/POC has broad open spaces.

In contrast to recommendations in the literature (Anderson and Ingram 1993), hand-sorting was not successful to collect the earthworms for three reasons: The individual size (approx. 2 cm to 110 cm in length) and the behaviour of the various species differ greatly, and the worms are very inhomogenously distributed. A pre-study confirmed that formol-extraction in areas of 4 m<sup>2</sup> is an easy method to sample earthworms qualitatively and quantitatively. Therefore, two replicates of 4 m<sup>2</sup> each were taken per study site every three months. Unfortunately, the use of mustard, used successfully in Europe as a less toxic alternative to formol, was not efficient. The biomass was determined by weighing the preserved animals including gut content (fresh weight, FW).

**Table 1:** Short characterisation of the soil properties of the three study plots \*

Parameter	FLO	SEC	POA/POC
	Primary forest	Secondary forest	Polyculture
Vegetation	diverse	Secondary vegetation	Secondary vegetation
Soil Type	Sandy clay (60 % clay, 25 % sand, 15 % silt)		
pH (H <sub>2</sub> O)	4.2 - 4.8	4.7 - 5.0	4.2 - 6.0
Org. content	?	2.4 - 5.3	2.4 - 6.8

\* see also Foerster et al., this volume, p. 484

## RESULTS AND DISCUSSION

After five sampling dates in the period from July 1997 to June 1998, the following preliminary results can be presented (Table 2). Considering the differences like vegetation cover and anthropogenic influence in the three plots, the number of species is relatively low (approx. 7). All of them belong to the mainly neotropical family Glossoscolecidae. Besides some species widely distributed in Amazonia (*A. amazonius*, *U. brasiliensis*) at least two of them seem to be endemic to the Manaus region (*R. contornus*, *R. priolli*). The most conspicuous since biggest species (up to 110 cm long) belong to the genus *Rhinodrilus*. The peregrine species (i.e. circumtropical) *Pontoscolex corethrurus* was found on the plantation plot. A second, small peregrine species, *Dichogaster bolau* (Octochaetidae), which is often found at anthropogenic influenced sites in Brazil, occurred in another plantation plot nearby.

The abundance of earthworms in the three plots is low in comparison to many other tropical lowland rain forest sites (Table 3). On the other hand, since most of the species living on the three investigation plots are very large, the amount of biomass is among the highest numbers ever found in rain forests (up to 20 g FW per square meter). The literature values shown in Table 3 are based on nine studies on primary forests (Römbke and Verhaagh 1992) and just two studies on plantations and secondary forests (Gilot et al. 1995; Gonzales et al. 1996). Most of these studies conducted so far used only very few sampling dates.

The number of earthworms in the three plots seems to be more or less the same, showing a maximum in the rainy season. However, due to the absolute very low number, these data are highly variable. The earthworm biomass is nearly always higher in the primary forest than in the two other plots. In addition it seems that the POA/C has often the lowest amount of biomass. In contrast to other oligochaetes (especially Enchytraeidae; Römbke and Meller 1998), no clear correlation between abundance or biomass and abiotic factors (e.g. the season) has been observed.

**Table 2:** List of earthworm species (all belonging to the family Glossoscolecidae) found at the three EMBRAPA plots

Genus	Species	Author
<i>Andiorrhinus</i> sp.	not yet identified	
<i>Andiorrhinus</i>	<i>amazonicus</i>	Michaelsen, 1918
<i>Pontoscolex</i>	<i>corethrurus</i>	(Müller, 1857)
<i>Rhinodrilus</i>	<i>prov. contortus</i>	Cernosvitov, 1938
<i>Rhinodrilus</i>	<i>prov. priolli</i>	Righi, 1967
<i>Urobenus</i> ( <i>Rhinodrilus</i> )	<i>brasiliensis</i>	(Benham, 1887)
<i>Tuiba</i>	<i>dianae</i>	Righi et al. 1976

**Table 3:** Abundance [ind/m<sup>2</sup>] and biomass [g FW/m<sup>2</sup>] of earthworms in the three study plots (due to the low number of sampling dates ranges instead of mean values are given) and data from the literature

Parameter	FLO	SEC	POA/C
<b>Abundance</b>			
This study	0.5 – 4.1	0.6 – 3.2	0.5 – 5.5
Literature	1 - 132	171 - 189	91 - 150
<b>Biomass</b>			
This study	8.0 - 20.3	1.1 – 5.6	0.2 - 10.8
Literature	0.1 - 42.8	52 - 61	29 – 59

Due to the limited amount of data obtained so far, the reasons for the observed distribution pattern in time and space are not yet clear. However, the high biomass of earthworms, which might be higher than that of all other soil invertebrates together, indicates that they play a key role in ecological soil functions in these sites. Similar conclusions were already drawn by Fragoso and Lavelle (1995) who emphasised their important (direct or indirect) influence on the decomposition process. In mid-1999, the results of the earthworm sampling will be compared with data on various soil fauna groups and micro-organisms. Finally, these data will be used to model the specific contribution of these organisms to the decomposition of the organic matter, and on the importance of these processes for the nutrient supply to the plants.

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