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Endoparasite Fauna of Wild Capybaras (*Hydrochoerus hydrochaeris*) (Linnaeus, 1766) from the Upper Paraná River Floodplain, Brazil

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Abstract

In the present study, 10 capybaras (*Hydrochoerus hydrochaeris*) were necropsied, and their parasitological fauna were qualitatively analyzed from the Baía River, which belongs to the upper Paraná River floodplain, Brazil. Capybaras are the largest extant rodents and widely occur in Brazil. A parasitological evaluation is important for knowing the parasites that use this rodent as a definitive or intermediate host and to analyze the potential risks of these parasites to the human population (public health interest) or as commercial herbs (economic interest). The endoparasites here registered, with their respective percent occurrence, include the digeneans *Hippocrepis hippocrepis* and *H. fuelleborni* (20% each), *Philophthalmus lachrymosus* (10%), and *Taxorchis schistocotyle* (100%); the cestodes *Monoecocestus macrobursatus* (50%), *M. hydrochaeri* (70%), *Monoecocestus* sp. (10%), and one species of the Anoplocephalidae (10%); and the nematodes *Protozoophaga obesa* (100%) and *Strongyloides* sp. (10%). Because of tourism use of the study area, the zoonotic potential of some of these parasites, and the possibility of infecting livestock animals, the presence of these parasites should be monitored to evaluate if the insertion and maintenance of these animals in ecological association with humans (i.e., synanthropy) might foster public health problems or economic losses or whether there might be a viable situation.

Key Words: diversity, mammal, parasites, tropical, zoonosis, wildlife, capybaras, *Hydrochoerus hydrochaeris*

Introduction

Capybaras (*Hydrochoerus hydrochaeris*, Linnaeus, 1766) are herbivorous rodents with a semiaquatic habit, occurring in Central and South Americas, from east of the Andes to the mouth of the Paraná River (Nowak & Paradiso, 1992; Moreira & Pinheiro, 2013). In Brazil, they present a wide distribution (Silva, 1994; Moreira & Pinheiro, 2013), representing one of the wild fauna species with great potential for commercial breeding because of their rusticity, reproductive efficiency, and diversified feeding habits (Marvulo et al., 2002; Moreira & Pinheiro, 2013).

Humans changed the environment such that natural control of the capybara populations was altered (Ferraz, 2001; Pinto, 2003). Changes included expansion of cities and increased agriculture activities, as well as hunts of capybara predators and reduction of capybara hunting (Moreira & Macdonald, 1996). Still, capybaras quickly adapted to these changed conditions, shifting to habitats that presented constant water conditions such as rivers, lakes, and estuaries (Redford & Eisenberg, 1992).

This capybara species' ecological association with humans (i.e., synanthropy) can be etimental because these animals are reservoirs for several zoonotic pathogens (Marvulo et al., 2002; Siembieda et al., 2011); for example, *H. hydrochaeris* is a reservoir of *Trypanosoma evansi*, which affects mainly horses, and several *Rickettsia* spp., which are vectors of *Leptospira interrogans* and cause spotted fever, a disease that may infect humans and domestic animals (Muñoz & Chavez, 2001; Labruna et al., 2002).

A parasitological investigation of capybaras is justified to increase knowledge about the parasites that use this rodent as a host (parasitological interest) and to identify which of these parasites may be responsible for causing diseases in humans, such as *Fasciola hepatica* (public health interest), and in livestock, which might lead to commercial loss (Moreira & Pinheiro, 2013).

Endoparasites of capybaras include species from the following groups: Cestode such as *Monoecocestus* sp. (Proudman & Trees, 1999); Digenea such as *Hippocrepis hippocrepis* (Sinkoc et al., 2009); and Nematoda such as *Strongyloides* sp. (Costa & Catto, 1994; Sinkoc et al., 2004). The latter includes parasites that use fishes as intermediate hosts, which also have been described as infecting reptiles, amphibians, birds, and mammals (Eiras, 2005; Dyková et al., 2007; Prunescu et al., 2007; Bartholomew et al., 2008).

The life cycle of the Mixosporids is complex and poorly understood. In the case of some genera, it is necessary for its development to have an annelid oligochaete (*Tubifex tubifex*), present in an aquatic environment, as an intermediate host (Markiw & Wolf, 1983). Since capybaras stay for very long periods in water, it is biologically likely that this species may be suitable as host for Myxozoa.

Our research aimed at qualitatively analyzing the endoparasite fauna of *H. hydrochaeris*, collected from wild, healthy populations on the upper Paraná River floodplain, PR/MS, Brazil. We also discuss the dangerousness of inserting and maintaining these animals synathropically with human populations and livestock.

Methods

Study Area

The study was conducted on the upper Paraná River floodplain (22° 40' to 22° 45' S and 53° 15' to 53° 25' W) (Figure 1). On this stretch, the river presents a braided channel, with reduced declivity (0.09 m/km), an extensive floodplain, and wide

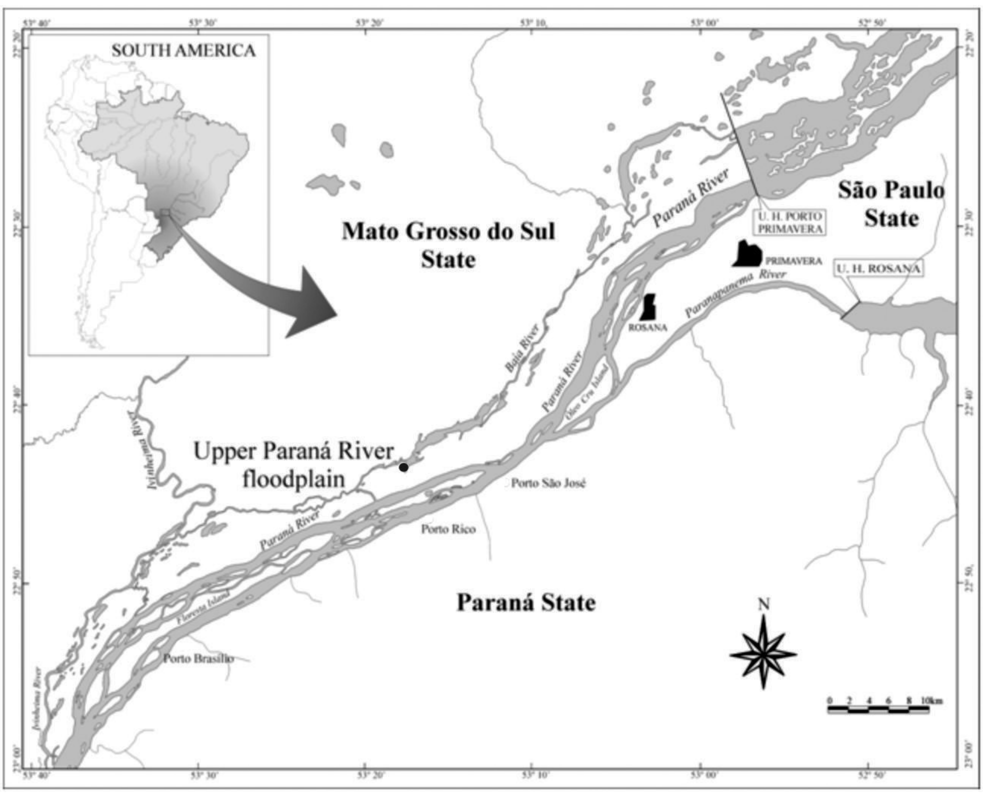

Figure 1. Study area: the high Paraná River floodplain, PR/MS, Brazil; the black spot indicates the collection site.

accumulation of sediments on its bed, with more than 300 small islands (Agostinho et al., 2004). This environment presents abundant aquatic and riparian vegetation, with a broad grazing area—an appropriate location for the establishment of capybara populations.

Host Collection
The capybaras were sacrificed via shotgun along the Baía River in April 2012, with proper authorization of the government (ICMBIO/SISBIO, License No. 28858-1). Necropsies and the confirmation of gender were performed immediately after sacrifice and, on the Advanced Base of Research of NUPÉLIA (Research Nucleus of Limnology, Ichthyology and Aquiculture), county of Porto Rico, State of Paraná, analyses of internal organs were performed. The necropsies were conducted according to pathological analysis protocols for wild mammals (Quse & Falzoni, 2008).

Parasite Collection
After removing the gastrointestinal tract, portions of the stomach, small and large intestine, caecum, and colon-rectum were isolated with hemostat tweezers and analyzed separately on plastic trays. Each capybara had eyes, brain, kidney, bladder, lungs, heart, reproductive organs, and body cavities (i.e., oral, thoracic, abdominal, and cranial) examined in order to detect the presence of parasites. For Myxozoa detection, all organs were carefully inspected under a stereomicroscope (Zeiss Stemi SV6, ×20 magnification). For detection of plasmodium, the contents of the gallbladder were centrifuged for 5 min in a Servall angle centrifuge type XL; timing began after a maximum of approximately 4,800 revolutions/min. The contents were then examined under an optical microscope to detect spores (Eiras et al., 2006).

According to Eiras et al. (2006), the digeneans were placed between glass slides for dorsoventral compression and then fixed in 5% formaldehyde solution. The cestodes were fixed in heated formalin 5%; both groups were stained using the technique of Hydrochloric Carmine. The nematodes were fixed in heated formalin 5% and mounted on slides.

Data Analysis
Identification of parasites was based on morphological characteristics, following taxonomic keys for helminth mammal parasites and related papers (Khalil et al., 1994; Gibson et al., 2005; Anderson et al., 2009; Gibbons, 2009). The parasite indices were calculated according to Bush et al. (1997).

Results

Of the 10 analyzed animals, all were adults; eight were males and two were females; and one of the females was at an advanced gestational stage. The fetuses and the placenta were analyzed only for metazoan parasites following the same methodology used for adults, and no transplacental transmission was confirmed.

The endoparasites found represented three taxonomic groups, and all adult hosts were parasitized by at least one digenean and one nematode species. The parasite community was composed of 10 species of parasites (Table 1). Of these 10 species, four were digeneans: *Hippocrepis hippocrepis* (Diesing, 1851), *H. fuelleborni* (Travassos & Vogelsang, 1930), *Philophthalmus lachrymosus* (Braun, 1902) and *Taxorchis schistocotyle* (Fischoeder, 1901); four species of cestodes: *Monoecocestus macrobursatum* (Rego, 1961), *Monoecocestus* sp., *M. hydrochaeri* (Baylis, 1928), and a specimen of the Anoplocephalidae; and two nematode species: *Protozoophaga obesa* (Diesing, 1851; Travassos, 1923) and *Strongyloides* sp. (Grassi, 1879). No Myxosporea were observed in the samples.

Table 1. Endoparasite species recorded in capybaras (*Hydrochoerus hydrochaeris*) from Paraná River floodplain

Parasite group	Parasite species
Digenea	*Hippocrepis hippocrepis*, Diesing, 1851
	Hippocrepis fuelleborni, Travassos & Vogelsang, 1930
	Philophthalmus lachrymosus, Braun, 1902
	Taxorchis schistocotyle, Fischoeder, 1901
Cestoda	*Monoecocestus* sp.
	Monoecocestus macrobursatum, Rego, 1961
	Monoecocestus hydrochaeri, Baylis, 1928
	Anoplocephalidae
Nematoda	*Protozoophaga obesa* (Diesing, 1851), Travassos, 1923
	Strongyloides sp., Grassi, 1879

The most abundant species, with a prevalence of 100%, were *Taxorchis schistocotyle* and *P. obesa*, followed by *M. hydrochaeri* and *M. macrobursatus* (70 and 50%, respectively). *Hippocrepis fuelleborni* were present at 30%; *H. hippocrepis* at 20%; and *P. lachrymosus*, *Monoecocestus* sp., *Strongyloides* sp., and the Anoplocephalidae cestode at 10% each (Figure 2).

Despite this high richness, parasite distribution was different among the analyzed hosts (Figure 3), with only two hosts presenting a parasite richness of six species; the parasite communities of capybara 1 and 3 were slightly different from the other hosts.

Three digenean species were present in the gut: the two *Hippocrepis* spp. were recorded in the small intestine, and *T. schistocotyle* was distributed throughout the intestinal lumen. *Philophthalmus lachrymosus* was present in the vitreous humor of only one host, with an intensity of three parasites.

All Cestoda and Nematoda species were found in the gastrointestinal tract, especially in the small intestine, large intestine, and intestinal cecum. However, the specimens classified as Anoplocephalidae and *Strongyloides* sp. showed low intensity—of one and six specimens, respectively. *Protozoophaga obesa* was found parasitizing the pyloric region of the stomach for all hosts.

Discussion

The capybara is the largest living rodent in the world and, as a generalist herbivore, adapts well to various environmental conditions, particularly to the floodplains. All endoparasites found in this study had been previously recorded for the capybara (Sinkoc et al., 1995, 2004, 2009; Ribeiro & Amato, 2003); however, this is the first evaluation of parasites in wild populations in the floodplain of the upper Paraná River. Gastrointestinal parasites of the capybara are not yet fully known in all the places that this host is distributed, and there is plenty to examine regarding their pathogenicity and biological aspects (Truppel, 2009); however, it is likely these parasites cause harm to the host, thereby increasing economic losses on the production system or reducing their ecological fitness in natural environments (Cueto, 2013).

Among the 10 species of parasites, the *P. obesa* had 100% occurrence, similar to the findings of Costa & Catto (1994), Casas et al. (1995), and Salas & Herrera (2004). The presence of eggs, larvae, and adults of *P. obesa* has been confirmed in Argentina, as well as in Brazil, in Porto Alegre, and on the Taim reservoir (Hoffmann et al., 1986; Sinkoc et al., 1995; Santa Cruz et al., 2005; Sarmiento et al., 2005), supporting the hypothesis that this parasite is common to the capybara, with high presence in wild or captive individuals.

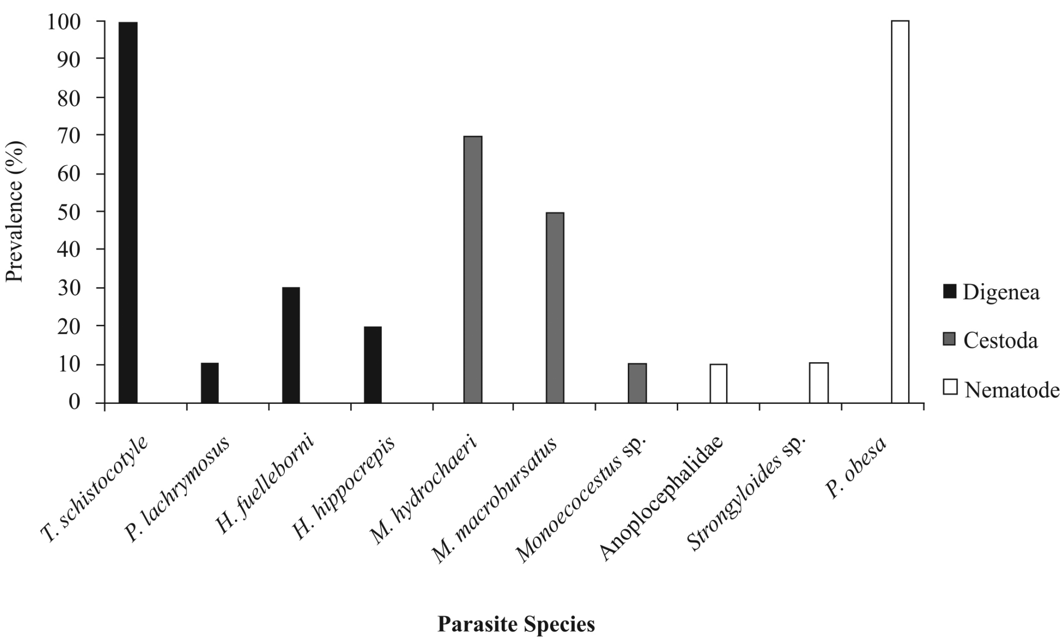

Figure 2. Percentage occurrence of the parasite fauna found in capybaras (*Hydrochoerus hydrochaeris*) from the high Paraná River floodplain, PR/MS, Brazil, collected in April 2012

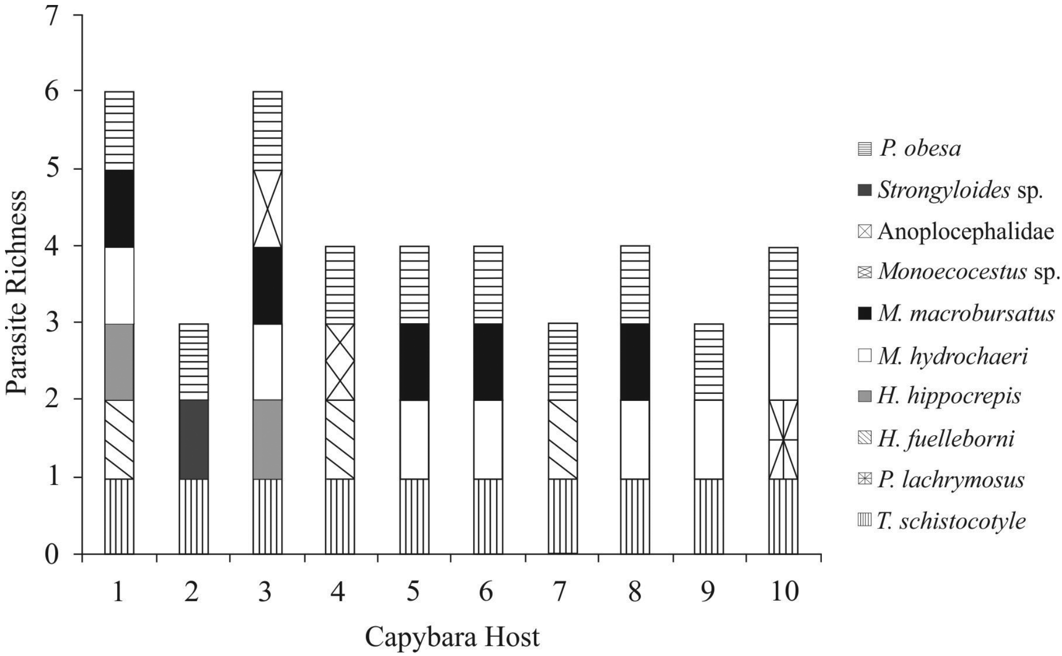

Figure 3. Distribution and diversity of the endoparasites of capybara from the high Paraná River floodplain, PR/MS, Brazil, collected in April 2012

The high parasite prevalence and intensity may be related to the large amount of eggs produced by females of *P. obesa*, promoting greater viability for infection (Sinkoc et al., 2009). The morphological features of the eggs with their wraps and resistant binder substance provide greater environmental resistance (Ribeiro & Amato, 2003). Salas & Herrera (2004) suggested that *P. obesa* might be a symbiont, not a parasite, since this species has a high intensity in capybaras sampled in different countries without showing any major health effects on hosts.

Protozoophaga obesa and *Strongyloides* sp. are Oxyuridae, pinworms already described infecting wild capybara in South America (Ribeiro & Amato, 2003; Sinkoc et al., 2004), but this is the first record in the Paraná River basin. The percentage found for *Strongyloides* sp. (10%) was lower from those reported by Costa & Catto (1994), *S. chapini* (47.8%), and Sinkoc et al. (2004) (28.71%).

Ribeiro & Amato (2003) have shown that female pinworms migrate from the primary site of infection (cecum and colon) to the anus of the host, releasing a viscous fluid full of eggs in this location, which adhere to the perianal region of the animal. This explains the presence of both the *P. obesa* and *Strongyloides* sp. parasites all the way from the stomach to the anus. The great amount of eggs that is aggregated to this binder substance indicates that the eggs are released into the environment. Thus, the cycle would be completed when capybaras eat in a pasture full of aggregated eggs or through the coprophagic habit presented by capybaras (Urquhart et al., 1998).

The presence of *Strongyloides* sp. on the hosts analyzed herein also poses a zoonotic problem. Several studies have reported the presence of *Strongyloides* sp. on humans (McCarthy & Moore, 2000; Mafuyai et al., 2013), a highly important infection primarily because of its potential for serious and even lethal disease in immunosuppressed patients, causing severe diarrhea (Coker et al., 2000). Moreover, these parasites had shown small specificity to other mammal hosts, either in the wild or on domestic species (Dillard et al., 2007; Mafuyai et al., 2013), a factor which may be responsible for zoonosis' borne infections as the floodplain of the upper Paraná River represents a tourism area, showing alterations of the environment, and an increase of human populations and their movements, leading to an increased contact between humans and infected animals (Brown, 2004). The zoonotic potential of *Strongyloides* sp. was previously described in Dillard et al. (2007) and Olsen et al. (2009).

The percentage of *H. hippocrepis* (20%) was lower than that reported by Sutton et al. (1995) in Argentina (52.9%), Salas & Herrera (2004) (80%), and Sinkoc et al. (2009) (62.5%). In Pantanal, Mato Grosso (Brazil), Costa & Catto (1994) considered this species as potentially pathogenic due to its high infestation intensity (3,832), with a prevalence of 34.8%. However, the prevalence found in this study for this parasite was the same as that observed by Casas et al. (1995) in Bolivia. No previous study reported occurrence of zoonotic issues with this parasite.

The *Taxorchis schistocotyle* habitat is the cecum-colon mucosa, and the presence of this helminth was first reported in Brazil by Travassos (1922). Then, Arantes (1985), Nascimento et al. (1991), Costa & Catto (1994), Bonuti et al. (2002), and Sinkoc et al. (2004) reported this parasite in capybaras from Brazil; Lombardero & Moriena (1973) reported *T. schistocotyle* in Argentina; Tarbes (1980) and Salas & Herrera (2004) reported it in Venezuela; and Casas et al. (1995) reported it in Bolivia.

No previous study reported occurrence of zoonotic issues with *H. hippocrepis* and *T. schistocotyle*, even in places where suitable intermediate hosts showed the potentiality for digeneans (Souza et al., 2008). This work also reported a high number of snail species on the upper Paraná River floodplain, which may explain the high prevalence of Digenea species found in this work when compared with other regions and studies (Lodge et al., 1987; Bavia et al., 1999).

This study also confirmed a new infection site for the *Philophthalmus* parasite, which alerts to the possibility of zoonotic cases. This trematode was already confirmed infecting humans in several parts of the world, including South America (Mimori et al., 1982; Gutierrez et al., 1987; Lang et al., 1993; Lamothe-Argumedo et al., 2003; Waikagul et al., 2006; Literák et al., 2013). More details can be found in Souza et al. (2015).

The oribatid rodents are usually hosts of cestodes from the Anoplocephalidae, and the presence of *Monoecocestus* sp. in the analyzed capybaras indicates favorable conditions to maintain these and other Anoplocephalidae species in the environment analyzed herein. Although Proudman & Trees (1999) established low intensity of this parasitic group in domestic animals, the presence of these parasites should be carefully observed in animal production since parasite intensity is directly related to the fitness of the host.

Although more than 80 species have already been described parasitizing capybaras (Eberhardt et al., 2013), abundance data are scarce because most studies focused on parasite taxonomy. Since parasite abundance may affect rates of reproduction and of survival of infected animals, the relationship between this variable and host characteristics such as body weight and condition are important aspects to be studied (Caughley & Sinclair, 1994), but these factors were not considered in the present study.

The presence of parasites in the intestinal lumen may be an indirect manipulation of the host—for example, by increasing the demand for food simply by reducing the levels of nutrients circulating in the host (Barber & Arnott, 2000). In livestock, the presence of the parasite, added to stressors generated by confinement, may cause the emergence of parasitic diseases and the consequent loss of fitness by the host, representing potential financial losses (Urqhart et al., 1998).

This work provided more information about the parasitic fauna of the capybara, providing a database that enables future inferences of the effects of parasites in the present host. But more studies about the parasite fauna of various Brazilian wildlife animals are necessary as this type of research is of great importance in defining areas of occurrence of these pathogens and for installing control management.

The potential for environmental contamination depends upon a variety of factors, including the number of infected non-human hosts, the number of transmissive stages excreted; agricultural practices; host behaviour and activity; socioeconomic and ethnic differences in human behaviour; geographic distribution; sanitation; safety of drinking water, food sources, and supplies; and the climate and hydrogeology of the area (Slifko et al., 2000). Considering these aspects in the studied area—tourist use of the upper Paraná River floodplain that increases the level of contact between humans and infected animals and the recreational use of untreated water, besides the sociability of the capybaras—turns the insertion and maintenance of these animals into a dangerous, synathropic habit (Brown, 2004).

It is difficult to measure the effect of parasites on hosts since the examination of carcasses may underestimate mortality and other sublethal effects in host reproduction (Holt, 1993). To understand the parasite effects on wild hosts, experiments should be designed with this goal. Otherwise, the examination of carcasses would only provide speculations about these effects. Previous studies have observed that there are degrees of variation in the abundances of helminth among different social groups (Holt, 1993); therefore, future studies on parasite fauna may include a greater number of female and juvenile capybaras besides different social groups.

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