

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*, *Opisthodrilus borellii borellii*, *Opisthodrilus* sp., *Dichogaster (Diplotheodrilus) gracilis*, *Dichogaster* sp. and a species of the Criodrilidae family. Four species of earthworms were identified in Arenápolis: *Pontoscolex (Pontoscolex) corethrurus*, *Dichogaster (Diplotheodrilus) gracilis*, *Dichogaster (Diplotheodrilus) 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.

Minhocas do Mato Grosso e novos registros de espécies do estado

Resumo – O objetivo deste trabalho foi determinar qualitativamente a diversidade de minhocas em áreas sob influência humana, em uma região de transição de Pantanal–Cerrado–Floresta Amazônica, no Estado de Mato Grosso. As minhocas foram coletadas nos municípios de Barra do Bugres e Arenápolis e estudadas em conjunto com espécies previamente identificadas de outros municípios do Estado, em um total de 29 pontos de coletas em 17 municípios. Em Barra do Bugres, foram coletadas e identificadas sete espécies de minhocas: *Goiascolex vanzolinii*, *Pontoscolex (Pontoscolex) corethrurus*, *Opisthodrilus borellii borellii*, *Opisthodrilus* sp., *Dichogaster (Diplotheodrilus) gracilis*, *Dichogaster* sp. e uma espécie da família Criodrilidae. Em Arenápolis foram identificadas quatro espécies: *Pontoscolex (Pontoscolex) corethrurus*, *Dichogaster (Diplotheodrilus) gracilis*, *Dichogaster (Diplotheodrilus) affinis* e *Dichogaster* sp. Ao todo, 32 espécies/subespécies de minhocas são conhecidas em Mato Grosso, 22 nativas e 10 exóticas.

Termos para indexação: biodiversidade, floresta tropical, 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 Arenópolis (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, Arenópolis, 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), *Opisthodrilus borellii borellii* Rosa, 1895 and *Opisthodrilus* sp. Two of the remainder belonged to the Acanthodrilidae family—*Dichogaster (Diplotheodrilus) gracilis* (Michaelsen, 1892) and *Dichogaster* sp. – and one to the Criodrilidae family (Table 1).

In Gilmar Mourão Farm, Arenópolis, four earthworm species were identified: *P. corethrurus*, *Dichogaster (Diplotheodrilus) affinis* (Michaelsen, 1890), *D. gracilis* and *Dichogaster* sp. (Table 1).

The species *P. corethrurus* may be considered a peregrine earthworm at the sites (Brown et al., 2006). Originating from the Guyana Plateau, it spread throughout the tropical and subtropical regions of the

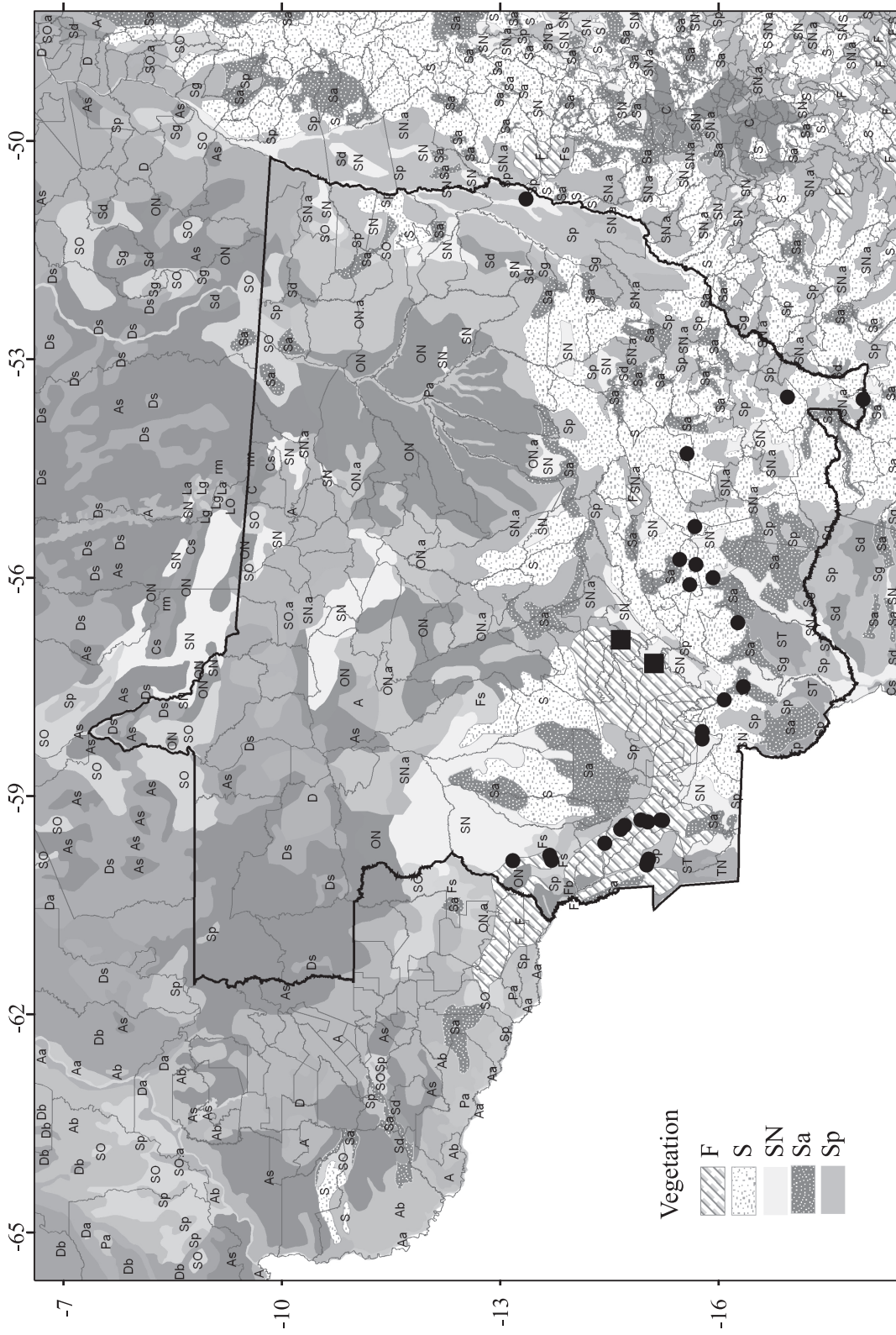


Figure 1. Map of Mato Grosso state, highlighting: ●, locations where earthworms have been collected and ■, new first collections in this study (Barra do Bugres and Arenópolis). F, Forest; S, Cerrado; SN, Cerrado/Forest Transition; Sa, Cerrado Grassland; Sp, Cerrado of Pantanal. Other vegetation types in the map are: A, Open Ombrophylous Forest; As, Submountain Open Ombrophylous Forest; Ds, Submountain Dense Ombrophylous Forest; D, Dense Ombrophylous Forest; F, Semideciduous Seasonal Forest; Fa, Semideciduous Seasonal Forest; Fb, Lowland Semideciduous Seasonal Forest; Fs, Submountain Semideciduous Seasonal Forest; C, Deciduous Seasonal Forest; Sd, Forested Savanna; Sa, Wooded Savanna; Sg, Grassy-woody Savanna; SO, Contact Savanna/Ombrophylous Forest; SN, Contact Savanna/Seasonal Forest; ON, Ombrophylous Forest/Seasonal Forest; ON, Contact; ST, Contact Savanna/Savanna Steppe; TN, Savanna Steppe/Seasonal Forest; PA, Savanna Steppe 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
Glossoscolecidae				
1 <i>Andiorrhinus</i> (<i>Amazonidrilus</i>) <i>torquemadai</i> (Righi, 1984)	Cáceres, Pontes e Lacerda, Vila Bela da Santíssima Trindade	Native	Cerrado, Cerrado Grassland, Forest, Cerrado of Pantanal	Righi (1984b, 1985a, 1985a)
2 <i>Diachaeta</i> (<i>Amazo</i>) <i>kammerae</i> Righi, 1984	Poconé	Native	Cerrado	Righi (1984d)
3 <i>Enantodrilus borelli</i> 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 <i>Gotascolex pepus</i> Righi, 1972	Cocalinho, Comodoro, Pontes e Lacerda, Vila Bela da Santíssima Trindade	Native	Cerrado of Pantanal, Forest	Righi (1972, 1984b), Righi & Guerra (1985)
5 <i>Gotascolex vanzolinii</i> Righi, 1984	Barra do Bugres, Cocalinho, Vila Bela da Santíssima Trindade	Native	Forest, Cerrado of Pantanal	Righi (1984c, 1990), This study
6 <i>Opisthodrilus adneae</i> Righi, 1984	Cáceres	Native	Cerrado, Cerrado Grassland	Righi (1984b)
7 <i>Opisthodrilus borelli borelli</i> Rosa, 1895	Cuiabá, Barra do Bugres, Cáceres, Mirassol D'Oeste	Native	Forest, Cerrado, Cerrado Grassland, Cerrado/Forest Transition	Righi (1972, 1984b), This study
8 <i>Opisthodrilus borelli tuberculiferus</i> Righi, 1984	Poconé	Native	Cerrado	Righi (1984d)
9 <i>Opisthodrilus</i> sp.	Barra do Bugres	Native	Forest	This study
10 <i>Pontoscolex</i> (<i>Pontoscolex</i>) <i>corethrurus</i> (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	Cerrado/Forest Transition, Cerrado, Forest, Cerrado Grassland,	Righi (1984a, 1984b), Righi & Guerra (1985), Brown & James (2007), CGR/MZUSP ⁽²⁾ , This study
11 <i>Rhinodrilus mortis</i> Righi, 1972	Campo Verde	Native	Cerrado	Righi (1972)
12 <i>Rhinodrilus motucu</i> Righi, 1971	Cuiabá, Poconé, Santo Antônio do Leveger	Native	Cerrado	Righi (1984d, 1985a), COFM ⁽³⁾
13 <i>Rightiodrilus tocaninensis pola</i> Righi, 1984	Pontes e Lacerda, Vila Bela da Santíssima Trindade	Native	Forest, Cerrado of Pantanal	Righi (1984b)
14 <i>Rightiodrilus tocaninensis tocaninensis</i> Righi, 1984	Pontes e Lacerda	Native	Forest	Righi & Guerra (1985)
15 <i>Urobenus brasiliensis</i> Benham, 1886	Campo Verde	Native	Cerrado	Righi (1972, 1985b)
Ocerodrilidae				
16 <i>Belladrilus</i> (<i>Belladrilus</i>) <i>aura</i> Righi, 1984	Pontes e Lacerda	Native	Forest	Righi (1984b)
17 <i>Belladrilus</i> (<i>Belladrilus</i>) <i>pocajui</i> Righi, 1984	Poconé	Native	Cerrado	Righi (1984c, 1990)
18 <i>Eukerria cuca</i> Righi, 1984	Cuiabá	Native	Cerrado	Righi (1984c)
19 <i>Eukerria eiseniana</i> (Rosa, 1895)	Cáceres, Cuiabá, Pontes e Lacerda	Native?	Cerrado, Cerrado Grassland, Forest	Righi (1972, 1984b), Righi & Guerra (1985)
20 <i>Eukerria emete</i> Righi & Guerra, 1985	Comodoro, Nova Lacerda, Pontes e Lacerda	Native	Forest	Righi & Guerra (1985), Righi (1990)
21 <i>Gordiodrilus habessinus</i> Michaelson, 1913	Cáceres, Comodoro, Pontes e Lacerda	Exotic	Cerrado, Cerrado Grassland, Forest	Righi (1984b, 1990), Righi & Guerra (1985)
22 <i>Nematogenia lacuum</i> Beddard, 1893	Cáceres, Mirassol D'Oeste, Nova Lacerda, Vila Bela da Santíssima Trindade	Exotic?	Cerrado, Cerrado Grassland, Cerrado/Forest Transition, Forest,	Righi (1984b), Righi & Guerra (1985)
Ocerodrilidae sp.				
23 <i>Ocerodrilus occidentalis</i> Eisen, 1878	Alto Garças	Exotic	Cerrado of Pantanal	COFM ⁽³⁾
	Poconé	Exotic	Cerrado	CGR/MZUSP ⁽²⁾
Acanthodrilidae				
24 <i>Dichogaster</i> (<i>Diplotheocodrilus</i>) <i>affinis</i> (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 <i>Dichogaster</i> (<i>Diplotheocodrilus</i>) <i>anna</i> (Horst, 1893)	Arenápolis, Santo Antônio do Leveger	Exotic	Cerrado	Righi (1984a)

Continue...

Table 1. Continuation.

No. Family Genus/Species/Subspecies	Municipality	Origin ⁽¹⁾	Vegetation	References
26 <i>Dichogaster (Diplotheocodrilus) boltau</i> (Michaelsen, 1891)	Chapada dos Guimarães, Nova Lacerda, Pontes e Lacerda, Poconé, Santo Antônio do Leveger, Vila Bela da Santíssima Trindade	Exotic	Cerrado, Forest, Cerrado of Pantanal	Righi (1972, 1984a, 1984b, 1984c, 1990), Righi & Guerra (1985)
27 <i>Dichogaster (Diplotheocodrilus) gracilis</i> (Michaelsen, 1892)	Barra do Bugres, Cáceres, Pontes e Lacerda, Vila Bela da Santíssima Trindade	Exotic	Cerrado, Cerrado Grassland, Forest, Cerrado of Pantanal	Righi (1984b, 1990), Righi & Guerra (1985), This study
28 <i>Dichogaster (Diplotheocodrilus) modiglianii</i> (Rosa, 1896)	Cáceres, Pontes e Lacerda	Exotic	Cerrado Grassland, Forest	Righi & Guerra (1985), Righi (1984d, 1990)
29 <i>Dichogaster (Diplotheocodrilus) saltiens</i> (Beddard, 1893)	Cuiabá, Poconé, Pontes e Lacerda, Santo Antônio do Leveger, Vila Bela da Santíssima Trindade	Exotic	Cerrado, Forest, Cerrado of Pantanal	Righi (1972, 1984a, 1984b, 1984c)
30 <i>Dichogaster</i> sp.	Barra do Bugres, Arenópolis	Exotic?	Forest	This study
31 <i>Pickfordia (Omodeoscolex) divergens</i> (Cognetti, 1905)	Santo Antônio do Leveger	Native	Cerrado	Righi (1984a)
Criodrilidae				
32 Species of the family Criodrilidae	Barra do Bugres	Native	Forest	This study

⁽¹⁾Native or exotic to the Center-West region of Brazil. ⁽²⁾Gilberto Righi Collection, Museu de Zoologia da Universidade de São Paulo. ⁽³⁾Fritz Müller Oligochaete Collection at Embrapa Florestas.

globe, and is the most successful South American earthworm (Righi, 1990). *G. vanzolinii* and *O. borellii 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*, *D. gracilis* and *D. affinis* are also presented.

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