

# From 1900 to 2000: History of Earthworm taxonomy in the North and Northeast of Brazil and its current distribution in Brazilian Biomes

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**Abstract.** One of the initial milestones for earthworm taxonomy was the work of Michaelsen (1900), “Das Tierreich Oligochaeta”. During this period only two exotic species of the genus *Amyntas* were recorded for the North and Northeast of Brazil. A century has passed and little is known about the taxonomy of earthworms in these two regions and the distribution of these organisms in Brazilian Biomes. The Brazilian territory is divided into six large biomes, Amazonian, Caatinga, Cerrado, Atlantic Forest, Pampa, and Wetlands. Little is known about the distribution of earthworms in these environments. This article provides a review of the literature on the progress of taxonomy in northern and northeastern Brazil over a century and provides the current distribution of earthworms in Brazilian biomes. In the first four decades the taxonomy has advanced at a slow pace, with only 19 new species recorded. With the beginning of Gilberto Righi’s work, earthworm taxonomy has advanced significantly. After Righi’s death in 1999, taxonomy in the North and Northeast has only begun breathing again within the past two years, in which the description of nine new species and two new genera have appeared. There are currently 174 species distributed in thirteen of the sixteen states that make up the North and Northeast regions of Brazil. Regarding distribution, the Amazon, Mata Atlantica and Cerrado biomes stand out for being the most diverse in genera and species, while the Caatinga, Pampa and Pantanal biomes are less diversified. In addition, the Caatinga and Pampa are the only biomes having more exotic species than native species.

**Key-Words.** Biodiversity; Gilberto Righi; Hotspots; Invertebrates.

**Resumo.** Um dos marcos iniciais para a taxonomia de minhocas foi o trabalho de Michaelsen (1900) Das Tierreich Oligochaeta. Nesse período, apenas duas espécies exóticas do gênero *Amyntas* foram registradas no Norte e Nordeste do Brasil. Um século se passou e pouco se sabe sobre a taxonomia das minhocas nessas duas regiões e a distribuição desses organismos nos Biomas brasileiros. O território brasileiro é dividido em seis grandes Biomas, Amazônia, Caatinga, Cerrado, Mata Atlântica, Pampa e Pantanal. Pouco se sabe sobre a distribuição de minhocas nesses ambientes. Este artigo fornece uma revisão da literatura sobre o progresso da taxonomia no Norte e Nordeste do Brasil ao longo de um século e qual é a atual distribuição de minhocas nos Biomas brasileiros. Nas primeiras quatro décadas, a taxonomia avançou em ritmo lento, com apenas 19 novas espécies registradas. Com o início dos trabalhos de Gilberto Righi, a taxonomia das minhocas avançou significativamente. Após a morte de Righi, em 1999, a taxonomia no Norte e Nordeste só começou a respirar novamente nos últimos dois anos, nos quais houve a descrição de nove novas espécies e dois novos gêneros. Atualmente, existem 174 espécies distribuídas em treze dos dezesseis estados que compõem as regiões Norte e Nordeste do Brasil. Em relação à distribuição, os Biomas Amazônia, Mata Atlântica e Cerrado se destacam por serem os mais biodiversos em gêneros e espécies, enquanto os Biomas Caatinga, Pampa e Pantanal são menos diversificados. Além disso, Caatinga e Pampa são os únicos biomas que possuem mais espécies exóticas que espécies nativas.

**Palavras-Chave.** Biodiversidade; Gilberto Righi; Hotspots; Invertebrados.

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## INTRODUCTION

The first major work on worm systematics was published in 1900 by Michaelsen, where he recognized 11 families and 11 subfamilies, which contained 152 genera and about 1,200 species.

Before Michaelsen, one of the main references to earthworms was Charles Darwin's book (1881) "The formation of vegetable mould through the action of worms with observations on their habits", which was largely responsible for changing the way these organisms were viewed by the population, that considered worms to be pests harmful to the soil (Walton, 1928).

In Brazil, the most comprehensive and representative work involving earthworms was published in 2007 by Brown & James, which addressed the biology, ecology and distribution of earthworms, being the first national work to relate the distribution of these organisms with Brazilian Biomes.

In general, Biome can be defined as "a homogeneous area that is arranged on a regional scale, being influenced by the same processes of formation" (Coutinho, 2006). In Brazil there are six biomes: Amazonian, Caatinga, Cerrado, Atlantic Forest, Wetlands, and Pampa. Importantly, all of these biomes suffer from some kind of anthropogenic pressure (Nascimento & Ribeiro, 2017), which can cause or accelerate biodiversity loss (Silva et al., 2018). Among the groups most susceptible to this loss of biodiversity are earthworms, organisms essential for soil biology (Ojha & Devkota, 2014) and considered to be ecosystem engineers (Jones et al., 1994).

However, even with the comprehensive work of Brown & James (2007), data on earthworm taxonomy and distribution are still scarce and sometimes outdated. Much of this scarcity of data is the result of the low number of active specialists capable of developing work

in this area of research (Fragoso et al., 2003). Given this context, the present work provides a bibliographical review on the history of earthworm taxonomy in North and Northeast Brazil and updates the distribution of this group in the Brazilian Biomes.

## METHODOLOGY

The present work is the result of a literature review. The story was divided into four periods. The first corresponds to the year 1900, the second to the period 1901-1940, the third to 1941-1980, and the fourth to the period spans the years 1981-2018. Two letters were used to abbreviate the northern and northeastern states (AC = Acre; AM = Amazonas; AP = Amapá; BA = Bahia; CE = Ceará; MA = Maranhão; PA = Pará; PB = Paraíba; PE = Pernambuco; RO = Rondonia; RR = Roraima; SE = Sergipe; TO = Tocantins). The distribution map was created with the assistance of the Quantum Gis Program (2018). The other analyzes were performed with the SigmaPlot 14.0 program (2017).

## RESULTS AND DISCUSSION

In 1900, no species of earthworms were described from the North and Northeast. Only two exotic species, *Amyntas gracilis* (Kinberg, 1867) and *Amyntas pallidus* (Michaelsen, 1892) were recorded for the State of Amazonas. Both species were reported by Rosa (1894). It is important to note that in this period Brazil did not have an active earthworm taxonomist, which may explain the low number of species records.

Over the next four decades the taxonomy of earthworms in the North and Northeast signalled a slight advance. During this period 19 new species were recorded, of which 18 were native (Table 1). However, until that time, Brazil as a whole had no active taxonomists, and all records of these four decades were only possible thanks to Michaelsen (1918, 1926, 1928, 1934) and Cernosvitov (1934, 1935, 1939). Importantly, despite progress, taxonomy was advancing at a rate of approximately 0.4 species per year. By the end of these four decades only six of the sixteen states that make up the North and Northeast had recorded earthworm species.

In the following period, which spans from 1941 to 1980, the advance was much higher compared to the previous period. In all, 73 new species were recorded for the North and Northeast of Brazil, 58 of which were native (Table 2). This period is also marked by the emergence of Gilberto Righi, today considered the greatest earthworm taxonomist in Brazil (Fragoso et al., 2003). Righi was responsible for the description of 50 of the 58 native species recorded in this period. This corresponds to almost 90% of the species. In addition, all exotic species were reported by him. This only further emphasizes his importance for Brazilian earthworm taxonomy.

In the last period, from 1981 to 2018, the number of species recorded was slightly higher than in the previous

**Table 1.** Earthworm species recorded in the period 1901-1940 in the North and Northeast of Brazil.

Species	State	Native/Exotic	Author	Reference
<i>Aptodrilus salatheii</i>	AM, RR	Native	Michaelsen, 1934	Michaelsen, 1934
<i>Andiorrhinus pictus</i>	AM	Native	Michaelsen, 1926	Michaelsen, 1926
<i>Andiorrhinus planaria</i>	AM	Native	Michaelsen, 1934	Michaelsen, 1934
<i>Andiorrhinus proboscideus</i>	PA	Native	Cernosvitov, 1939	Cernosvitov, 1939
<i>Andiorrhinus rubescens</i>	AM	Native	Michaelsen, 1926	Michaelsen, 1926
<i>Diachaeta carsevenica</i>	AP	Native	Cernosvitov, 1934	Cernosvitov, 1934
<i>Dichogaster bolau</i>	AM, AP	Exotic	Michaelsen, 1891	Michaelsen, 1927; Cernosvitov, 1935
<i>Enantiodrilus borellii</i>	AM, PA	Native	Cognetti, 1902	Michaelsen, 1927
<i>Glyphidrilocrius ehrhardti</i>	AM	Native	Michaelsen, 1926	Michaelsen, 1926
<i>Martiodrilus ohausi</i>	AM	Native	Michaelsen, 1917	Michaelsen, 1917
<i>Neogaster americanus</i>	AP	Native	Cernosvitov, 1934	Cernosvitov, 1934
<i>Paulistus taunayi</i>	BA	Native	Michaelsen, 1926	Michaelsen, 1926
<i>Rhinodrilus annulatus</i>	AP	Native	Cernosvitov, 1934	Cernosvitov, 1934
<i>Rhinodrilus garbei</i>	PE	Native	Michaelsen, 1926	Michaelsen, 1926
<i>Rhinodrilus lakei</i>	AM, RR	Native	Michaelsen, 1934	Michaelsen, 1934
<i>Rhinodrilus longus</i>	AP	Native	Cernosvitov, 1934	Cernosvitov, 1934
<i>Rhinodrilus romani</i>	AM	Native	Michaelsen, 1928	Michaelsen, 1928
<i>Wegeneriona brasiliiana</i>	PA	Native	Cernosvitov, 1939	Cernosvitov, 1939
<i>Wegeneriona michaelseni</i>	AP	Native	Cernosvitov, 1934	Cernosvitov, 1934

**Table 2.** Earthworm species recorded in the period 1941-1980 in the North and Northeast of Brazil.

Species	State	Native/Exotic	Author	Reference
<i>Amyntas morrisi</i>	BA	Exotic	Beddard, 1892	Righi, 1971
<i>Andiorrhinus amazonius</i>	AM	Native	Michaelsen, 1918	Righi et al., 1976
<i>Andiorrhinus tarumanis</i>	AM, RR	Native	Righi et al., 1976	Righi et al., 1976
<i>Andiodrilus icomi</i>	AM, AP	Native	Righi, 1971	Righi, 1971; Righi et al., 1976
<i>Areco reco</i>	AM	Native	Righi et al., 1978	Righi et al., 1978
<i>Atatina gatesi</i>	AM	Native	Righi et al., 1978	Righi et al., 1978
<i>Atatina puba</i>	PA	Native	Righi, 1971	Righi, 1971
<i>Bauba santosi</i>	SE	Native	Righi, 1980a	Righi, 1980a
<i>Brinkhurstia americana</i>	AM	Exotic	Brinkhurst, 1964	Righi et al., 1978
<i>Cirodrilus angeloi</i>	AP	Native	Righi, 1975	Righi, 1975
<i>Dariodrilus ferrarius</i>	AM	Native	Righi et al., 1978	Righi et al., 1978
<i>Diachaeta atroaris</i>	AM	Native	Righi et al., 1978	Righi et al., 1978
<i>Diachaeta xecatu</i>	AM	Native	Righi et al., 1978	Righi et al., 1978
<i>Diachaeta juli</i>	AM	Native	Righi et al., 1978	Righi et al., 1978
<i>Diachaeta nia</i>	AM	Native	Righi et al., 1976	Righi et al., 1976
<i>Dichogaster affinis</i>	AM, BA	Exotic	Michaelsen, 1890	Righi, 1971; Righi et al., 1978
<i>Dichogaster annae</i>	BA	Exotic	Horst, 1883	Righi, 1968a
<i>Dichogaster andina</i>	AM, PA	Exotic	Cognetti, 1904	Righi et al., 1978
<i>Dichogaster badajoz</i>	AM	Native	Righi et al., 1978	Righi et al., 1978
<i>Dichogaster ibaia</i>	AM	Native	Righi et al., 1978	Righi et al., 1978
<i>Dichogaster modiglianii</i>	AM	Exotic	Rosa, 1896	Righi et al., 1978
<i>Dichogaster saliens</i>	AM, BA, MA	Exotic	Beddard, 1893	Righi, 1971, 1972; Righi et al., 1978
<i>Eudrilus eugeniae</i>	BA, MA, PA, PE, SE	Exotic	Kinberg, 1867	Righi, 1967b, 1972
<i>Eukerria asilis</i>	PA, PE	Native	Righi, 1968b	Righi, 1968b, 1971
<i>Eukerria guamais</i>	AM, PA	Native	Righi, 1971	Righi, 1971; Righi et al., 1978
<i>Eukerria uma</i>	BA	Native	Righi, 1968b	Righi, 1971
<i>Eukerria taisa</i>	PA	Native	Righi, 1983	Righi, 1971
<i>Exisdrilus rarus</i>	AM	Native	Righi et al., 1978	Righi et al., 1978
<i>Glossodrilus geayi</i>	AP	Native	Cernovitov, 1934	Righi, 1971
<i>Glossodrilus antunesi</i>	AP, MA	Native	Righi, 1971	Righi, 1971, 1972
<i>Hyperiodrilus africanus</i>	PE	Exotic	Beddard, 1891	Righi, 1972
<i>Holoscolex caramuru</i>	AM, AP	Native	Righi, 1975	Righi, 1995, 1978
<i>Holoscolex nemorosus tacoa</i>	AM	Native	Righi et al., 1978	Righi et al., 1978
<i>Haplodrilus tagua</i>	AM	Native	Righi et al., 1978	Righi et al., 1978
<i>Liodrilus ipu</i>	PA	Native	Righi, 1975	Righi, 1975
<i>Martiodrilus duodenarius</i>	AP	Native	Michaelsen, 1918	Righi, 1971
<i>Martiodrilus matapi</i>	AP	Native	Righi, 1969	Righi, 1971
<i>Metaphire californica</i>	BA	Exotic	Kinberg, 1867	Righi, 1971
<i>Meroscolex marcusii</i>	AM	Native	Righi & Ayres, 1976	Righi & Ayres, 1976
<i>Meroscolex eudoxiae</i>	AM	Native	Righi et al., 1978	Righi et al., 1978
<i>Nematogenia panamaensis</i>	BA	Exotic	Eisen, 1900	Brown & James, 2007
<i>Neogaster gavrilovi</i>	AP	Native	Righi & Caballero, 1970	Righi & Caballero, 1970
<i>Neogaster aidae</i>	AP	Native	Righi, 1975	Righi, 1975
<i>Nouraguesia amaparis</i>	AP	Native	Righi, 1971	Righi, 1971
<i>Omodescolex divergens</i>	AM	Native	Cognetti, 1905	Righi, 1978
<i>Onychochaeta serieia</i>	TO	Native	Righi, 1971	Righi, 1971
<i>Pickfordia tocaya</i>	AM	Exotic	Righi et al., 1978	Righi et al., 1978
<i>Polypheretima elongata</i>	BA, PE	Exotic	Perrier, 1872	Righi, 1971, 1980b
<i>Pontoscolex corethrurus</i>	AM, AP, PA, PE	Exotic	Müller, 1857	Righi, 1967a
<i>Pontodrilus litoralis</i>	PE	Exotic	Grube, 1855	Brown & James, 2007
<i>Rhinodrilus adelaie</i>	CE	Native	Cordero, 1943	Cordero, 1943
<i>Rhinodrilus mamita</i>	CE	Native	Cordero, 1943	Cordero, 1943
<i>Rhinodrilus lucilleae</i>	AM	Native	Righi et al., 1976	Righi et al., 1976
<i>Rhinodrilus priollii</i>	AM	Native	Righi, 1967a	Righi, 1967a
<i>Rhinodrilus bursiferus</i>	AP	Native	Righi, 1971	Righi, 1971
<i>Rhinodrilus curiosus</i>	AM	Native	Righi et al., 1976	Righi et al., 1976
<i>Rhinodrilus motucu</i>	BA	Native	Righi, 1971	Righi, 1971
<i>Rhinodrilus francisci</i>	PE	Native	Cordero, 1944	Cordero, 1944
<i>Rhinodrilus panxin</i>	PA	Native	Righi, 1971	Righi, 1971

Species	State	Native/Exotic	Author	Reference
<i>Righiodrilus aioca</i>	AP	Native	Righi, 1975	Righi, 1975
<i>Righiodrilus freitasi</i>	AP	Native	Righi, 1971	Righi, 1971
<i>Righiodrilus marcusae</i>	PA	Native	Righi, 1969	Righi, 1969
<i>Righiodrilus mucupois</i>	AP	Native	Righi, 1970	Righi, 1970
<i>Righiodrilus cigges</i>	AP	Native	Righi, 1970	Righi, 1970
<i>Righiodrilus schubarti</i>	AM	Native	Righi et al., 1978	Righi et al., 1978
<i>Righiodrilus sucunduris</i>	AM	Native	Righi et al., 1976	Righi et al., 1976
<i>Righiodrilus tinga</i>	AP	Native	Righi, 1971	Righi, 1971
<i>Righiodrilus tocantinensis</i>	PA	Native	Righi, 1972	Righi, 1972
<i>Tiguassu reginae</i>	AM	Native	Righi et al., 1978	Righi et al., 1978
<i>Tuiba dianae</i>	AM	Native	Righi et al., 1976	Righi et al., 1976
<i>Urobenus gitus</i>	PA	Native	Righi, 1971	Righi, 1971
<i>Urobenus buritis</i>	AM	Native	Righi et al., 1976	Righi et al., 1976
<i>Wegeneriona cernositovi</i>	AP	Native	Righi & Caballero, 1970	Righi & Caballero, 1970

period. In all, 80 new species were recorded, 70 of them native (Table 3). From the beginning to the middle of this period, Righi still remains predominant in Brazilian taxonomy, being responsible for the description of 49 of the 70 native species recorded. With Righi's death in 1999, Brazilian taxonomy suffered a great loss, which was reflected in the following decade, where only one species was described in Brazil. In the North and Northeast region, earthworm taxonomy only resumed walking, even if at a slow stride, in the last two years, with the description of nine new species and two new genera. The data only highlights the importance and impact that the presence of only one taxonomist can have for a given region.

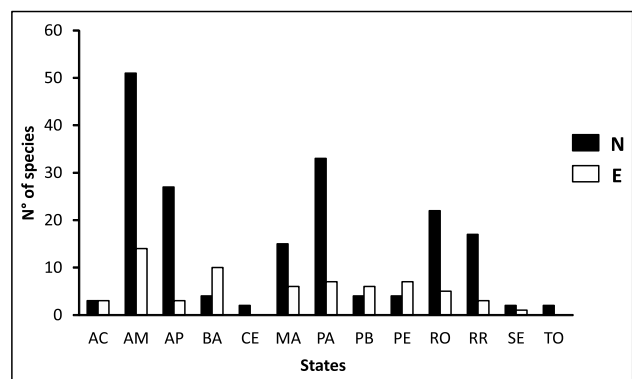


Figure 1. Native (N) and exotic (E) species numbers recorded in each state.

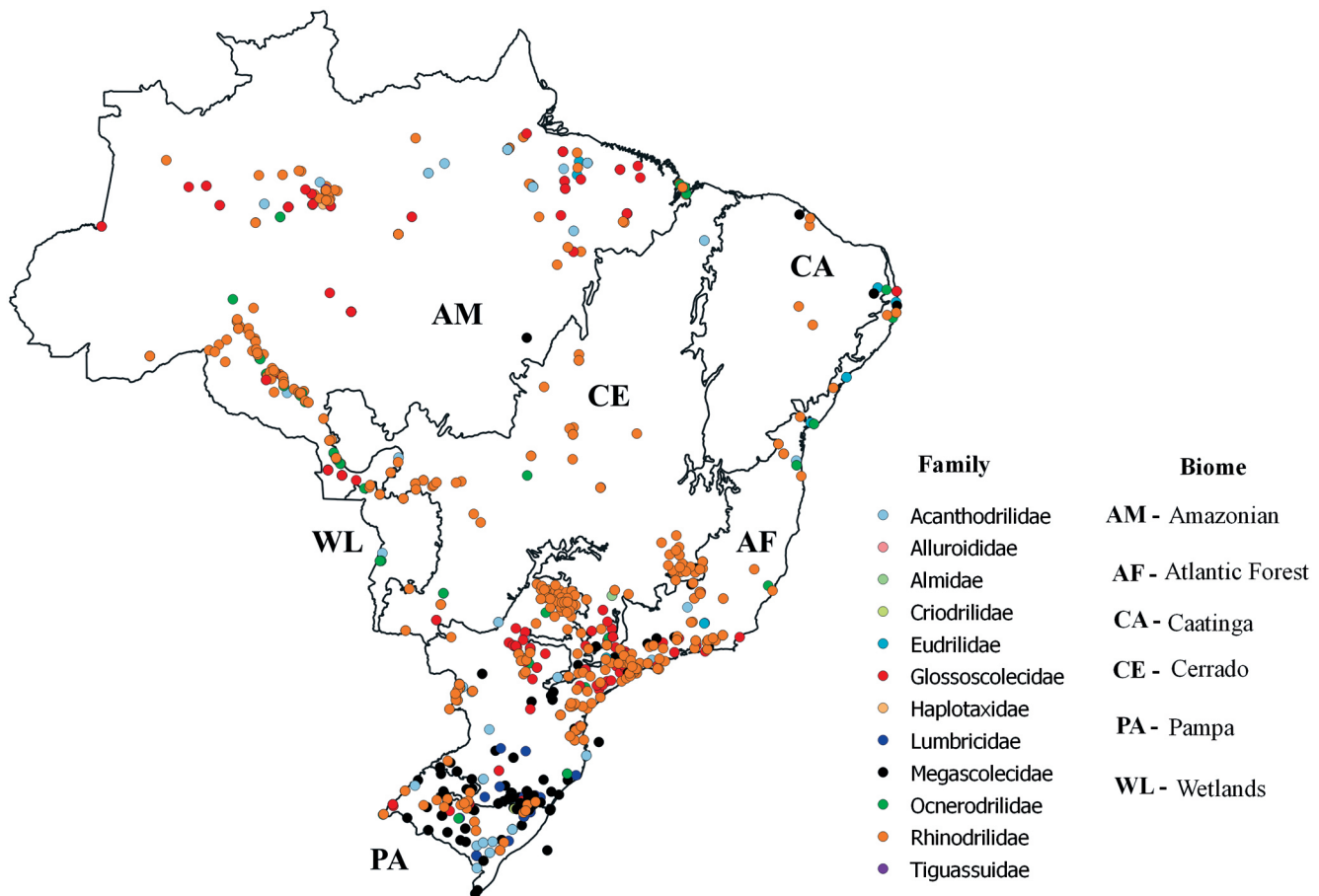


Figure 2. Distribution of earthworm families in Brazilian biomes.

**Table 3.** Earthworm species recorded in the period 1981-2018 in the North and Northeast of Brazil.

Species	State	Native/Exotic	Author	Reference
<i>Amyntas robustus</i>	PB	Exotic	Perrier, 1872	De Assis et al., 2017
<i>Andiorrhinus caudatus</i>	AM, PA, RO	Native	Righi et al., 1976	Adis & Righi, 1989; Righi, 1982a, 1986a
<i>Andiorrhinus evelineae</i>	RO	Native	Righi, 1986a	Righi, 1986a
<i>Andiorrhinus holmgreni</i>	RO	Native	Michaelsen, 1918	Righi, 1986a
<i>Andiorrhinus pauate</i>	RO	Native	Righi, 1986a	Righi, 1985
<i>Andiorrhinus rondoniensis</i>	RO	Native	Righi, 1986a	Righi, 1986a
<i>Andiorrhinus samuelensis</i>	RO	Native	Righi, 1986a	Righi, 1985
<i>Andiorrhinus (Turedrilus) miricuri</i>	MA	Native	Hernández-García et al., 2018c	Hernández-García et al., 2018c
<i>Andiorrhinus (Turedrilus) barrosoi</i>	MA	Native	Hernández-García et al., 2018c	Hernández-García et al., 2018c
<i>Andiorrhinus rodriguezii</i>	AM	Native	Feijoo et al., 2017	Feijoo et al., 2017
<i>Anteoides pigy</i>	PA	Native	Righi, 1982a	Righi, 1982a
<i>Arraia nelmae</i>	MA	Native	Hernández-García et al., 2018b	Hernández-García et al., 2018b
<i>Brasília punki</i>	MA	Native	Hernández-García et al., 2018b	Hernández-García et al., 2018b
<i>Crodrilus aidae</i>	PB	Native	Righi, 1994	Righi, 1994
<i>Crodrilus righii</i>	AM	Native	Zicsi et al., 2001	Zicsi et al., 2001
<i>Chibui bari</i>	AC	Native	Righi & Guerra, 1985	Righi & Guerra, 1985
<i>Diaguita vivianeae</i>	AM	Exotic	Righi, 1984	Righi, 1988b
<i>Diachaeta adisi</i>	AM	Native	Righi, 1989a	Righi, 1989a
<i>Diachaeta arawak</i>	AM	Native	Righi, 1989a	Righi, 1989a
<i>Diachaeta aceoca</i>	PA	Native	Righi, 1982a	Righi, 1982a
<i>Diachaeta adnae</i>	RO	Native	Righi, 1989a	Righi, 1989a
<i>Diachaeta mura</i>	AM	Native	Righi, 1989b	Righi, 1989b
<i>Dichogaster modiglianii</i>	RR	Exotic	Rosa, 1896	Righi & Guerra, 1985
<i>Dichogaster saliens</i>	PA, RO	Exotic	Beddard, 1893	Righi, 1988b, 1990
<i>Dichogaster gracilis</i>	AM, PB, RO	Exotic	Michaelsen, 1892	Righi, 1990
<i>Eukerria eiseniana</i>	RO, RR	Native	Rosa, 1895	Righi, 1984, 1986b
<i>Eukerria subandina</i>	RO	Native	Rosa, 1895	Righi, 1986b
<i>Eukerria kuekenenthalii</i>	AM	Exotic	Michaelsen, 1908	Righi, 1988b
<i>Eukerria mucu</i>	RO	Native	Righi, 1988a	Righi, 1988a
<i>Goiascolex cabrelli</i>	RO	Native	Righi, 1971	Righi, 1986b
<i>Goiascolex edgardi</i>	RO	Native	Righi, 1986b	Righi, 1986b
<i>Goiascolex pepus</i>	TO, RO	Native	Righi, 1972	Righi, 1986b, 1990
<i>Gordiodrilus habessinus</i>	RO	Native	Michaelsen, 1913	Righi, 1988a; Righi & Guerra, 1985
<i>Glossodrilus baiuca</i>	RR	Native	Hamoui & Donatelli, 1983	Hamoui & Donatelli, 1983
<i>Glossodrilus motu</i>	RR	Native	Righi, 1990	Righi, 1990
<i>Holoscolex dossantosi</i>	MA	Native	Hernández-García et al., 2018a	Hernández-García et al., 2018a
<i>Holoscolex alatus</i>	MA	Native	Hernández-García et al., 2018a	Hernández-García et al., 2018a
<i>Holoscolex fernandoi</i>	MA	Native	Hernández-García et al., 2018a	Hernández-García et al., 2018a
<i>Haplodrilus amazonicus</i>	AM	Native	Righi, 1983	Righi, 1983
<i>Liodrilus mendesi</i>	MA, PB	Native	Righi, 1994	Righi, 1994; Sousa et al., 2020*
<i>Lourdesia paraibaensis</i>	PB	Native	Righi, 1994	Righi, 1994
<i>Meroscolex roraimensis</i>	RR	Native	Righi, 1984	Righi, 1990
<i>Metataxis bare</i>	RR	Native	Righi, 1988b	Righi, 1988b
<i>Nematogenia lacuum</i>	RO	Exotic	Beddard, 1893	Righi, 1984, 1988a
<i>Neogaster angeloi</i>	AP	Native	Righi, 1988b	Righi, 1988b
<i>Ocnerodrilus occidentalis</i>	AM, PA	Exotic	Eisen, 1878	Righi, 1988b
<i>Ocnerodrilus potyuara</i>	PB	Exotic	Righi, 1994	Righi, 1994
<i>Omodeoscolex divergens</i>	PA	Native	Cognetti, 1905	Righi, 1984, 1989b
<i>Pithemera bicincta</i>	PB	Exotic	Perrier, 1875	De Assis et al., 2017
<i>Pontoscolex cuasi</i>	AP, PA, RR	Native	Righi, 1984	Righi, 1984, 1988b, 1990, 1998
<i>Pontoscolex maracaensis</i>	RR	Native	Righi, 1984	Righi, 1984
<i>Pontoscolex nogueirai</i>	PA, RR	Native	Righi, 1984	Zicsi & Csuzdi, 1999
<i>Pontoscolex franzi</i>	PA	Native	Zicsi & Csuzdi, 1999	Zicsi & Csuzdi, 1999
<i>Pontoscolex vandersleeni</i>	AM	Native	Michaelsen, 1933	Zicsi et al., 2001
<i>Pontoscolex pydanieli</i>	RO	Native	Righi, 1988a	Righi, 1988a, 1990
<i>Pygmaedrilus amapaensis</i>	AP	Native	Righi, 1988b	Righi, 1988b
<i>Rhinodrilus jucundus</i>	PA	Native	Righi, 1985	Righi, 1985, 1989b
<i>Rhinodrilus pitun</i>	PE	Native	Righi & Moraes, 1990	Righi & Moraes, 1990
<i>Rhinodrilus contortus</i>	AM	Native	Cernovitov, 1938	Zicsi et al., 2001

Species	State	Native/Exotic	Author	Reference
<i>Rhinodrilus elisianae</i>	AM, PA, RO	Native	Righi et al., 1976	Zicsi & Csuzdi, 1999; Righi, 1986b, 1988a, 1990
<i>Rhinodrilus lourdesae</i>	RO	Native	Righi, 1986b	Righi, 1986b
<i>Rhinodrilus marcusae</i>	BA	Native	Righi, 1985	Righi, 1985
<i>Righiodrilus amazonius</i>	PA	Native	Zicsi & Csuzdi, 1999	Zicsi & Csuzdi, 1999
<i>Righiodrilus arapaco</i>	RR	Native	Righi, 1982b	Righi, 1982b
<i>Righiodrilus oliveirae</i>	RR	Native	Righi, 1982b	Righi, 1982b, 1998
<i>Righiodrilus dithecae</i>	AP	Native	Righi, 1988b	Righi, 1988b
<i>Righiodrilus moju</i>	PA	Native	Santos et al., 2017	Santos et al., 2017
<i>Righiodrilus gurupi</i>	MA	Native	Santos et al., 2017	Santos et al., 2017
<i>Righiodrilus tico</i>	AM, RR	Native	Righi, 1982b	Righi, 1982b, 1988b, 1998
<i>Righiodrilus venancioi</i>	AM, PA	Native	Righi, 1982a	Righi, 1982a
<i>Righiodrilus viseuensis</i>	PA	Native	Santos et al., 2017	Santos et al., 2017
<i>Righiodrilus mairaro</i>	RR	Native	Righi, 1982b	Righi, 1982b
<i>Righiodrilus uete</i>	RO	Native	Righi, 1988a	Righi, 1988a
<i>Righiodrilus fontebonensis</i>	AM	Native	Righi, 1988b	Righi, 1988b
<i>Righiodrilus ortonae</i>	PA	Native	Righi, 1988b	Righi, 1988b
<i>Righiodrilus dithecae</i>	AP	Native	Righi, 1988b	Righi, 1988b
<i>Urobenus petrerei</i>	MA, PA	Native	Righi, 1985	Righi, 1985
<i>Urobenus igpigpuera</i>	PA	Native	Righi, 1982a	Righi, 1982a
<i>Urobenus brasiliensis</i>	AM, MA, PA	Native	Benham, 1887	Römbke et al., 1999; Righi, 1985
<i>Wegeneriona belenensis</i>	PA	Native	Righi, 1988b	Righi, 1988b

\* Sousa et al., 2020\* is still in the process of being published.

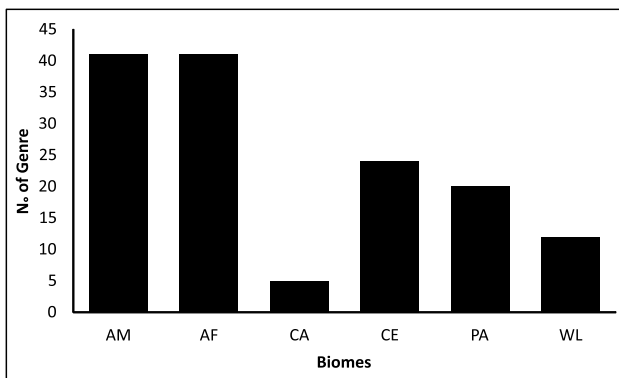


Figure 3. Number of genera in each Brazilian biome.

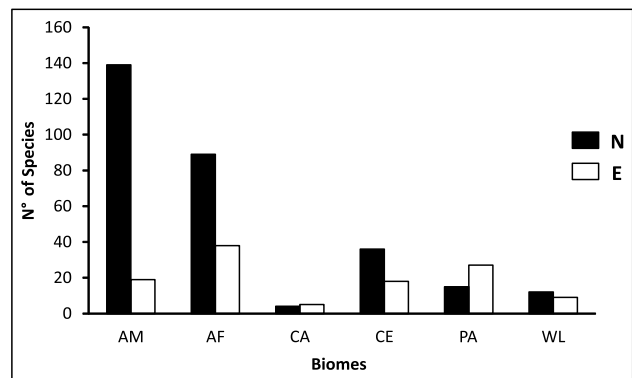


Figure 4. Number of native (N) and exotic (E) species in Brazilian biomes.

After a century, three of the sixteen states that make up the North and Northeast of Brazil (Alagoas, Piauí and Rio Grande do Norte) do not yet have any earthworm recorded. The states with the largest number of species are Amazonas (AM), Pará (PA) and Amapá (AP), while Ceará (CE), Tocantins (TO) and Sergipe (SE) have the lowest numbers (Fig. 1).

The states of Bahia (BA), Paraíba (PB) and Pernambuco (PE) stand out for being the only ones with more exotic than native species (Fig. 1), while Amazonas is the one with the largest number of native species.

Regarding distribution, there are twelve families of earthworms distributed in six Brazilian biomes, with Acanthodrilidae, Ocnerodrilidae and Rhinodrilidae being the only ones present in all biomes (Fig. 2). Glossoscolecidae, Megascolecidae and Rhinodrilidae also stand out for their abundance in the Brazilian territory. Attention is drawn to the distribution of the family Megascolecidae, which is more abundant in southern Brazil (Fig. 2).

In relation to earthworm genera, 82 are found within the six biomes. The Amazonian and Atlantic Forest bi-

omes stand out because they represent more than half of the genera found in Brazilian soil (Fig. 3), while in the Caatinga biome only five earthworm genera are found, being the poorest in genera of the six biomes.

Among all biomes, Caatinga and Pampa are the only ones that have more exotic than native species (Fig. 4), which may be an indication that these biomes are undergoing environmental degradation processes. On the other hand, this result may be correlated with the small number of studies with earthworms, a factor that is related to the low level of active taxonomy in Brazil. As for the Brazilian Wetland, more than 40% of the species found are exotic. As expected, the Amazonian and Atlantic Forest biomes are the ones that hold the largest number of earthworm species, most of which are native species. This result highlights the richness of these two biomes in particular, and the attention that these two biomes should receive regarding to the conservation of native species.

It is important to emphasize that native species of earthworms are sensitive to anthropic disturbances (Winsome et al., 2006), and in some cases can be elimi-

nated by exotic species (Pop & Pop, 2006). Thus measures aimed at the conservation of these biomes are of utmost importance for the conservation of these native species and of the possible new species that have not yet been described.

## CONCLUSION

In the first decades after 1900, the taxonomy of earthworms in the North and Northeast advanced slowly, mainly due to the absence of active specialists in this period. The greatest advance was made between the 60's and 90's, which corresponds to the period of Gilberto Righi's works. There are currently 174 species distributed in 13 states of the North and Northeast of Brazil. Earthworms can be found in all Brazilian biomes, with the families Rhinodrilidae, Megascolecidae and Glossoscolecidae being the most representative. The Amazonian and Atlantic Forest biomes stand out for their great biodiversity of earthworms, while the Cerrado presents intermediate values both at the level of families and in genera and species. It is important to emphasize that this work is only a small step towards the better knowledge of this group of organisms. Of utmost importance, and yet often "despised", this group may be taken as a basis for future work on this topic.

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