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Rapid Communication

First record of introduced species *Lumbriculus variegatus* Müller, 1774 (Lumbriculidae, Clitellata) in Brazil

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Abstract

The present work reports the finding of an introduced annelid, *Lumbriculus variegatus* Müller, 1774, in freshwaters of Minas Gerais (Brazil). The Family Lumbriculidae has a Holartic distribution and in recent years was introduced in aquatic environments of Patagonia (Argentina). This is the first report of the family in Brazil. The samples were collected with a D-shaped hand-net with 250µm opening mesh between 2011 (September) and 2012 (January, April and June) in an urban stream in Poços de Caldas, southwest of the State of Minas Gerais (Brazil).

Key words: Oligochaeta, invasive species, urban streams, Minas Gerais

Introduction

The deliberate or accidental introduction of species by human activities may cause substantial environmental and economic damage, affecting population dynamics of native species, food web dynamics, and ecosystem processes (Vitousek et al. 1997; Blackburn and Duncan 2001). Humans have greatly facilitated the spread of aquatic invasive species through intentional stocking, aquarium releases, canal construction, and international shipping (Rahel 2007). The establishment of introduced species and their consequences have been analyzed in numerous studies (e.g. Mooney and Hobbs 2000; Gherardi 2007), and the impact in general includes modification of habitats, food web alterations, changes in community structure, competition with native species, bioaccumulation and magnification of toxic substances in tissues (Savini et al. 2010). Therefore, each new finding of non-indigenous species can be significant, and understanding the introduction, establishment and spread of these species is needed to evaluate their impact on native biodiversity.

The Family Lumbriculidae Vejdovský, 1884 (Annelida: Clitellata) is widespread in the Holarctic Region. The aquatic oligochaete *Lumbriculus variegatus* was first described by Müller (1774). It is found throughout North America, Europe, and northern Asia. It has also been introduced in South Africa, Australia and New Zealand. In more recent years it was introduced in South America, and has been found in Patagonia, Argentina (Miserendino 2007). Patagonia is the southernmost region of Argentina and Chile, and populations of many other exotic species have been established there. These new introductions include freshwater, marine, and terrestrial species from hatcheries and animal farms (Pascual and Ciancio 2007). In Brazil, many authors have reported freshwater introductions of fish (Pompeu and Alves 2003; Azevedo-Santos et al. 2011), invertebrates (Fernandez et al. 2003; Zanata et al. 2003) and plants (Thomaz et

Figure 1. Map of Vai-e-Volta stream (Poços de Caldas, MG, Brazil) with the sampling points.

al. 2009; Sousa 2011). *Lumbriculus variegatus* was not cited in the data base of exotic species in Minas Gerais published by the Instituto Horus in cooperation with The Nature Conservancy and Biodiversitas in Brazil.

L. variegatus could be characterized as an invasive species due to its fast dispersal, success in adaptation and mass occurrence in some recipient areas. The presence of this species can disturb relations within a benthic community, and consequently, can influence the aquatic ecosystem food web. The species prefers shallow habitats at the edges of ponds, lakes, rivers or marshes where it feeds on decaying vegetation, microorganisms and algae (Brinkhurst and Gelder 1991). Favorite microhabitats include layers of decomposing leaves, submerged rotting logs, or sediments at the base of emergent vegetation, such as *Typha* sp. (Drewes 1999). *L. variegatus* is known to have remarkable powers of segmental regeneration. Its normal mode of vegetative reproduction is asexual autotomy into two or more fragments (architomy) (Drewes and Fourtner 1990). The rapid autotomy, in combination with the high rate of survival of body fragments and rapid rate of segment regeneration, provide adaptive strategies for surviving predatory pressures (Lesiuk and Drewes 1999). It is the most common oligochaete species used in evaluation of freshwater toxicity, and was proposed by American Society of Testing and Materials (ASTM 1995) as a standard organism for bioaccumulation studies.

The number of freshwater Oligochaeta species registered in South America is very imprecise, but a total of about 171 aquatic species have been reported by Christoffersen (2007), excluding the Enchytraeidae. In addition, the Family Lumbriculidae was not reported in the catalogue of the aquatic microdrile oligochaetes from South America by Christoffersen (2007), which seems to be a Holartic family with endemic species living in the cool subarctic or alpine water bodies and only a few peregrine species are widely distributed (Timm and Martin 2015).

Material and methods

The study material was collected using a D-shaped hand-net with 250 µm mesh in 2011 (September) and 2012 (January, April and June) in an urban stream in Poços de Caldas, in southwestern Minas Gerais State (Brazil). Vai-e-Volta stream (Figure 1) is a small, low-order waterbody, which forms a major basin river system of the city. Its watershed covers an area of approximately 4.9 km^2, of which the upper 32% is within a protected area, and the lower 42% is fully urbanized. Poços de Caldas is a city within the plateau of the same name in the southern region of Minas Gerais, at 1200–1696 m a.s.l., and located within a volcanic formation. Specimens were fixed with 10% formalin, manually separated from the sediment, stained with borax carmine and mounted on slides for identification. The keys used for identification were Brinkhurst and Jamieson (1971) and Wetzel et al. (2007). All specimens were deposited in the collection of Instituto de Ciência e Tecnologia, Universidade

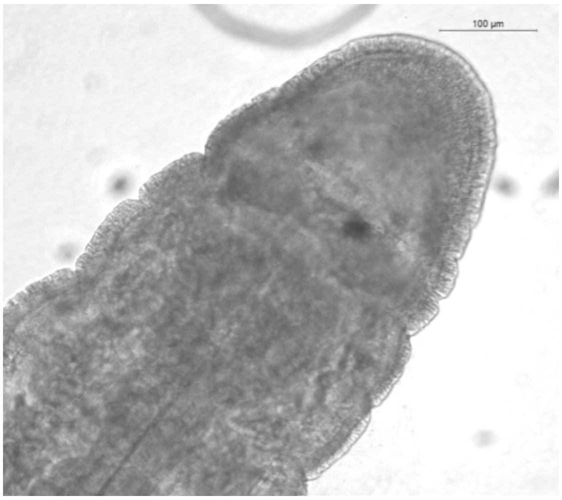

Figure 2. Prostomium and anterior segments of *Lumbriculus variegatus* collected at Vai-e-Volta stream, Poços de Caldas, Minas Gerais State, Brazil. Photomicrograph by M. Marchese.

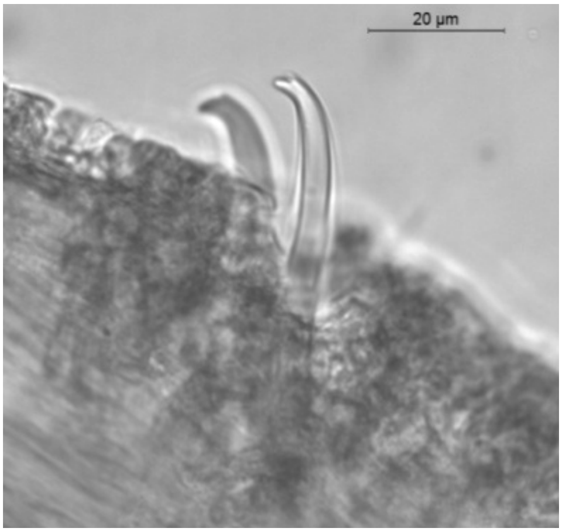

Figure 3. Dorsal chaetae of *Lumbriculus variegatus* collected at Vai-e-Volta stream, Poços de Caldas, Minas Gerais State, Brazil. Photomicrograph by M. Marchese.

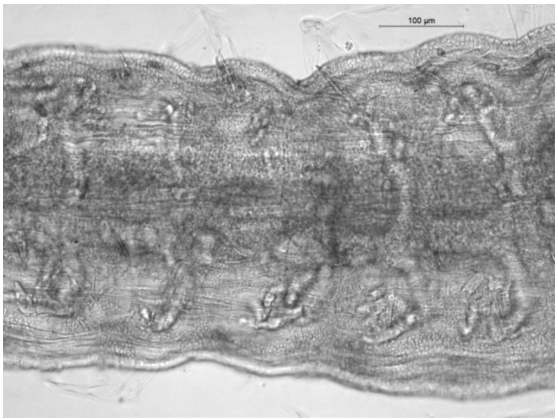

Figure 4. Posterior segments showing the lateral blood vessels of *Lumbriculus variegatus* collected at Vai-e-Volta stream, Poços de Caldas, Minas Gerais State, Brazil. Slides deposited in Instituto de Ciência e Tecnologia, Universidade Federal de Alfenas, MG Brazil. Photomicrograph by M. Marchese.

Federal de Alfenas, Poços de Caldas, MG Brazil. To characterize the sampling sites, pH, electrical conductivity, dissolved oxygen concentration and temperature were measured with a multisensor device (Horiba® model U-22). Current velocity was measured with a JDC Electronic®Flowatch model FL-K2 flowmeter.

The samples were collected in six places in the stream. P1 (21º48′49.23″S and 46º34′26.10″W) and P2 (21º48′43.36″S and 46º34′23.70″W) were located in a natural area without human impact, P3 (21º48′38.84″S and 46º34′22.05″W) and P5 (21º48′07.85″S and 46º34′31.73″W) were situated in a natural area with little anthropic influence, and P4 (21º48′08.37″S and 46º34′11.91″W) and P6 (21º47′31.58″S and 46º34′08.84″W) were placed in the urban area. To assess the differences among sites, each environmental variables was subjected to non-parametric analyses of variance (Kruskal–Wallis test, $P<0.05$).

Description and distribution

Lumbriculus variegatus Müller, 1774 (Figure 2) is common in ponds, lake edges and streams, and may form large populations in mosses and vegetation. It fragments easily, and most populations of *L. variegatus* reproduce asexually by fragmentation followed by regeneration (Lesiuk and Drewes 1999).

The sexual forms, quite scarce in this species, show considerable variability in the number and placement of the reproductive organs. For this reason, the genus has been referred to as the *Lumbriculus* complex (Giani and Rodriguez 1993). Gustafsson et al. (2009) reported genetic variation and suggests a division of the current taxon *Lumbriculus variegatus* into at least two different lineages, which show differences in mitochondrial as well as nuclear genes, and diploid as well as polyploid populations.

The asexual forms can be identified by their long, parallel-sided bodies and the branched lateral blood vessels in the posterior end and both head and tail ends tend to have regenerating segments.

Table 1. Main limnological parameters of Vai-e-Volta stream (Poços de Caldas, MG, Brazil). The values in parentheses refer to the mean and the standard deviation.

Sampling sites	pH	Conductivity µS.cm^{-1}	Dissolved oxygen mg.L^{-1}	Temperature ºC	Water flow m.s^{-1}
1	5.6 - 8.6	14.6 - 16.4	4.1 - 9.6	16.7 - 20.1	0.2 - 0.4
	(6.7 ± 1.3)	(15.3 ± 0.8)	(7.7 ± 2.5)	(18.1 ± 1.5)	(0.3 ± 0.1)
2	6.2 - 8.2	14.9 - 16.7	4.1 - 9.6	16.8 - 20.3	0.1 - 0.5
	(6.9 ± 0.9)	(15.5 ± 0.8)	(7.7 ± 2.5)	(18.3 ± 1.5)	(0.3 ± 0.2)
3	6.0 - 7.9	16.1 - 19.9	4.0 - 9.7	17.2 - 20.0	0.2 - 0.4
	(6.7 ± 0.9)	(17.8 ± 1.8)	(7.6 ± 2.6)	(18.3 ± 1.2)	(0.3 ± 0.1)
4	5.8 - 6.1	84.2 - 97.5	3.3 - 8.6	18.6 - 21.3	0.3 - 0.7
	5.9 ± 0.1)	(89.0 ± 5.9)	(5.8 ± 2.3)	(19.3 ± 1.4)	(0.5 ± 0.2)
5	6.0 - 6.2	17.1 - 64.1	4.2 - 9.3	16.9 - 21.4	0.1 - 0.4
	(6.1 ± 0.1)	(42.5 ± 19.9)	(7.4 ± 2.3)	(18.9 ± 1.9)	(0.2 ± 0.2)
6	5.8 -5.9	97.1 - 140	3.8 - 8.2	19.1 - 22.8	0.3 - 0.5
	(5.8 ± 0.1)	(111.8 ± 20.1)	(6.2 ± 2.2)	(20.3 ± 1.7)	(0.4 ± 0.1)

The main characteristics of specimens collected from this urban stream in Brazil were prostomium rounded conical and proboscis absent. Chaetae 2 per bundle, with upper tooth very reduced (Figure 3). Lateral blood vessels in body wall of posterior segments elaborately branched (Figure 4). Colour in live specimens dark red with greenish tinge anteriorly. The specimens registered were immature.

From the literature it is known that mature individuals present one or more pairs of male pores, between VII and XII. Usually 4 pairs of spermathecal pores begin two segments, or sometimes one segment, posterior to atrial segment(s) and open between the lateral dorsal lines of chaetae. One pair of testes and 1–2 pairs of ovaries begin in post-atrial segments (Brinkhurst and Jamieson 1971).

Results and discussion

Data of environmental variables are summarized in Table 1. The Kruskal-Wallis analysis of variance among the sites was not significant for any of the environmental variables ($p>0.05$). However, sites 4 and 6, where *L. variegatus* was recorded, had the highest mean conductivity values.

The specimens of *L. variegatus* were exclusively collected at sampling points 4 and 6, located in the urban area, and no worms were found in the preserved area. More than a hundred individuals were identified.

It is not easy to understand the introduction and establishment of *L. variegatus* in this urban stream. Apparently it has not widely spread, because it has not yet been found in the preserved area. Our main hypothesis for this introduction is that it has been released into the wild from pet fish stores or aquaria, because aquatic oligochaetes are widely used as fish foods (Timm and Martin 2015). The live, dried or frozen worms are available with a commercial name “California blackworms” at tropical fish stores or pet shops in the USA. They are easily cultured, and large populations may become established within a couple of months from small numbers of stock worms. In addition, the formation of resistant cysts has been observed in *L. variegatus* by Cook (1969), which increases their possibility of distribution. Some oligochaete species are able to form cysts as an adaptive strategy to survive dehydration or freezing of the sediment. Therefore, *L. variegatus* could be introduced in streams as live worms or as cysts, to colonize new habitats favorable for its development. Nevertheless, it may be that this oligochaete species is in an early stage of establishment, because it was found only in the urban reach of the studied stream. Therefore, it is very important to monitor this introduction during the next years.

It is also important to highlight the imminent risk of zoonotic disease transmission due to the presence of *L. variegatus* in urban environments, given that this species can be an intermediate host of the parasite *Dioctophyme renale,* which can affect various domestic and wild mammals and occasionally humans (Pedrassani 2009; Hernández-Russo et al. 2014). However, *D. renale* already occurs in Argentina, Brazil, Paraguay and Uruguay, so presumably, it has other oligochaete hosts. Thus, we recommend further studies for mapping this species and its geographical distribution as well as toxicological analysis to verify the presence or absence of larval stages of helminth parasites in this annelid.

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