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New locality records for *Guerrerostrongylus zetta* (Travassos, 1937) Sutton & Durette-Desset, 1991 (Nematoda: Heligmonellidae) parasitizing *Oligoryzomys nigripes* (Olfers, 1818) (Rodentia: Sigmodontinae) from southern Brazil

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Abstract: *Guerrerostrongylus zetta* had been found in a number of different species of rodents from northern and southeastern Brazil as well as Argentina. Between 2008 and 2010, specimens of *Oligoryzomys nigripes* (*n* = 14) were collected and necropsied. The nematodes encountered were identified as *G. zetta* due their morphological traits. Prevalence was 78%, with a mean intensity of infection of 5.63 helminths/host. This report fills in a lacuna in the known distribution of *G. zetta*, and provides the first record of this parasite in the state of Rio Grande do Sul, Brazil.

Key words: Black-footed Pygmy Rice Rat; rodent; parasite; helminth fauna; taxonomy

The family Cricetidae Fischer, 1817 includes the subfamily Sigmodontinae Wagner, 1843 that encompasses 74 genera and 236 species (Musser and Carleton 2005). Cricetids are found in a variety of habitats around the world and may present terrestrial, arboreal, fossorial, saltatorial or semi-aquatic habits as an adaptive response to the different environments they inhabit (Silva 1984). At least 21 species of sigmodontine rodents are known to occur in the state of Rio Grande do Sul, southern Brazil (Christoff et al. 2013).

Two species of *Oligoryzomys* Bangs, 1900 are found in Rio Grande do Sul (Christoff et al. 2013), *Oligoryzomys flavescens* (Whaterhouse, 1837) and *Oligoryzomys nigripes* (Olfers, 1818). *Oligoryzomys nigripes* is considered to be a scansorial, primarily nocturnal species found in open areas or forests of all the major types of vegetation found in Rio Grande do Sul (Christoff et al. 2013). The species is typically herbivorous, complementing its diet with invertebrates, such as the larvae of lepidopterans, coleopterans and hemipterans (Barlow 1969; Christoff et al. 2013).

In Rio Grande do Sul, the helminth fauna of rodents is scarce. There are only five parasites reported: *Angiostrongylus costaricenses* Morera and Céspedes, 1971 in *O. nigripes* and *Sooretamys angouya* Fischer, 1814 (Graeff-Teixeira et al. 1990); *Trichuris travassosi* Gomes, Lanfredi, Pinto & Souza, 1992 in *O. nigripes* (Gomes et al. 1992); *Hymenolepis diminuta* (Rudolphi, 1819) and *Moniliformis moniliformis* (Bremser, 1811) in *Rattus rattus* (Linnaeus, 1758) (Marques and Scroferneker 2003) and *Nematomystes scapteromi* (Ganrozig, Oku, Okamoto, Malgor & Kammiya, 1999) Jiménez-Ruiz & Gardner, 2003 in *Scapteromys tumidus* Waterhouse, 1837 (Duarte et al. 2015). In the present study, *Guerrerostrongylus zetta* (Travassos, 1937) Sutton & Durette-Desset, 1991 is reported in *O. nigripes* from Rio Grande do Sul, Brazil, enlarging the locality records.

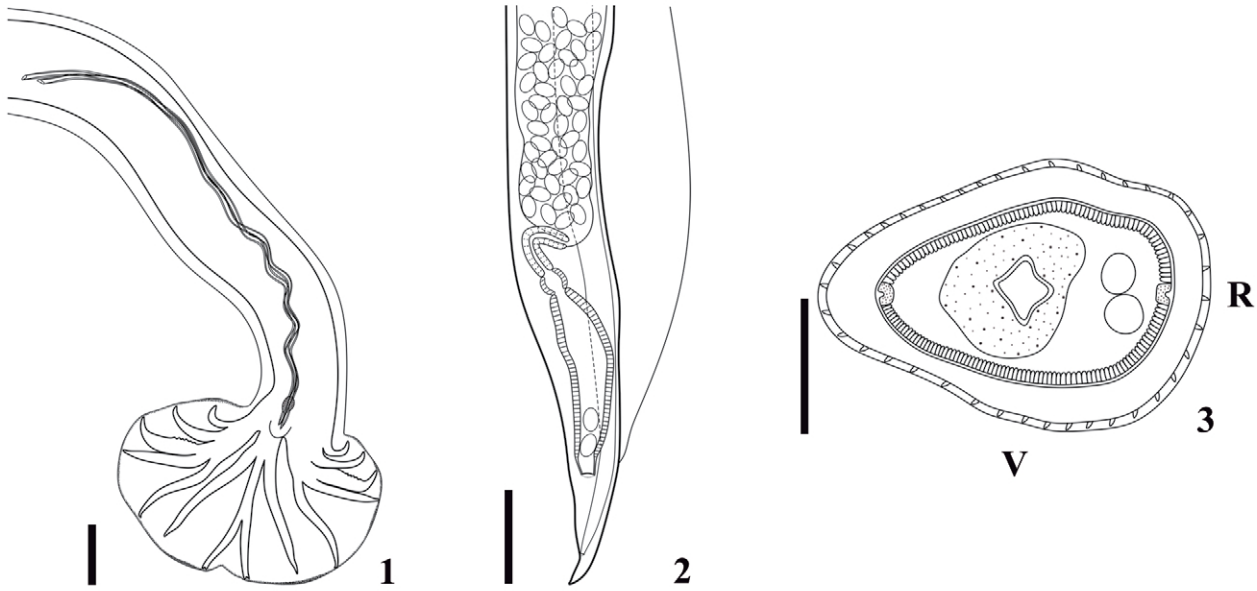
Specimens of *O. nigripes* (*n* = 14) were collected between 2008 and 2010 with Sherman and Tomahawk traps in the municipalities of Cerro Largo (28°14′97″ S, 054°76′52″ W), Vacaria (28°52′49″ S, 050°88′24″ W), Bom Jesus (28°45′04″ S, 050°41′77″ W) and São Gabriel (30°31′53″ S, 054°27′01″ W), in the state of Rio Grande do Sul, Brazil. The rodents were donated for analysis, and necropsied, with the viscera being separated in Petri dishes, immersed in 0.85% saline solution. The nematodes found during the examination of these specimens were fixed in A.F.A. (70° GL ethanol; formalin 37%; glacial acetic acid) at 65°C, and then stored in 70° ethanol, based on the protocol of Amato

and Amato (2010). The measurements and drawings of the nematodes were obtained from specimens clarified with Amann's lactophenol (Humason 1979).

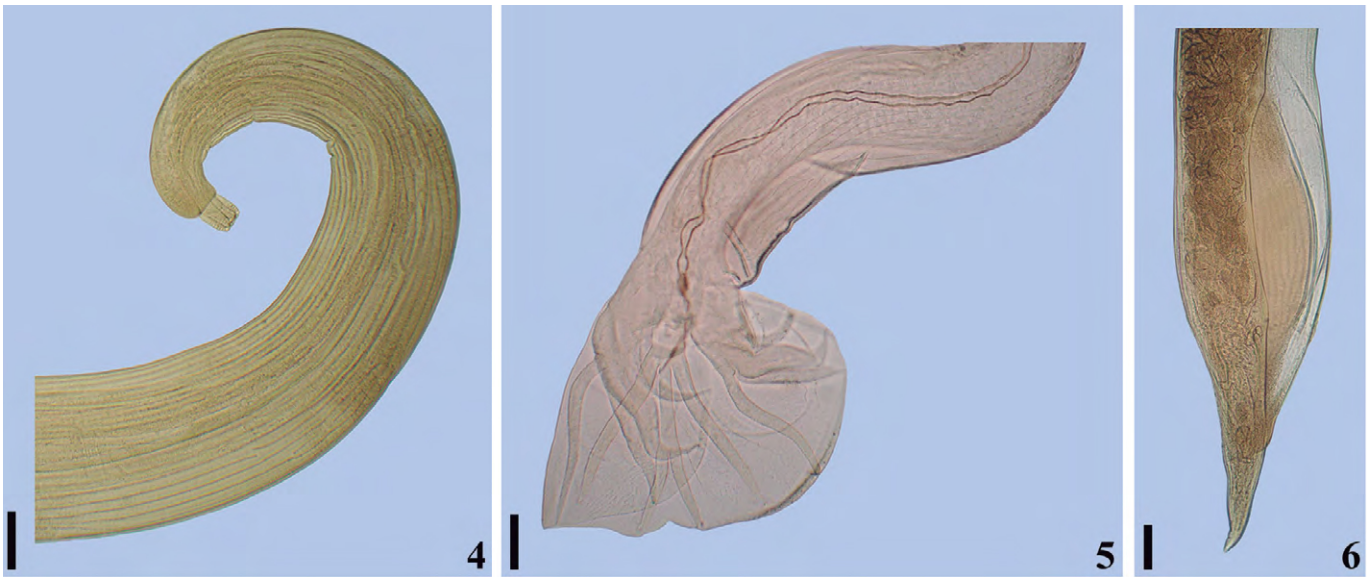
All measurements are given in micrometers (µm), unless otherwise indicated. The number of specimens measured for a specific character only appears between parentheses when it was not possible to measure all the specimens, and the measurements are indicated as in Gallas and Silveira (2013). Ecological terminology follows Bush et al. (1997). The line drawings were prepared using a drawing tube and the photomicrographs were taken with a camera attached to the microscope. The systematics and determination of the helminths followed Durette-Desset (2009) and Gibbons (2010), and the identification of the host was based on Christoff et al. (2009, 2013). Voucher specimens of the host were deposited in the Coleção de Vertebrados of the Museu de Ciências Naturais da ULBRA (MCNU), and specimens of the nematodes were deposited in the Coleção Helmintológica of the same museum (CHMU), in Canoas, Brazil.

Guerrerostrongylus zetta (Travassos, 1937) Sutton & Durette-Desset, 1991
Figures 1–6

Description based on 20 specimens. Heligmonellidae, Nippostrongylinae. Small to medium, delicate and filiform nematodes. Cuticle bearing synlophe with numerous ridges (40–46) of similar size. Cephalic vesicle well developed. Males with caudal bursa of type 2-2-1



Figures 1–3. Incomplete diagrams of *Guerrerostrongylus zetta* (Travassos, 1937) Sutton & Durette-Desset, 1991. **1**: Male posterior extremity. Scale bar = 150 µm. **2**: Female posterior extremity. Scale bar = 150 µm. **3**: Transverse section at mid-body of female, showing the orientation of the synlophe (abbreviations: V- ventral and R- right). Scale bar = 50 µm.



Figures 4–6. Photomicrographs of *Guerrerostrongylus zetta* (Travassos, 1937) Sutton & Durette-Desset, 1991. **4**: Male anterior extremity. **5**: Male posterior extremity. **6**: Female posterior extremity. All scale bars = 100 µm.

tending to 1-3-1. Females monodelphic, with vulva next to the anus, conic tail, without spine.

Males (*n* = 10). Body 6.6–10.7 mm (8.5 ± 1.4 mm) long, 83–157 (121 ± 23) wide. Anterior extremity with cephalic vesicle, 55–64 (60 ± 5) long, 46-55 (51 ± 5) wide. Nerve ring and excretory pore 182–314 (242 ± 49; *n* = 7) and 323-425 (368 ± 39; *n* = 7) from anterior extremity, respectively. Deirids not observed. Esophagus 369–498 (423 ± 40) long, 28–37 (29 ± 3; *n* = 9) wide at anterior extremity and 46-74 (50 ± 9; *n* = 9) at the posterior extremity. Posterior extremity with symmetrical to subsymmetrical caudal bursa, of type 2-2-1 tending to 1-3-1. Rays 2 and 3 directed forwards; ray 2 smaller than ray 3, not reaching as far as the margin of the bursa. Rays 4 and 5 contiguous in the proximal portion, divergent at the extremities, forming a V-shaped. Ray 6 arising from common trunk of rays 4–6 and reaching the bursal margin. Ray 8 arising at the base of the dorsal ray, not reaching the bursal margin. Dorsal ray divided at about mid-length into two branches, each branch bifurcated into two small branches, rays 9 (external branch) and 10 (internal branch). Spicules thin and long, usually twisted in the distal portion, 0.8–1.3 mm (1.1 ± 0.2 mm) long. Gubernaculum 38–52 (44 ± 5; *n* = 9) long, 19–21 (19 ± 1; *n* = 9) wide. Telamon not observed. Genital cone not hypertrophied. Papillae zero and seven not observed.

Females (*n* = 10). Body 10.2–17.9 mm (14.5 ± 2.4 mm) long, 157–230 (195 ± 31) wide. Anterior end with cephalic vesicle 46-64 (57 ± 8) long, 46-64 (56 ± 7) wide. Nerve ring and excretory pore 434 (*n* = 1), 455 and 470 (463 ± 10; *n* = 2) from anterior extremity, respectively. Deirids not observed. Esophagus 500–672 (506 ± 199; *n* = 8) long, 37–46 (38 ± 3; *n* = 8) wide at anterior extremity and 55-64 (57 ± 3; *n* = 8) at posterior extremity. Vulva 157–277 (210 ± 47; *n* = 9) from posterior extremity. Ovejector with vestibule 277–507 (370 ± 75; *n* = 8) long, 92–138 (118 ± 20; *n* = 7) wide; sphincter 35–47 (37 ± 4; *n* = 9) long, 24–52 (31 ± 9; *n* = 9) wide; and infundibulum 138–267 (190 ± 47; *n* = 7) long, 46–55 (47 ± 3; *n* = 7) wide. Anus 42–61 (49 ± 6) from posterior extremity. Eggs numerous, elongated, measuring 47–73 (64 ± 7; *n* = 50) long and 23–40 (32 ± 4; *n* = 50) wide.

Taxonomic summary:

Synonyms: *Longistriata zetta* Travassos, 1937; *Hassalstrongylus zeta* Durette-Desset, 1971; *Guerrerostrongylus zeta* (Travassos, 1937) Sutton & Durette-Desset, 1991.

Host: *Oligoryzomys nigripes* (Olfers, 1818).

Voucher specimens of the host: MCNU-2484.

Localities: Cerro Largo (28°14′97″ S, 054°76′52″ W), Vacaria (28°52′49″ S, 050°88′24″ W), Bom Jesus (28°45′04″ S, 050°41′77″ W) and São Gabriel (30°31′53″ S, 054°27′01″ W), state of Rio Grande do Sul, Brazil.

Sites of infection: small and large intestines.

Prevalence: 78%.

Mean intensity of infection: 5.63 helminths/host.

Mean abundance of infection: 4.42 helminths/host.

Voucher specimens of the helminth: CHMU 99-1-1 (Male) and CHMU 99-1-2 (Female).

The family Heligmonellidae Skrjabin & Schikhobalova, 1952 includes four subfamilies distinguished by the orientation of the synlophe, the presence or absence of a carene and the vertebrate species that act as definitive hosts (Durette-Desset 2009; Gibbons 2010). Of these subfamilies, Nippostrongylinae Durette-Desset, 1971 includes 30 genera of nematodes that parasitize rodents and have an ample geographic distribution (Durette-Desset and Digiani 2012; Digiani and Kinsella 2014). In the Neotropical Region, most of these nematode parasites infect primarily sigmodontinean rodents (Digiani et al. 2003).

The genus *Guerrerostrongylus* was proposed by Sutton and Durette-Desset (1991) to accommodate *Guerrerostrongylus uruguayensis* Sutton & Durette-Desset, 1991, a parasite of *Oryzomys flavescens* (= *Oligoryzomys flavescens* Waterhouse, 1837) in Uruguay. Durette-Desset (1971) transferred *Longistriata zetta* Travassos, 1937 to the genus *Hassalstrongylus* Durette-Desset, 1971, which was later transferred to *Guerrerostrongylus* by Sutton and Durette-Desset (1991), based on the diagnostic traits of the genus. *Guerrerostrongylus* is currently known to include four species: *Guerrerostrongylus gomesae* Simões, Santos & Maldonado-Júnior, 2012, *G. uruguayensis*, *Guerrerostrongylus ulysi* Digiani, Notarnicola & Navone, 2012, and *G. zetta* (Digiani et al. 2012; Simões et al. 2012b). Differences among the species include the number and size of the ridges in the synlophe, the morphology of the causal bursa, in particular the dorsal and rays 6 and 8, and the morphology and length of the spicules (Sutton and Durette-Desset 1991; Digiani et al. 2012; Simões et al. 2012b). The nematodes retrieved in the present study all presented the morphological traits of *G. zetta*, as redescribed by Digiani et al. (2012).

There is some controversy over the spelling of the epitet specific – whether *zetta* or *zeta* is correct – but in the present study, the *zetta* form, used by Digiani et al. (2012) was adopted. With the exception of the body length of the males (6.6–10.7 mm) and females (10.2–17.9 mm), the measurements recorded for *G. zetta* in the present study were similar to those reported by Vicente et al. (1997), Digiani et al. (2012) and Simões et al. (2012b).

In Brazil, the mammals known to host *G. zetta* include *Galea spixii* (Wagler, 1831), *Nectomys squamipes* (Brants, 1827), *Cerradomys subflavus* (Wagner, 1842), and *O. nigripes* in the states of Goiás and Bahia (Pinto et al. 1982); *Thrichomys pachiurus* Wagner, 1845 in the Brazilian Pantanal (Simões et al. 2012b); and *Akodon cursor* Winge, 1887, *Euryoryzomys russatus* (Wagner,

Figure 7. Map showing known geographic distribution (1-8) and new records (9-12) of *Guerrerostrongylus zetta* (Travassos, 1937) Sutton & Durette-Desset, 1991. **1**: Inhaúmas, state of Bahia. **2**: Formosa, state of Goiás. **3**: Brazilian Pantanal. **4**: Teresópolis, state of Rio de Janeiro. **5**: Guapimirim, state of Rio de Janeiro. **6**: Angra dos Reis, state of Rio de Janeiro. **7**: Misiones Province, Argentina. **8**: Misiones Province, Argentina. **9**: Cerro Largo, state of Rio Grande do Sul. **10**: Vacaria, state of Rio Grande do Sul. **11**: Bom Jesus, state of Rio Grande do Sul. **12**: São Gabriel, state of Rio Grande do Sul.

1848), and *O. nigripes* in the state of Rio de Janeiro (Gomes et al. 2003; Simões et al. 2011, 2012a) (Figure 7). When Travassos described *G. zetta* as *L. zetta*, he did not cite the scientific name of the host, referring to it only as the 'rato-rapé' from Rio de Janeiro (Pinto et al. 1982; Digiani et al. 2012). The type host may be *Nectomys squamipes* (Brants, 1827) as confirmed by Simões et al. (2012b), although Digiani et al. (2012) pointed that a number of *N. squamipes* specimens examined in Rio de Janeiro (Gomes et al. 2003) and Argentina (Digiani et al. 2012) were negative for *G. zetta*. Digiani et al. (2012) also recorded *G. zetta* in *O. nigripes* in Argentina (Figure 7).

Ecological parameters of *G. zetta* available in the literature were compared with data from the present study (Table 1). These values suggest that *G. zetta* may be considered a dominant species in the helminth fauna of *O. nigripes*, as suggested by Digiani et al. (2012) in Argentina, a characteristic also recorded in southeastern Brazil by Simões et al. (2011, 2012a) and now reported in southern Brazil, in the present study.

Guerrerostrongylus zetta has the broadest known geographical distribution of any *Guerrerostrongylus* species, and is the only species known to infect a number of different hosts (Digiani et al. 2012; Simões et al. 2012a). In the present study, *G. zetta* is reported for the first time from Rio Grande do Sul, in southern Brazil. However, as discussed above, there is a controversy over the identity of the type host of *G. zetta*, reinforcing the need for the identification of the host in any reports of the occurrence of these parasites. The identification of the host is normally facilitated by the use of appropriate identification keys or consultations with taxonomic specialists, to ensure the avoidance of incomplete or inconsistent reporting. Similarly, Digiani et al. (2012) considered that some published reports of *G. zetta* lack adequate descriptions or illustrations, and require systematic confirmation. These unconfirmed reports and the possible incorrect identification of hosts need to be rectified if the understanding of the diversity and distribution of the parasites of rodents and other vertebrates is to advance reliably.

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Table 1. Comparison of the ecological parameters of *G. zetta* in rodents.

Host (*n*)	Prevalence (%)	Mean intensity (helminths/host)	Mean abundance (helminths/host)	Reference
E. russatus (*n* = 11)	54.5	45.7	—	Gomes et al. (2003)
A. cursor (*n* = 14)	28	17.6	—	Gomes et al. (2003)
A. cursor (*n* = 25)	4	0.04	—	Simões et al. (2011)
O. nigripes (*n* = *)	57.1	10.7	—	Gomes et al. (2003)
O. nigripes (*n* = 57)	21.4	30.8	6.61	Simões et al. (2011)
O. nigripes (*n* = 14)	100	16.2	—	Digiani et al. (2012)
O. nigripes (*n* = 53)	18.5	—	—	Simões et al. (2012a)
O. nigripes (*n* = 57)	21.4	30.8	—	Simões et al. (2012b)
O. nigripes (*n* = 14)	78	5.63	4.42	Present study

* the number of hosts examined was not stated.

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