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inventory

Aquatic oligochaeta (Annelida: Clitellata) in extractive reserve Lake Cuniã, Western Brazilian Amazon

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Abstract: Oligochaeta is one of the most common and abundant taxon in continental aquatic fauna. However, knowledge of their distribution in Brazilian ecosystems is still incomplete and fragmented. Thus, the aim of this study was to develop an inventory of aquatic oligochaetes in the Extractive Reserve of Lake Cuniã in the State of Rondônia, Brazil. Collections of data were performed during the dry (August 2015) and rainy seasons (February 2016). The sediment samples were collected near the lakeside region using the kick sampling method and a kick-net sampler (mesh size of 0.25mm). This paper provides a catalog with 12 taxon from a total of 383 specimens, distributed into two families: Naididae (95.08%) and Opistocystidae (4.92%). The Pristininae subfamily was the most significant (85.68%), followed by subfamilies: Naidinae (8.36%), Tubificinae (0.52%) and Rhyacondrilinae (0.52%). In addition, some species such as *Allonais inaequalis*, *Aulophorus furcatus*, *Dero nivea*, *Pristina synclites*, *Pristina menoni* and *Opistocysta serrata*, were recorded for the first time in the Brazilian Amazon region. Therefore, the results of this study contribute to increase knowledge on the distribution of the Oligochaeta class in Brazil, particularly in the North of the country, which is so extensive and rich in water resources, but not extensively studied.

Keywords: *Biodiversity, aquatic macroinvertebrates, Amazon region, Microdrili.*

Oligoquetos aquáticos (Annelida: Clitellata) na reserva extrativista Lago do Cuniã, Amazônia Ocidental Brasileira

Resumo: Oligochaeta é um dos táxons mais comuns e abundantes na fauna aquática continental. No entanto, o conhecimento da sua distribuição nos ecossistemas brasileiros ainda é incompleto e fragmentado. Assim, o objetivo deste estudo foi desenvolver um inventário de oligoquetos aquáticos na Reserva Extrativista do Lago Cuniã no estado de Rondônia, Brasil. Foram realizadas duas coletas, cobrindo o período seco (agosto 2015) e chuvoso (fevereiro 2016). As amostras de sedimento foram coletadas perto da região marginal do lago pelo método de amostragem *Kick sampling* usando um amostrador *Kick-net* (malha de 0,25 mm). Nós catalogamos 12 táxons do total de 383 espécimes, distribuídos em duas famílias: Naididae (95,08%) e Opistocystidae (4,92%). A subfamília Pristininae foi a mais significativa (85,68%), seguida das subfamílias: Naidinae (8,36%), Tubificinae (0,52%) e Rhyacondrilinae (0,52%). Além disso, algumas espécies, como *Allonais inaequalis*, *Aulophorus furcatus*, *Dero nivea*, *Pristina synclites*, *Pristina menoni* e *Opistocysta serrata*, tiveram o primeiro registro na Amazônia brasileira. Assim, os resultados deste estudo contribuem para aumentar o conhecimento da distribuição da classe Oligochaeta no Brasil, particularmente no Norte do país, que é tão extenso e rico em recursos hídricos, porém pouco estudado.

Palavras-chave: *Biodiversidade, macroinvertebrados aquáticos, região amazônica, Microdrili.*

Introduction

Even though tropical regions are considered the most important in biodiversity, the biotas of these areas are rarely explored and still possess many undescribed species (Lewinsohn & Prado, 2005). In this context, Brazilian invertebrate diversity remains largely unknown, mainly because some groups receive more attention than others (Hortal et al. 2015) and the difficulties in taxonomic identification discourage the development of new studies. This results in fragmented and scarce information on the invertebrate fauna (Magurran, 2011), especially in continental aquatic ecosystems, where the information about this group is even more incomplete (Agostinho et al. 2005).

Aquatic Oligochaeta worms are one of the most abundant organisms in continental aquatic fauna and can be found in sediments, in water columns or associated to other organisms such as molluscs (Gorni & Alves, 2006), aquatic macrophytes (Alves & Gorni, 2007), insect larvae (Corbi et al. 2004), bryophytes (Gorni & Alves, 2007), sponges (Gorni & Alves, 2008a) and amphibians (Oda et al., 2015). It is important to highlight that these organisms are important for organic matter cycling of freshwater ecosystems, bioturbation processes, biomonitoring research, aquatic ecotoxicology and test organisms (Chapman, 2001, Corbi et al. 2015).

However, despite the importance of Oligochaeta in the dynamics of aquatic environments, there have been few scientific studies focused on registering these organisms in Brazilian ecosystems (Gorni & Alves, 2008b). Consequently, Christofferson (2010) affirms that studies on oligochaetes in South America are a pioneer phase.

In the Brazilian Amazon, Du Bois- Reymond Marcus (1947; 1949a; 1949b) and Marcus (1942; 1943; 1944) were the first researchers to register many of the species known in scientific literature. Eventually, some species of Oligochaeta were recorded by Imler (1989) and Collado & Schmelz (2000; 2001). Similarly, organisms of this class have been identified in the Ecuadorian Amazon (Turcotte & Harper, 1982) and Colombian Amazon (Carvajal et al., 2009). However, studies on the Amazon aquatic macrofauna have not evolved to present specific levels of species identification (Cleto-Filho & Walker, 2001, Lopes et al. 2011, Aviz et al. 2012).

This study provides a checklist of aquatic oligochaete in The Extractive Reserve of Lake Cuniã - Rondônia, in the Western Brazilian Amazon, and proposes a catalog of the local species found and their ecological information.

Materials and Methods

1. Area of Study

This study was conducted in the Extractive Reserve of Lake Cuniã (Figure 1), located about 130 kilometers from Porto Velho, on the left bank of the lower Madeira River. With an area of approximately 55.850 hectares, the Reserve has two distinct areas. The first is formed by a piece of land that has a diverse environment with high biodiversity and the second is a floodplain area with seasonal water flow throughout the year. The wet season occurs from November to April and the dry season from May to October.

2. Data collection

Two expeditions were conducted, covering the dry season (August 2015) and the rainy season (February 2016). Sediment samples were collected on seven sites that are near the lakeside region and have floodplain characteristics: S1 (08° 20' 15.5"S 63° 31' 38.5" W), S2 (08° 20' 08.9" S 63° 31' 04.8" W), S3 (08° 19' 44.3" S 63° 31' 23.4" W), S4 (08° 19' 37,3" S 63° 30' 29.2" W), S5 (08° 19' 10.9" S 63° 30' 01.9" W), S6 (08° 19' 22.8" S 63° 29' 29.5" W) and S7 (08° 18' 40.0" S 63° 29' 19.0" W). These sites are periodically inundated by the overflow of the lake and present a specific diversity of morphologically adapted vegetation that tolerate this seasonal flood pulse (Martinez & Le Toan, 2006). Furthermore, these sites are organically rich, due to the large amounts of organic substances, originated from local vegetation, that are dissolved in flood water (Junk, 1997). Sample collection was done using the kick sampling method and a kick-net sampler (mesh size of 0.25mm) as described by Alves et al. (2008) and Docile et al. (2016).

Samples were oxygenated with aquarium pumps to maintain the organisms living during the screening process. For organism selection, small portions of the samples were put into translucent trays containing water and subsequently fixed in 10% formalin and preserved in 70% alcohol (Alves & Gorni, 2007). Semi-permanent slides were prepared and the taxonomic criteria adopted by Righi (1984) and Brinkhurst & Marchese (1989) were followed in order to identify Oligochaeta. The identified specimens were deposited in the Zoological Collection of the University of Araraquara (UNIARA). Water temperature, dissolved oxygen, pH and electrical conductivity were measured in each site of the lake with a multiparameter sensor (YSI 5560). The concentrations of organic matter were determined

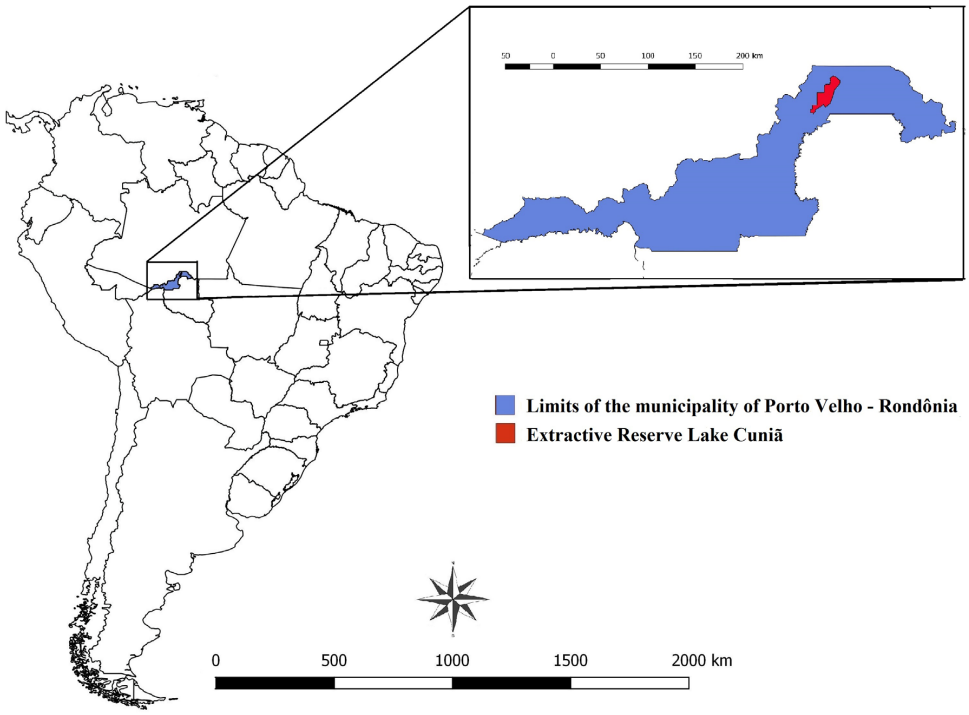

Figure 1. Location of Extractive Reserve Lake Cuniã in the state of Rondônia, Brazil.
Source: Own author (2016)

by mass loss. For this purpose, sediment samples were dried for 12 hours at 60 °C and then ignited at 550 °C for 5 h, according to Maitland (1979).

Information on oligochaeta species in Brazil were searched for in the following databases: Scopus, Google Scholar, and Scielo, with no date filter. Papers by Marcus (1942, 1943, 1944) and Christoffersen (2007) were also consulted for obtaining additional data.

Results

The dissolved oxygen in the rainy season reached a maximum of 5.250 mg/L in S5, while the minimum for the dry season was 1.950 mg/L in S6. The oxygen concentration measured in the Cuniã Lake followed a pattern previously found by Almeida & Melo (2009) in Amazon lakes. Temperature was high, electrical conductivity was low, especially during the dry season, and the pH was acid at all sites of the lake. Regarding organic matter, sites S6 and S7 presented the highest concentrations throughout the year and presented a small increase during the rainy season (Table 1).

This study provides a catalog with 12 taxa from a total of 383 specimens, distributed in two families: Naididae (95.08%) and Opistocystidae (4.92%). The subfamily Pristininae was the most significant (85.68%), followed by subfamilies: Naidinae (8.36%), Tubificinae (0.52%) and Rhyacondrilinae (0.52%) (Table 2).

The *Dero* sp. species was only collected in dry season samples, but we were not able to properly count the number of gills, making it impossible to identify the species level. Similarly, the *Bothrioneurum* sp. species and immature tubificinae were not identified at more specific levels. *Pristina* sp.1 showed a different dorsal needle setae compared to the species already described in literature, and may be a new species of the genus.

1. List and considerations about species

Allonais inaequalis (Stephenson, 1911) (Figure 2a)

A species common in freshwater ecosystems of tropical and subtropical regions (Timm, 1999, Suriano-Affonso et al. 2011). In Brazil, it has been found in the State of São Paulo associated with other organisms such as gastropods (Gorni & Alves, 2006), aquatic macrophytes (Alves & Gorni, 2007), and sponges (Gorni & Alves, 2008a). It has also been recorded in an urban stream by Alves et al. (2006).

Aulophorus furcatus (Müller, 1774) (Figure 2b)

A cosmopolitan species, characterized by the presence of gills and palps in the posterior region of its body (Brinkhurst & Marchese, 1989). Its occurrence in Brazilian aquatic environments has been registered in the States of São Paulo, Paraná, Minas Gerais, Pernambuco and Rio

Table 1 - Mean and standard deviation of the environmental variables (measured in the dry season in August 2015 and rainy season in January 2016). W.T.: Water Temperature (ºC); E.C.: Electrical Conductivity (µs/cm); D.O.: Dissolved Oxygen (mg/L) and pH; O.M.: Organic matter (%).

				Dry			
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**
W.T (ºC)	28.20 (1.903)	29.28 (0.080)	29.21 (0.067)	29.52 (0.076)	29.21 (0.042)	29.70 (0.017)	29.44 (0.100)
E. C. (µs/cm)	10.00 (0.000)	10.00 (0.000)	11.00 (0.000)	26.33 (0.577)	19.00 (0.000)	41.33 (0.577)	25.00 (0.000)
D. O. (Mg/L)	3.540 (0.606)	3.450 (0.334)	3.830 (0.204)	3.880 (0.040)	4.780 (0.153)	1.430 (0.149)	2.350 (0.078)
pH	4.263 (0.042)	4.320 (0.185)	4.397 (0.045)	4.667 (0.032)	4.730 (0.017)	4.933 (0.075)	4.750 (0.044)
O.M (%)	8.6 (7.6)	10.3 (7.6)	9.5 (1.3)	19.8 (6.8)	5.7 (3.1)	19.4 (10.6)	15.1 (2.4)
				Rainy			
W. T. (ºC)	29.10 (0.091)	29.23 (0.031)	29.27 (0.070)	28.91 (0.119)	29.11 (0.292)	30.27 (0.363)	29.70 (0.605)
E. C. (µs/cm)	31.00 (1.000)	25.00 (1.732)	31.67 (1.528)	55.00 (1.000)	61.00 (0.000)	66.67 (1.155)	69.67 (1.155)
D. O. (Mg/L)	4.030 (0.085)	4.60 (0.254)	4.90 (0.023)	4.170 (0.178)	5.250 (0.131)	1.950 (0.116)	2.840 (0.055)
pH	4.883 (0.055)	4.817 (0.072)	4.937 (0.059)	5.060 (0.040)	5.187 (0.050)	5.317 (0.075)	5.400 (0.026)
O.M (%)	5.7 (2.0)	5.7 (2.8)	10.9 (7.3)	7.7 (6.8)	12.9 (9.3)	20.9 (10.2)	16.3 (10.7)

Table 2: Oligoqueta taxa registered in the Extractive Reserve Lake Cuniã.

Season				**Dry**							**Rainy**			
Sites	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**
Naididae Family														
Naidinae Subfamily														
Allonais inaequalis													x	x
Aulophorus furcatus		x		x										
Aulophorus costatus														x
Dero digitata								x						
Dero nivea								x		x		x		
Dero sp.				x	x	x								
Pristininae Subfamily														
Pristina synclites		x						x			x	x		x
Pristina menoni									x					
Pristina sp.1					x									
Tubificinae Subfamily														
Immature Tubificinae						x								
Rhyacodrilinae Subfamily														
Bothrioneurum sp.				x										
Opistocystidae Family														
Opistocysta serrata								x			x			

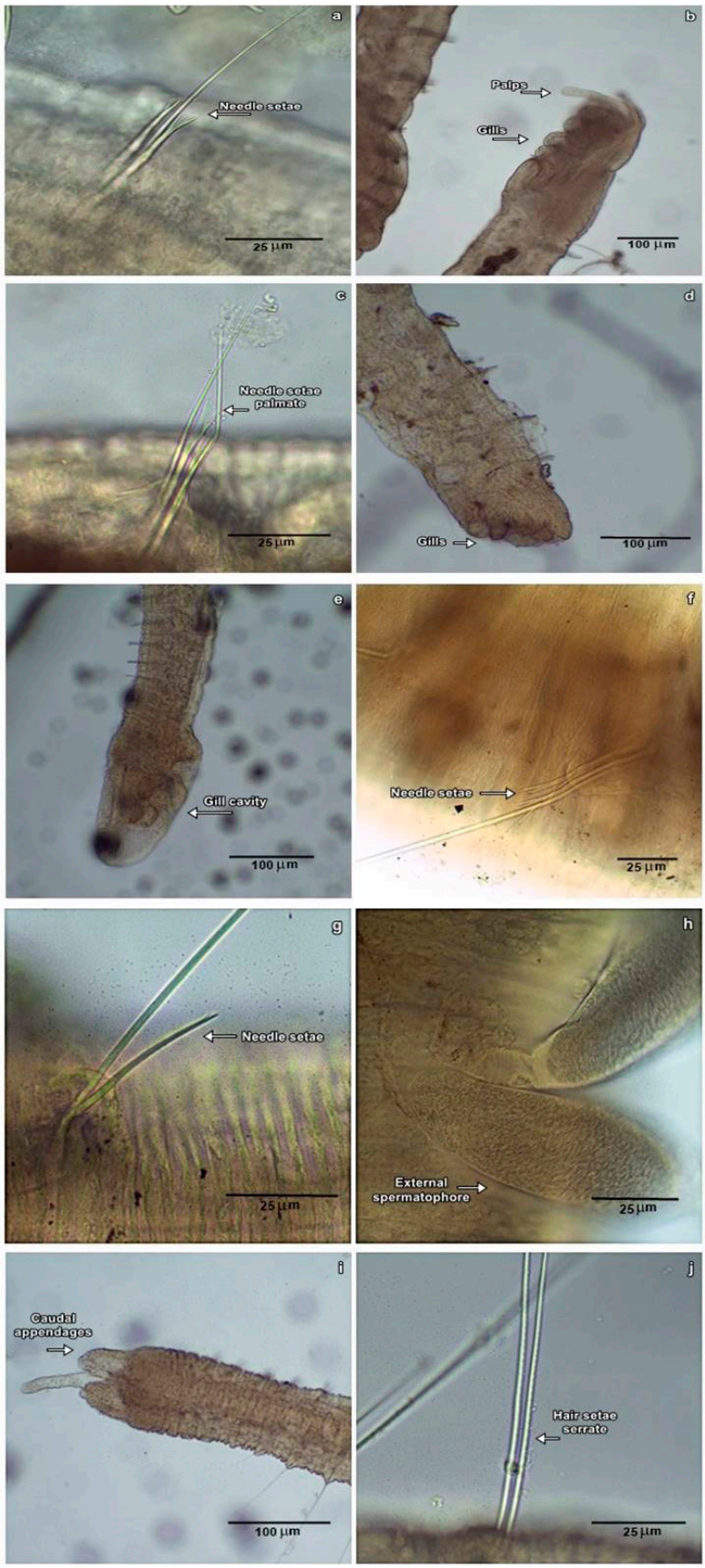

Figure 2. a: Needle setae of *Allonais inaequalis*; **b**: Gill cavity of *Aulophorus furcatus*; **c**: Needle setae palmate of *Aulophorus costatus*; **d**: Gills of *Dero digitata*; **e**: Gills of *Dero nivea*; **f**: Needle setae of *Pristina synclites*; **g**: Needle setae of *Pristina menoni*; **h**: External spermatophore of *Bothrioneurum* sp.; **i**: Caudal appendages of *Opistocysta funiculus*; **j**: Hair setae serrate of *Opistocysta funiculus*.

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Grande do Sul. It also frequently lives in association with other organisms such as Nymphaea (Marcus, 1944), gastropods (Gorni & Alves, 2006), macrophytes (Montanholi-Martins & Takeda, 2001) and also to decomposing macrophyte leaves (Martins et al. 2011). It has been already detected in floodplain habitats (Ragonha & Takeda, 2014), in streams of preserved areas (Rodrigues et al. 2013) and in irrigated rice fields (Stenert et al. 2012).

Aulophorus costatus Du Bois-Reymond Marcus,1944 (Figure 2c)

Its main characteristic is the palmate dorsal needle seta and gill cavity with two pairs of gills (Brinkhurst & Marchese, 1989). Registration in Brazil has already occurred in the States of Amazonas and Pará, as well as in São Paulo, in association with other organisms such as macrophytes (Alves & Gorni, 2007) and sponge specimens (Gorni & Alves, 2008a).

Dero digitata (O. F. Müller, 1773) (Figure 2d)

In Brazil, this species has been registered in the State of São Paulo, in association with gastropods (Gorni & Alves, 2006) and macrophytes (Alves & Gorni, 2007), in reservoirs (Pamplin et al. 2005) and in urban streams (Alves & Lucca, 2000). In the Amazon region, it has been registered in many rivers in the State of Pará, such as Tapajós River, Cururu River, Acara River, Cupari River, Juruena River and São Samuel River (Marcus 1942, Marcus, 1944, Du Bois-Reymond Marcus, 1947, 1949a, 1949b). It has also occurred in areas of rice fields in Rio Grande do Sul (Stenert et al. 2012).

Dero nivea Aiyer 1930 (Figure 2e)

This species is cosmopolitan and is mainly characterized by its prolonged gill cavity (Brinkhurst & Marchese, 1989). Its incidence in Brazil is more significant in the State of São Paulo, but has also been recorded in Rio Grande do Sul. Like other species of Oligochaeta, it can live in association with other organisms, but is especially found on aquatic vegetation (Correia & Trivinho-Strixino, 1998, Trivinho-Strixino et al. 2000, Alves & Gorni, 2007).

Pristina synclites Stephenson, 1925 (Figure 2f)

The records of this species occurrence are in the State of São Paulo, where it was found in urban streams with low concentration of dissolved oxygen (Alves et al. 2006) and in organically enriched reservoirs (Fusari & Fonseca-Gessner, 2006).

Pristina menoni (Aiyer, 1929) (Figure 2g)

Species with records only in São Paulo and Paraná. It has been recorded that it associates with bryophytes (Gorni & Alves, 2007). It has also been found in urban stream waters in São Paulo (Alves et al. 2006) and in the Ivinhema River in Paraná (Montanholi-Martins and Takeda, 2001).

Bothrioneurum sp. (Figure 2h)

This genus is mainly characterized by the presence of a sensitive organ in the prostomium and the presence of an external spermatophore (Brinkhurst & Marchese, 1989). Its occurrence has been cataloged in the States of São Paulo, Minas Gerais, Amazonas, Pará and Rio Grande do Sul. It also occurs mainly in the sediments of degraded sites (Alves & Lucca, 2000; Suriani et al. 2007) and in the streams of preserved areas (Rodrigues et al. 2013). In the south of the country, it has been collected in rice fields (Stenert et al. 2012). In the Amazon region, it was found in Pará, near the County of Belterra, by Marcus (1942) and Du Boys-Reymond Marcus (1947, 1949a and 1949b) and in Central Amazon by Irmler (1989) and Collado & Schmelz (2000; 2001).

Opistocysta serrata Harman, 1970 (Figure 2i, j)

Serrate hair seta, the presence of proboscis and three (one median and two lateral) caudal appendages (Brinkhurst & Marchese, 1989) characterize this species. In Brazil it was collected only in the States of Paraná (Montanholi-Martins & Takeda, 2001) and Mato Grosso do Sul (Takeda et al., 2000).

Discussion

This study showed the occurrence of 12 taxa, representing approximately 13.95% of 86 species registered in Brazil (Christoffersen, 2007). In addition, this was the first registration of some species, such as *Allonais inaequalis*, *Aulophorus furcatus*, *Dero nivea*, *Pristina synclites*, *Pristina menoni* and *Opistocysta serrata*, in the Brazilian Amazon region. According to Christoffersen (2010) the catalogued oligochaetes from South America represent only a fraction of their true diversity, which emphasizes the need for more studies that contemplate species inventory in neotropical regions. Most of the global biodiversity data still comes from temperate regions and refer mainly to important and economically valuable taxa. These shortfalls in biodiversity information need to be recognized and quantified for more accurate conservation assessments and actions (Hortal et al. 2015).

In the aquatic community of Oligochaeta, the Naididae family stands out as the most abundant and diverse, consisting of eight subfamilies and comprising about 50% of the described species on the planet (Rodriguez & Reynoldson, 2011). Moreover, according to Martin (1996) Naididae is a cosmopolitan family, which is very common in lakes. In this study, this family was the most abundant (95.08%), mainly represented by the Pristininae subfamily (85.68%). Some species are periphytic naidids (*Pristina*), some have gills and respiratory appendages that allow inhabiting systems where oxygen is a limiting factor (*Dero*, *Aulophorus*) and others are more often found in sediment (Tubificinae, *Bothrioneurum*) (Martin, 1996).

From a regional perspective, the State of São Paulo has the highest species richness, with 75 species recorded (Gorni et al. 2015), but little is known about these species in other Brazilian States, which reinforces the importance of studies that seek to verify the occurrence of Oligochaeta in other places. Only recent inventories conducted in States, such as Minas Gerais (Rodrigues et al. 2013) and Rio Grande do Sul (Stenert et al. 2012) have started to change this scenario.

The results of this research will contribute to increase knowledge on Oligochaeta in tropical ecosystems, since some species were reported for the first time in the Western Brazilian Amazon. In this context, it is important to promote other biodiversity studies in areas with difficult access, because according to Hortal et al. (2007) species inventories are more frequent in places that offer more research infrastructure and logistics.

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