Earthworms from Mato Grosso, Brazil, and new records of species from the state

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Abstract – The objective of this work was to undertake a qualitative assessment of earthworm diversity in areas under human influence, in a region of Cerrado–Pantanal–Amazon rainforest transition, in the state of Mato Grosso, Brazil. The earthworms were collected in the municipalities of Barra do Bugres and Arenápolis, and were studied together with species previously identified from other municipalities. Seventeen municipalities, at 29 sampling points of Mato Grosso State, have been sampled. Seven species of earthworms were collected and identified in Barra do Bugres: Goiascolex vanzolinii, Pontoscolex (Pontoscolex) corethrurus, Opisthodrillus borellii borellii, Opisthodrillus sp., Dichogaster (Diplothecodrilus) gracilis, Dichogaster sp. and a species of the Criodrilidae family. Four species of earthworms were identified in Arenápolis: Pontoscolex (Pontoscolex) corethrurus, Dichogaster (Diplothecodrilus) gracilis, Dichogaster (Diplothecodrilus) affinis and Dichogaster sp. In total, 32 earthworm species/subspecies are known from Mato Grosso, 22 native and 10 exotic.

Index terms: biodiversity, tropical forest, Oligochaeta.

Introduction

Earthworms are present in almost all terrestrial ecosystems, and are one of the most important components of the soil invertebrate macrofauna. Approximately 8,300 species of oligochaetes have been described (of which more than 5,700 are valid species), in 38 families and 811 genera (Reynolds & Wetzel, 2009). Roughly 50% of these (around 4,000) are megadrile earthworms (Reynolds, 1994), although many more species are still expected to be found (Fragoso et al., 2003). For instance, James & Brown (2006) estimated that more than 3,000 species may occur in the Neotropics, although only 960 are presently known (Fragoso & Brown, 2007). Currently, 305 species/subspecies of earthworms (megadrili), in 65 genera, are known from Brazil (Brown & James, 2007); of these, 259 are native (85%) and 46 exotic (15%).

However, extensive areas in Brazil are still unexplored and have never been sampled for earthworms (James & Brown, 2006). If estimates for earthworm biodiversity are correct, the majority of species in the country are yet to be found and described (Brown & James, 2007). Consequently, new locations should be sampled, which represents a great challenge, since there are few Brazilian researchers working in this area.
Mato Grosso is a state with few samplings and great potential for earthworm diversity. The state has an area of 903,386 km² and a tropical climate. The center of the state features plateaus, the west plains and swamps, and the north depressions and residual plateaus. The vegetation in Mato Grosso is characterized by three major Brazilian biomes: the Cerrado (Brazilian savannah) in the Eastern half, the Amazon in the Northwest, and the Pantanal (marsh) in the West. The state’s major economic activities are agriculture and extractive industry (forestry, mining and rubber) (Abutakka & Lima, 2006).

The aim of this study was to undertake a qualitative assessment of earthworm diversity in an area under human influence, in a region of Cerrado‑Pantanal‑Amazon rainforest transition, and to synthesize the information on earthworm diversity (collection sites, species present) in the state of Mato Grosso, Brazil.

Materials and Methods

Sampling sites were located in the surroundings of Gilmar Mourão Farm, in the municipality of Arenápolis (14°39'09.5"S, 56°51'23.0"W), and in Jauquara Farm, located in the municipality of Barra do Bugres (57°10'50"S, 15°06'36"W), Mato Grosso state, Brazil. Both cities are in a region of transition between Cerrado, Pantanal and Amazon rainforest biomes, characterized by a high degree of human influence, due to agricultural activities in the area. The site sampled in Jauquara Farm, Barra do Bugres, consisted of a pasture with predominance of Brachiaria humidicula interspersed with islands of native vegetation locally known as “Cucurutis.” The soil is classified as Gleissolo Háplico (Typic Haplaquox) in the Brazilian soil classification system (Sistema brasileiro de classificação de solos, 1999; Mapa de solos do Brasil, 2001) with sandy texture. Between December and mid-May, the soil is saturated, due to a shallow water table.

In Gilmar Mourão Farm, Arenápolis, samples were taken in the surroundings of the main farm house, which featured bushy vegetation, few large trees and stacks of fence points within a pasture of Brachiaria brizantha. In open areas, used for cattle grazing and cropping, which had recently been prepared for planting through plowing, harrowing and liming, no earthworms were found. The soil is classified as Latossolo Vermelho-Amarelo (Typic Hapludox) (Sistema brasileiro de classificação de solos, 1999) with sandy texture.

For qualitative purposes, i.e. to verify earthworm species diversity at each site, the digging method described by Righi (1990) was used in December 2007, in Jauquara Farm, and in January 2008, in Gilmar Mourão Farm, during the rainy season. Samples were taken from holes dug to 30–40 cm depth, and the earthworms were carefully removed by hand and sorted. Later, the specimens found were preserved in 4% formaldehyde solution, and after three months, they were transferred into 70% alcohol solution.

For identification purposes, keys and descriptions of families, genera and species according to Righi (1990) and Blakemore (2002), were used. The specimens collected were deposited in the Fritz Müller Oligochaete Collection (Curitiba, Paraná) of Embrapa Florestas.

Earthworm distribution data for the municipalities of Mato Grosso were obtained from the literature describing previous collections, undertaken mainly by Dr. Gilberto Righi. Other data were taken from the list of specimens deposited in the Fritz Müller Oligochaete Collection and the Gilberto Righi Collection at the Museu de Zoologia, Universidade de São Paulo.

The collecting was performed in five types of vegetation: Amazon rainforest, Cerrado/Forest transition, Cerrado, Cerrado grassland and Cerrado of Pantanal (Figure 1, Table 1), according to Manual técnico da vegetação brasileira (1992).

Results and Discussion

In Jauquara Farm, Barra do Bugres, seven earthworm species were identified, of which four belonged to the Glossoscolecidae family: Goiascolex vanzolinii Righi, 1984, Pontoscolex (Pontoscolex) corethrurus (Müller, 1857), Opisthodrillus borellii borellii Rosa, 1895 and Opisthodrillus sp. Two of the remainder collected were deposited in the Fritz Müller Oligochaete Collection (Curitiba, Paraná) of Embrapa Florestas. For identification purposes, keys and descriptions of families, genera and species according to Righi (1990) and Blakemore (2002), were used. The specimens collected were deposited in the Fritz Müller Oligochaete Collection and the Gilberto Righi Collection at the Museu de Zoologia, Universidade de São Paulo.

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The collecting was performed in five types of vegetation: Amazon rainforest, Cerrado/Forest transition, Cerrado, Cerrado grassland and Cerrado of Pantanal (Figure 1, Table 1), according to Manual técnico da vegetação brasileira (1992).
Figure 1. Map of Mato Grosso state, highlighting: •, locations where earthworms have been collected and ■, new first collections in this study (Barra do Bugres and Arenápolis). F, Forest; S, Cerrado; SN, Cerrado/Forest Transition; Sa, Cerrado Grassland; Sp, Cerrado of Pantanal. Other vegetation types in the map are: A, Open Ombrophyllous Forest; As, Submountain Open Ombrophyllous Forest; Ds, Submountain Dense Ombrophyllous Forest; D, Dense Ombrophyllous Forest; F, Semidecidual Seasonal Forest; Fa, Semidecidual Seasonal Forest; Fs, Submountain Semidecidual Seasonal Forest; C, Deciduous Seasonal Forest; Sd, Forested Savanna; Sa, Wooded Savanna; Sg, Grassy-cwoody Savanna; SO, Contact Savanna/Ombrophyllous Forest; SN, Contact Savanna/Seasonal Forest; ON, Ombrophyllous Forest/Seasonal Forest; ON, Contact; ST, Contact Savanna/Savanna Steppe; TN, Savanna Steppe/Seasonal Forest; PA, Vegetation with Fluvial Influence and/or Lacustrine; rm, Mountain Refuges. (Adapted from IBGE, 1992).
Table 1. Earthworm species associated with vegetation, and municipalities in collection locations, in the state of Mato Grosso.

| No. | Family                      | Genus/Species/Subspecies                                      | Municipality                                                                 | Origin(1)                                                                 | Vegetation                                                                 | References                                      |
|-----|-----------------------------|--------------------------------------------------------------|------------------------------------------------------------------------------|---------------------------------------------------------------------------|----------------------------------------------------------------------------|-------------------------------------------------|
| 1   | Glossoscoleidae             | *Andoidrilus (Amazonidrilus) torquemadai* (Righi, 1984)     | Cáceres, Pontes e Lacerda, Vila Bela da Santíssima Trindade                  | Native                                                                    | Cerrado, Cerrado Grassland, Forest, Cerrado of Pantanal                   | Righi (1984b, 1985a, 1985a)                     |
| 2   |                             | *Diachaeta (Anamo) kannerae* Righi, 1984                     | Poconé                                                                       | Native                                                                    | Cerrado                                                                    | Righi (1984d)                                  |
| 3   |                             | *Enantiodrilus borellii* Cognetti, 1902                      | Comodoro, Nova Lacerda, Pontes e Lacerda, Vila Bela da Santíssima Trindade  | Native                                                                    | Forest, Cerrado of Pantanal                                               | Righi (1984b, 1984d, 1990), Righi & Guerra (1985) |
| 4   |                             | *Goiascoles pepus* Righi, 1972                               | Cocalinho, Comodoro, Pontes e Lacerda, Vila Bela da Santíssima Trindade     | Native                                                                    | Cerrado                                                                    | Righi (1972, 1984b), Righi & Guerra (1985)    |
| 5   |                             | *Goiascoles vanzolinii* Righi, 1984                          | Barra do Bugres, Cocalinho, Vila Bela da Santíssima Trindade                 | Native                                                                    | Forest, Cerrado of Pantanal                                               | Righi (1984c, 1990), This study                |
| 6   |                             | *Opisthodrilus adae* Righi, 1984                             | Cuiabá, Barra do Bugres, Cáceres, Mirassol D'Oeste                           | Native                                                                    | Cerrado                                                                    | Righi (1984b)                                  |
| 7   |                             | *Opisthodrilus borelli borelli* Rosa, 1895                   | Cuiabá, Barra do Bugres                                                     | Native                                                                    | Forest, Cerrado, Cerrado Grassland, Cerrado/Forest Transition             | Righi (1972, 1984b), This study                |
| 8   |                             | *Opisthodrilus sp.*                                          | Poconé                                                                       | Native                                                                    | Cerrado                                                                    | Righi (1984d)                                  |
| 9   |                             | *Pontoscoles (Pontoscoles) corethrurus* (Müller, 1857)      | Alto do Araguaia, Alto Garças, Arenápolis, Barra do Bugres, Cáceres, Comodoro, Cuiabá, Nova Lacerda, Pontes e Lacerda, Primavera do Leste, Santo Antônio do Leveger | Native                                                                    | Forest, Cerrado, Forest Transition, Cerrado, Forest, Cerrado Grassland,  | Righi (1984a, 1984b), Righi & Guerra (1985), Brown & James (2007), CNGMZUSP(2), This study |
| 10  |                             | *Rhitodrilus mortis* Righi, 1972                             | Campo Verde                                                                  | Native                                                                    | Cerrado                                                                    | Righi (1972)                                   |
| 11  |                             | *Rhitodrilus motuca* Righi, 1971                             | Cuiabá, Poconé, Santo Antônio do Leveger                                    | Native                                                                    | Cerrado                                                                    | Righi (1984d, 1985a), COFM(3)                  |
| 12  |                             | *Rhitodrilus tocantinensis pola* Righi, 1984                 | Pontes e Lacerda, Vila Bela da Santíssima Trindade                          | Native                                                                    | Forest, Cerrado of Pantanal                                               | Righi (1984b)                                  |
| 13  |                             | *Rhitodrilus tocantinensis* Righi, 1984                      | Pontes e Lacerda, Vila Bela da Santíssima Trindade                          | Native                                                                    | Forest, Cerrado of Pantanal                                               | Righi & Guerra (1985)                          |
| 14  |                             | *Urobenus brasiliensis* Benham, 1886                         | Campo Verde                                                                  | Native                                                                    | Cerrado                                                                    | Righi (1972, 1985b)                            |
| 15  | Ocnerodrilidae              | *Beladriu* (Beladriu) aura Righi, 1984                       | Pontes e Lacerda                                                             | Native                                                                    | Forest                                      | Righi (1984b)                                  |
| 16  |                             | *Beladriu* (Beladriu) pocaju Righi, 1984                     | Poconé                                                                       | Native                                                                    | Cerrado                                                                    | Righi (1984c, 1990)                            |
| 17  |                             | *Eukirria cuca* Righi, 1984                                  | Cuiabá                                                                       | Native                                                                    | Cerrado                                                                    | Righi (1984c)                                  |
| 18  |                             | *Eukirria eiseniana* (Rosa, 1895)                            | Cáceres, Cuiabá, Pontes e Lacerda                                            | Native?                                                                   | Cerrado, Cerrado Grassland, Forest           | Righi (1972, 1984b), Righi & Guerra (1985)    |
| 19  |                             | *Eukirria eme* Righi & Guerra, 1985                          | Comodoro, Nova Lacerda, Pontes e Lacerda                                    | Native                                                                    | Forest                                      | Righi & Guerra (1985), Righi (1990)            |
| 20  |                             | *Gordioscoles hubessinus* Michaelson, 1913                   | Cáceres, Comodoro, Pontes e Lacerda                                          | Exotic                                                                   | Cerrado, Cerrado Grassland, Forest          | Righi (1984b, 1990), Righi & Guerra (1985)    |
| 21  |                             | *Nematogenia lacrum* Beddard, 1893                           | Cáceres, Mirassol D'Oeste, Nova Lacerda, Vila Bela da Santíssima Trindade   | Exotic                                                                   | Cerrado, Cerrado Grassland, Cerrado/Forest Transition, Forest, Cerrado of Pantanal | Righi (1984b, Righi & Guerra (1985)           |
| 22  | Ocnerodrilidae sp.          | *Ocnerodrilus occidentalis* Eisen, 1878                      | Alto Garças                                                                  | Exotic                                                                   | Cerrado                                      | COFM(3)                                        |
| 23  |                             |                                                             | Poconé                                                                       | Exotic                                                                   | Cerrado                                      | CNGMZUSP(2)                                    |
| 24  | Acanthodrilidae             | *Dichogaster (Diplocoecodrilus) affinis* (Michaelson, 1890) | Arenápolis, Cáceres, Chapada dos Guimarães, Poconé, Pontes e Lacerda          | Exotic                                                                   | Forest, Cerrado, Cerrado Grassland, Cerrado of Pantanal                   | Righi (1972, 1984b, 1984c), This study         |
| 25  |                             | *Dichogaster (Diplocoecodrilus) annae* (Horst, 1893)         | Arenápolis, Santo Antônio do Leveger                                         | Exotic                                                                   | Cerrado                                      | Righi (1984a)                                  |

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Globe, and is the most successful South American earthworm (Righi, 1990). *G. vanzolinii* and *O. borellii* are native species, while *Opisthodrilus* sp. and the species of *Criodrilidae* may be new species and require further research. This is the first time that the latter species has been recorded in the state; two other species of this family have already been found in marsh areas in Rio Grande do Sul (Lima & Rodríguez, 2007) and Mato Grosso do Sul (Brown & James, 2007). Members of this family tend to be more aquatic and are frequently found in flooded areas or sites with shallow water tables.

The remaining species in the study belong to the *Acanthodrilidae* family, and in Brazil these are as likely to be exotic as native (James & Brown, 2006). Of the three species identified in this study, two are exotic of wide distribution: *D. gracilis* and *D. affinis* (Brown et al., 2006). The third species, *Dichogaster* sp., warrants further study, as its taxonomic characteristics do not fit the descriptions of species of this genus known in the country. The specimens of this genus, found in the two collection sites, are very similar, and probably belong to the same species.

Mato Grosso state is divided into 141 municipalities; but only 17 have collection sites (Table 1 and Figure 1). Therefore, only 12% of the municipalities have had at least one collection site for earthworms. In these 17 municipalities, earthworms have been collected from a total of 29 sites (Figure 1), revealing 32 earthworm species/subspecies in 17 genera and 4 families; of this total, 22 species/subspecies are native and 10 may be considered exotic (Table 1). Approximately half (15 species/subspecies) belong to the *Glossoscolecidae* family, and the other half can be divided into the *Ocnerodrilidae* and *Acanthodrilidae* families, each with 8 species, and the *Criodrilidae* family, with one species.

Fifty two percent of the sampled points were in forest and 31% in Cerrado. A large part of the state, especially the Northern region, which is predominantly covered in Amazon rainforest, does not have a single record of earthworm collection yet. Considering the number of new species found by Righi (1990) in his surveys of the region, there is significant potential to find new species, which will require greater collection efforts in the state. These efforts should be encouraged, particularly given the growing human pressure on natural resources and native vegetation, including the paving of the BR-163 road (Cuiabá-Santarém), and the spread of intensive agriculture in the region.
Conclusion

Three new earthworm species, *Opisthodrilus*, *Dichogaster* and *Criodrilidae* sp., were added to the list of species known from the state of Mato Grosso, raising the total to 32 known species. New location records for *P. corethrurus*, *G. vanzolinii*, *O. borellii borellii*, *D. gracilis* and *D. affinis* are also presented.

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