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 Amynthas 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 Amynthas 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, Amazonia, Caatinga, Cerrado, Mata Atlântica, Pampa e Pantanal. Pouco se sabe sobre a distribuição de minhocas nessas 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 géneros. Atualmente, existem 174 espécies distribuídas em treze dos dezenove 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 géneros 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.
INTRODUCTION

The first major work on worm systematic 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 = Rondônia; 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, Amynthas gracilis (Kimberg, 1867) and Amynthas palidus (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

| Species          | State | Native/Exotic | Author       | Reference   |
|------------------|-------|---------------|--------------|-------------|
| Aporodrilus salater | AM, RR | Native | Michaelsen, 1934 | Michaelsen, 1934 |
| Andromicrus pictus  | AM    | Native | Michaelsen, 1926 | Michaelsen, 1926 |
| Andromicrus planaria | AM    | Native | Michaelsen, 1934 | Michaelsen, 1934 |
| Andromicrus proboscidea | PA  | Native | Cernosvitov, 1939 | Cernosvitov, 1939 |
| Andromicrus rubescens  | AM    | Native | Michaelsen, 1926 | Michaelsen, 1926 |
| Diachaea casevicensis | AM    | Native | Cernosvitov, 1934 | Cernosvitov, 1934 |
| Dichogaster bolaudi | AM, AP | Exotic | Michaelsen, 1891 | Michaelsen, 1891; Cernosvitov, 1891 |
| Enantiophilus bobbili | AM, PA | Native | Cognetti, 1902 | Michaelsen, 1927 |
| Glyphidrilus echhardtii | AM    | Native | Michaelsen, 1926 | Michaelsen, 1926 |
| Martodrilus ohausii  | AM    | Native | Michaelsen, 1917 | Michaelsen, 1917 |
| Neogaster americanus | AP    | Native | Cernosvitov, 1934 | Cernosvitov, 1934 |
| Paulistus taunayi   | BA    | Native | Michaelsen, 1926 | Michaelsen, 1926 |
| Rhinodrilus annulatus | AP  | Native | Cernosvitov, 1934 | Cernosvitov, 1934 |
| Rhinodrilus garbei   | PE    | Native | Michaelsen, 1926 | Michaelsen, 1926 |
| Rhinodrilus lakei    | AM, RR | Native | Michaelsen, 1934 | Michaelsen, 1934 |
| Rhinodrilus longus   | AP    | Native | Cernosvitov, 1934 | Cernosvitov, 1934 |
| Rhinodrilus nemani   | AM    | Native | Michaelsen, 1928 | Michaelsen, 1928 |
| Wegeneriona brasiliensis | PA  | Native | Cernosvitov, 1939 | Cernosvitov, 1939 |
| Wegeneriona michaelseni | 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 |
|--------------------------|-------|---------------|-----------------|-----------|
| Amyntias morrisi         | BA    | Exotic        | Beddard, 1892   | Righi, 1971 |
| Andionthimus amazonius   | AM    | Native        | Michaelsen, 1918| Righi et al., 1976 |
| Andionthimus tarumanus   | AM, RR| Native        | Righi et al., 1976| Righi et al., 1976 |
| Andiodrilus xcoeni       | AM, AP| Native        | Righi, 1971     | Righi, 1971; Righi et al., 1976 |
| Aerea roco               | AM    | Native        | Righi et al., 1978| Righi et al., 1978 |
| Atasina gatesi           | AM    | Native        | Righi et al., 1978| Righi et al., 1978 |
| Atasina puba             | PA    | Native        | Righi, 1971     | Righi, 1971 |
| Baubas santosi           | SE    | Native        | Righi, 1980a    | Righi, 1980a |
| Brinkhurstia americana   | AM    | Exotic        | Brinkhurst, 1964 | Righi et al., 1978 |
| Cironodrilus angeli      | AP    | Native        | Righi, 1975     | Righi, 1975 |
| Daniodrilus femorius     | AM    | Native        | Righi et al., 1978| Righi et al., 1978 |
| Diachaeta atrousis       | AM    | Native        | Righi et al., 1978| Righi et al., 1978 |
| Diachaeta secata         | AM    | Native        | Righi et al., 1978| Righi et al., 1978 |
| Diachaeta julii          | AM    | Native        | Righi et al., 1978| Righi et al., 1978 |
| Diachaeta nia            | AM    | Native        | Righi et al., 1976| Righi et al., 1976 |
| Dichoagaster affinis     | AM, BA| Exotic        | Michaelsen, 1900| Righi, 1971; Righi et al., 1978 |
| Dichoagaster annae       | BA    | Exotic        | Horst, 1883     | Righi, 1968a |
| Dichoagaster andina      | AM, PA| Exotic        | Cognetti, 1904  | Righi et al., 1978 |
| Dichoagaster badajos     | AM    | Native        | Righi et al., 1978| Righi et al., 1978 |
| Dichoagaster inaka       | AM    | Native        | Righi et al., 1978| Righi et al., 1978 |
| Dichoagaster modiglianii | AM    | Exotic        | Rosa, 1896      | Righi, 1978 |
| Dichoagaster saliens     | AM, BA, MA| Exotic      | Beddard, 1893   | Righi, 1971; Righi et al., 1978 |
| Eudrilus eugenei         | BA, MA, PA, PE, SE| Exotic     | Kimberg, 1867   | Righi, 1967b, 1972 |
| Eukena asilis            | PA, PE| Native        | Righi, 1966b    | Righi, 1968b, 1971 |
| Eukena guamae            | AM, PA| Native        | Righi, 1971     | Righi, 1971; Righi et al., 1978 |
| Eukena uma               | BA    | Native        | Righi, 1966b    | Righi, 1971 |
| Eukena taisa             | PA    | Native        | Righi, 1980     | Righi, 1971 |
| Evandrologus rarus       | AM    | Native        | Righi et al., 1978| Righi et al., 1978 |
| Glossodrilus georgyi     | AP    | Native        | Cernosvitov, 1934| Righi, 1971 |
| Glossodrilus antunesis   | AP, MA| Native        | Righi, 1971     | Righi, 1971, 1972 |
| Hyperodrilus africanus   | PE    | Exotic        | Beddard, 1891   | Righi, 1972 |
| Holoscoles caracuru      | AM, AP| Native        | Righi, 1975     | Righi, 1995, 1978 |
| Holoscoles nemosus taxco | AM    | Native        | Righi et al., 1978| Righi et al., 1978 |
| Holodrilus tagua         | AM    | Native        | Righi et al., 1978| Righi et al., 1978 |
| Lindiella ipu            | PA    | Native        | Righi, 1975     | Righi, 1975 |
| Martiodrilus duodenanus  | AP    | Native        | Michaelsen, 1918| Righi, 1971 |
| Martiodrilus matapai     | AP    | Native        | Righi, 1969     | Righi, 1971 |
| Metaphire californica     | BA    | Exotic        | Kimberg, 1867   | Righi, 1971 |
| Meniscoles marcusi       | AM    | Native        | Righi & Ayres, 1976| Righi & Ayres, 1976 |
| Meniscoles nudiaeae      | AM    | Native        | Righi et al., 1978| Righi et al., 1978 |
| Nematomorpha panamaensis | BA    | Exotic        | Eisen, 1900     | Brown & James, 2007 |
| Neogaster gavlovii       | AP    | Native        | Righi & Caballero, 1970| Righi & Caballero, 1970 |
| Neogaster asiae          | AP    | Native        | Righi, 1975     | Righi, 1975 |
| Neureagueus amaparans    | AP    | Native        | Righi, 1971     | Righi, 1971 |
| Omodesodes diversgens    | AM    | Native        | Cognetti, 1905  | Righi, 1978 |
| Onychochaeta seriessa    | TO    | Native        | Righi, 1971     | Righi, 1971 |
| Pickfordia taxcoa        | AM    | Exotic        | Righi et al., 1978| Righi et al., 1978 |
| Polyphemerina elongata   | BA, PE| Exotic        | Perrier, 1872   | Righi, 1971, 1980b |
| Pontoscolex corethrurus  | AM, AP, PA, PE| Exotic      | Müller, 1857    | Righi, 1967a |
| Pontoscolex litoralis     | PE    | Exotic        | Grube, 1855     | Brown & James, 2007 |
| Rhinodrilus adelaeae     | CE    | Native        | Gordero, 1943   | Cordero, 1943 |
| Rhinodrilus mamita       | CE    | Native        | Gordero, 1943   | Cordero, 1943 |
| Rhinodrilus lucilleae    | AM    | Native        | Righi et al., 1976| Righi et al., 1976 |
| Rhinodrilus prolixii     | AM    | Native        | Righi, 1967a    | Righi, 1967a |
| Rhinodrilus bursiferus   | AP    | Native        | Righi, 1971     | Righi, 1971 |
| Rhinodrilus curiosus     | AM    | Native        | Righi et al., 1976| Righi et al., 1976 |
| Rhinodrilus motucu       | BA    | Native        | Righi, 1971     | Righi, 1971 |
| Rhinodrilus francisci    | PE    | Native        | Gordero, 1944   | Cordero, 1944 |
| Rhinodrilus panon        | PA    | Native        | Righi, 1971     | Righi, 1971 |
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.](image)

![Figure 2. Distribution of earthworm families in Brazilian biomes.](image)
Table 3. Earthworm species recorded in the period 1981-2018 in the North and Northeast of Brazil.

| Species                        | State | Native/Exotic | Author                        | Reference                  |
|--------------------------------|-------|---------------|-------------------------------|----------------------------|
| Amythas robustus              | PB    | Exotic        | Perrier, 1872                 | De Assis et al., 2017      |
| Andironthus caudatus          | AM, PA, RO | Native   | Righi et al., 1976          | Adis & Righi, 1989; Righi, 1982a, 1986a |
| Andironthus eveletineae       | RO    | Native        | Righi, 1986a                 | Righi, 1986a               |
| Andironthus holmgrenii        | RO    | Native        | Michaelsen, 1918             | Righi, 1986a               |
| Andironthus paupae            | RO    | Native        | Righi, 1986a                 | Righi, 1985                |
| Andironthus rondoniensis      | RO    | Native        | Righi, 1986a                 | Righi, 1986a               |
| Andironthus samuelensis       | RO    | Native        | Righi, 1986a                 | Righi, 1985                |
| Andironthus (Tunecridus) mirisci | MA | Native   | Hernández-García et al., 2018c | Hernández-García et al., 2018c |
| Andironthus (Tunecridus) barrosoi | MA | Native   | Hernández-García et al., 2018c | Hernández-García et al., 2018c |
| Andironthus rodriquezi        | AM    | Native        | Feijoo et al., 2017          | Feijoo et al., 2017        |
| Anteonides pigy               | PA    | Native        | Righi, 1982a                 | Righi, 1982a               |
| Arisa nelmae                  | MA    | Native        | Hernández-García et al., 2018b | Hernández-García et al., 2018b |
| Brasilisia punki              | MA    | Native        | Hernández-García et al., 2018b | Hernández-García et al., 2018b |
| Cinodrilus aidae              | PB    | Native        | Righi, 1994                 | Righi, 1994                |
| Cinodrilus righi              | AM    | Native        | Zici et al., 2001           | Zici et al., 2001          |
| Chubu bari                    | AC    | Native        | Righi & Guerra, 1985        | Righi & Guerra, 1985       |
| Diagusta vivianae             | AM    | Exotic        | Righi, 1984                 | Righi, 1988b               |
| Diachanta adropi              | AM    | Native        | Righi, 1989a                | Righi, 1989a               |
| Diachanta aronwiek            | AM    | Native        | Righi, 1989a                | Righi, 1989a               |
| Diachanta arocoa              | PA    | Native        | Righi, 1982a                | Righi, 1982a               |
| Diachanta adnora              | RO    | Native        | Righi, 1989a                | Righi, 1989a               |
| Diachanta marula              | AM    | Native        | Righi, 1989b                | Righi, 1989b               |
| Dic hospater modiglani        | RR    | Exotic        | Rosa, 1896                  | Righi & Guerra, 1985       |
| Dic hospater saliens          | PA, RO | Exotic   | Beddard, 1893               | Righi, 1988b, 1990        |
| Eukemia eversiana             | AM, PA, RO | Exotic   | Michaelson, 1892           | Righi, 1990                |
| Eukemia subandina             | RO    | Native        | Rosa, 1895                  | Righi, 1984, 1986b        |
| Eukemia tenuipendula          | RO    | Native        | Rosa, 1895                  | Righi, 1986b               |
| Eukemia musu                  | RO    | Native        | Righi, 1986a                | Righi, 1988b               |
| Gaoso dox croydri             | RO    | Native        | Righi, 1971                 | Righi, 1986b               |
| Gaoso dox edgardini           | RO    | Native        | Righi, 1986b                | Righi, 1986b               |
| Gaoso dox peepus              | TO, RO | Native   | Righi, 1972                 | Righi, 1986b, 1990        |
| Gaoso dox walesi              | RO    | Native        | Michaelson, 1913           | Righi, 1988a; Righi & Guerra, 1985 |
| Glossodrilus bathus           | RR    | Native        | Hamou & Donatelli, 1983     | Hamou & Donatelli, 1983    |
| Glossodrilus battus           | RR    | Native        | Righi, 1990                 | Righi, 1990                |
| Holoscolex excellens          | MA    | Native        | Hernández-García et al., 2018a | Hernández-García et al., 2018a |
| Holoscolex alatus             | MA    | Native        | Hernández-García et al., 2018a | Hernández-García et al., 2018a |
| Holoscolex fernandii          | MA    | Native        | Hernández-García et al., 2018a | Hernández-García et al., 2018a |
| Hoploderis amazonicus         | AM    | Native        | Righi, 1983                 | Righi, 1983                |
| Lindodrilus mendesi           | MA, PB | Native   | Righi, 1994                | Righi, 1994; Sousa et al., 2020 |
| Loudera paraolensis           | PB    | Native        | Righi, 1994                 | Righi, 1994                |
| Menoscolex ronimomsis         | RR    | Native        | Righi, 1984                 | Righi, 1990                |
| Metatobas bare                | RR    | Native        | Righi, 1988b                | Righi, 1988b               |
| Nematoscolex laeum            | RO    | Exotic        | Beddard, 1893               | Righi, 1984, 1988a        |
| Neogaster angeli               | AP    | Native        | Righi, 1988b                | Righi, 1988b               |
| Ocnerodrilus occidentalis     | AM, PA | Exotic   | Eisen, 1878                 | Righi, 1988b               |
| Ocnerodrilus otomana          | PB    | Exotic        | Righi, 1994                 | Righi, 1994                |
| Omodeoscolex divergens        | PA    | Native        | Cognetti, 1905             | Righi, 1984, 1989b        |
| Pithemena bicincta            | PB    | Exotic        | Perrier, 1875               | De Assis et al., 2017      |
| Pontoscolex cuosi             | AP, PA, RR | Native   | Righi, 1984                | Righi, 1984, 1988b, 1990, 1998 |
| Pontoscolex maracayensis      | RR    | Native        | Righi, 1984                 | Righi, 1984                |
| Pontoscolex nigeri             | PA, RR | Native   | Zici & Csuzdi, 1999        | Zici & Csuzdi, 1999        |
| Pontoscolex franzii           | PA    | Native        | Zici & Csuzdi, 1999        | Zici & Csuzdi, 1999        |
| Pontoscolex vandersilini      | AM    | Native        | Michaelson, 1933           | Zici et al., 2001          |
| Pontoscolex pydanei           | RO    | Native        | Righi, 1986a                | Righi, 1988a, 1990        |
| Pygmoaonodrilus amapanaensis  | AP    | Native        | Righi, 1988b                | Righi, 1988b               |
| Rhinodrilus jucundus           | PA    | Native        | Righi, 1985                | Righi, 1985, 1989b        |
| Rhinodrilus pittae            | PE    | Native        | Righi & Moraes, 1990       | Righi & Moraes, 1990      |
| Rhinodrilus contortus         | AM    | Native        | Cernossikov, 1938          | Zici et al., 2001          |
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 biomes 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-

| Species                  | State       | Native/Exotic | Author                  | Reference               |
|--------------------------|-------------|---------------|-------------------------|-------------------------|
| Rhinodrilus elisianae    | AM, PA, RO  | Native        | Righi et al., 1976     | Zicsi & Csuzdi, 1999; Righi, 1986b, 1988a, 1990 |
| Rhinodrilus lourense     | RO          | Native        | Righi, 1986b           | Righi, 1986b            |
| Rhinodrilus maracuru     | BA          | Native        | Righi, 1985            | Righi, 1985             |
| Rhinodrilus amazonius    | PA          | Native        | Zicsi & Csuzdi, 1999   | Zicsi & Csuzdi, 1999    |
| Rhinodrilus aparaca      | RR          | Native        | Righi, 1982b           | Righi, 1982b            |
| Rhinodrilus alveolus     | RR          | Native        | Righi, 1982b           | Righi, 1982b, 1998      |
| Rhinodrilus dithaeae     | AP          | Native        | Righi, 1988b           | Righi, 1988b            |
| Rhinodrilus maju         | PA          | Native        | Santos et al., 2017    | Santos et al., 2017     |
| Rhinodrilus gurupi       | MA          | Native        | Santos et al., 2017    | Santos et al., 2017     |
| Rhinodrilus tico         | AM, RR      | Native        | Righi, 1982b           | Righi, 1982b, 1988b, 1998 |
| Rhinodrilus venanciocii  | AM, PA      | Native        | Righi, 1982a           | Righi, 1982a            |
| Rhinodrilus vivesensis   | PA          | Native        | Santos et al., 2017    | Santos et al., 2017     |
| Rhinodrilus manaro       | RR          | Native        | Righi, 1982b           | Righi, 1982b            |
| Rhinodrilus uete         | RO          | Native        | Righi, 1988a           | Righi, 1988a            |
| Rhinodrilus fontebonensis| AM          | Native        | Righi, 1988b           | Righi, 1988b            |
| Rhinodrilus ortoneae     | PA          | Native        | Righi, 1988b           | Righi, 1988b            |
| Rhinodrilus dithaeae     | AP          | Native        | Righi, 1988b           | Righi, 1988b            |
| Urobenus peterei         | MA, PA      | Native        | Righi, 1985            | Righi, 1985             |
| Urobenus isiguassu       | PA          | Native        | Righi, 1982a           | Righi, 1982a            |
| Urobenus brasiliensis    | AM, MA, PA  | Native        | Benham, 1887           | Römbke et al., 1999; Righi, 1985 |
| Wegeneriona belanensis   | 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.
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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