

***Toxocara cati* (zeder, 1800) wild felines on the mountainous region of santa catarina, Brazil**

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Abstract. Wild animals host a wide range of parasites that are agents of primary or opportunistic diseases. Studying wild animals' parasitology is essential since these animals are hosts and reservoirs, influencing the ecosystem and the natural and domestic environment. From August 2007 to 2012, seven adult wild felines were found dead on federal and state highways. Among them, there were three *Puma concolor* (two males and one female), two *Leopardus tigrinus* (one male and one female), and two *Puma yagouaroundi* (two males). *P. concolor* presented the highest rates (56.35%) of parasite infection (111 out of 197), followed by *P. yagouaroundi* accounting 22.34% (44 out of 197) and *L. tigrinus*, which presented 21.32% (42 out of 197). However, about the gender of these parasites, 55.84% (110 out of 197) *T. cati* were females, and 44.16% (87 out of 197) were males. The detection of ascarids in wild felines brings essential contributions for ecology, relationships between parasites, prey, and predators. These species need great extensions for their displacement and search of food and thus pose a threat to domestic carnivores, human health, and, above all, a severe threat to endangered felines such as those presented in this paper.

Keywords: Helminth fauna, conservation, carnivorous, felines

***Toxocara cati* (zeder, 1800) em felinos selvagens na região serrana de Santa Catarina, Brasil**

Resumo. Os animais silvestres hospedam uma ampla gama de parasitas que são agentes de doenças primárias ou oportunistas. O estudo da parasitologia de animais silvestres é essencial, pois esses animais são hospedeiros e reservatórios, influenciando o ecossistema e o ambiente natural e doméstico. De agosto de 2007 a 2012, sete felinos selvagens adultos foram encontrados mortos em rodovias federais e estaduais. Entre eles, havia três *Puma concolor* (dois machos e uma fêmea), dois *Leopardus tigrinus* (um macho e uma fêmea) e dois *Puma yagouaroundi* (dois machos). *P. concolor* apresentou as maiores taxas (56,35%) de infecção parasitária (111 em 197), seguido por *P. yagouaroundi* com 22,34% (44 em 197) e *L. tigrinus*, que apresentou 21,32% (42 em 197). No entanto, quanto ao sexo desses parasitas, 55,84% (110 de 197) de *T. cati* eram fêmeas e 44,16% (87 de 197) eram machos. A detecção de ascarídeos em felinos selvagens traz contribuições essenciais para a ecologia, relações entre parasitas, presas e predadores. Essas espécies precisam de grandes extensões para seu deslocamento e busca de alimentos e, portanto, representam uma ameaça aos carnívoros domésticos, à saúde humana e, acima de tudo, uma grave ameaça aos felinos ameaçados de extinção como os apresentados neste artigo.

Palavras-chave: Helminthos, fauna, conservação, carnívoros, felinos

Introduction

Information about parasites' occurrence, distribution, and characteristics prevents different epidemical situations, especially zoonoses ([Alves et al., 2005](#); [Symeonidou et al., 2018](#)). In addition, identifying zoonotic parasites reveals details on the relationships between humans, parasites, and the environment, including additional hosts. However, the field still lacks essential information at the macro and micro epidemiological levels ([Macpherson, 2005](#)).

Wild animals are hosts to a wide range of parasites, which are primary or opportunistic disease agents. Therefore, the study of wild animal parasitology is crucial since these animals act as hosts and reservoirs, influencing the natural and domestic environments ([Santos et al., 2015](#)). Furthermore, disease-causing parasites are significant in wild animals, representing a threat to these animals' management and recovery programs, especially for animals threatened with extinction ([Santos et al., 2011](#)).

Infected animals, especially wanderers, can lay helminth eggs in the soil, acting as a source of infection for other animals and humans. Therefore, the type of soil is a relevant risk factor for human parasitic disease. The eggs and larvae need optimal temperature and moisture for their survival. These conditions are found in clayey soils that retain water. Ascarid eggs develop well in this type of soil, concentrating under the surface, mainly in the form of larvae, remaining viable and protected from solar radiation ([Quadros et al., 2014](#)).

The nematodes from the Ascarididae family, subfamily Ascarinae, comprise 21 species ([Despommier, 2003](#)). *Toxocara* and *Toxascaris* genera have the most epizootic importance among predatory mammals of the Canidae and Felidae families. Several studies indicate the occurrence of *Toxocara canis* (Werner, 1782) and *Toxascaris leonina* (Von Linstow, 1902) in domestic and wild canids, as well as *Toxocara cati* (Zeder, 1800) and *Toxascaris leonina* in felids. Although human infections with *T. canis* and *T. cati* are common worldwide, *T. leonina* larvae can cause human diseases such as emerging zoonoses ([Okulewicz et al., 2012](#)).

In many temperate countries, toxocarasis is a common helminthic infection. The nematode with varied biological characteristics such as paratenic hosts, irregular migration, and hypobiosis can contribute to its presence in animals and man. However, it also gives the ability to infect a wide range of hosts such as invertebrates and poultry ([Galvin, 1964](#)).

The human disease known as visceral larva *migrans* (VLM) is caused by larval stages that invade the musculature, brain, and eyes. However, immunological mechanisms seem to be ineffective in eliminating the infection. This lack of immune responsiveness may be due to the release of lectins, mucins, and enzymes that seem to interact and modulate host immunity ([Maizels, 2013](#)).

Human infections by *T. canis* or *T. cati* occur by accidental ingestion of embryonated eggs of these intestinal carnivore parasites, found in soil and sand contaminated with feces of these animals. The ingested eggs hatch in the small intestine, the larvae penetrate the mucosa and, through the circulation, reach different tissues, mainly the liver ([Marchioro et al., 2011](#)). Besides ingesting embryonated eggs, people can also acquire the infection by ingesting larvae in undercooked meat or viscera of infected paratenic hosts, such as chickens, ruminants, or pigs ([Overgaauw & van Knapen, 2013](#)).

VLM is an infectious disease with a nonspecific clinical presentation, which can evolve with systemic complications in vital organs such as the eye, liver, and central nervous system. Detection of anti-Toxocara IgGs by ELISA methods allows the disease diagnostic ([Carvalho & Rocha, 2011](#)). VLM may have manifestations such as cough, fever, abdominal pain, hepatomegaly, and skin lesions. Severe infections can cause severe respiratory, cardiovascular, neurological, and eye infections that lead to amaurosis ([Machado & El Achkar, 2003](#)).

The identification of parasitic fauna is required in wild animal reintroduction protocols ([IUCN, 1998](#); [FELASA, 1999](#)) and in the clinical routine of these animals, as the potential for infection of these parasites for domestic animals and the zoonotic potential must be considered ([Sibaja-Morales et al., 2009](#)). Given the above, this study aimed to identify the family Ascaridae parasites in wild cats from the Serrana region, Santa Catarina, Brazil.

Material & methods

From August 2007 to September 2012, seven adult wild cats, three *Puma concolor* (two males and one female), two *Leopardus tigrinus* (one male and one female), and two *Puma yagouaroundi* (two males) ([Figura 1A-C](#)) were found dead from roadkills on federal and state highways in the Santa Catarina mountain range according to [figure 2](#).



Figura 1. Dead felines run over on federal and state highways in the Santa Catarina mountain range. A. *Puma concolor*. B. *Leopardus tigrinus* e C. *Puma yagouaroundi*

The animals were rescued by the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA) and sent to the Zoology and Parasitology Laboratory of the University of Planalto Catarinense (UNIPLAC) for necropsies.

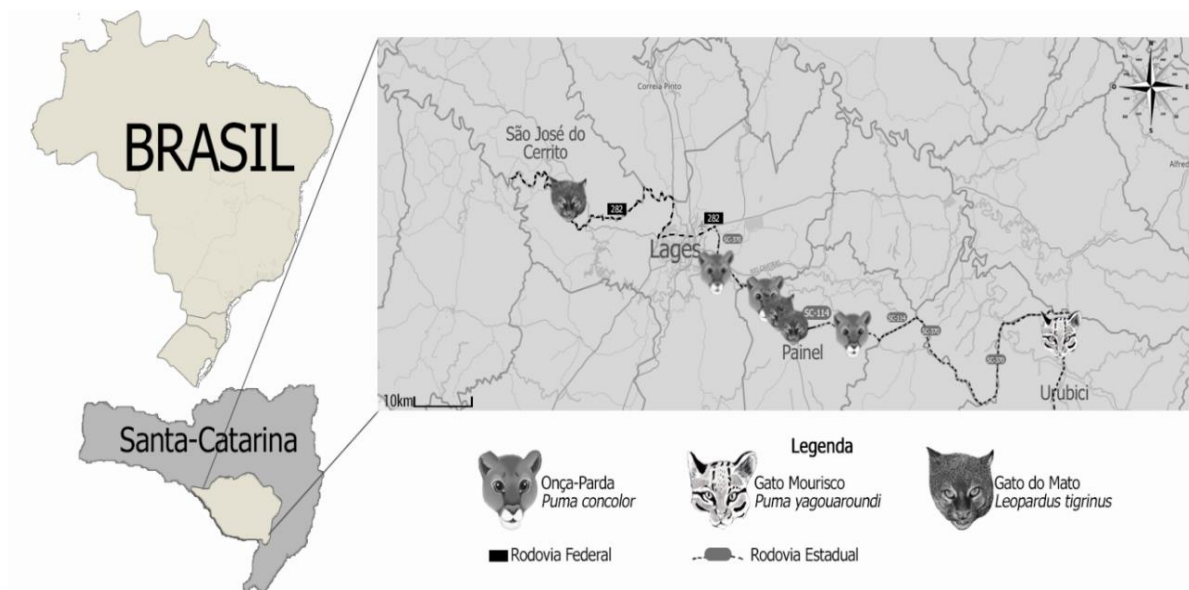


Figure 2. The geographical location of dead felines run over on federal and state highways in the Santa Catarina mountain range.

After the animals' necropsy, the viscera were removed, the stomach and intestinal contents were sieved, and the parasites were collected and stored in 70% alcohol.

Ascarid helminths were analyzed according to the lateral expansions of the cuticle (cervical wings). In contrast, regarding gender determination, the difference in the caudal region of males was used with the digitiform appendix ([Okulewicz et al., 2012](#)).

Results

From seven necropsied felines, were collected 197 specimens of *Toxocara cati*. The species that presented the highest infection of the parasite was *P. concolor* with 56.35% (111 out of 197), followed by *P. yagouaroundi* with 22.34% (44 from 197) and *L. tigrinus* with 21.32% (42 out of 197). The parasitological infection by *T. cati* concerning the felines is represented in [table 1](#).

In [Okulewicz et al. \(2012\)](#), the cervical wing on *T. cati* ([Figure 3A](#) and [B](#)) ends as an abrupt form according to [figure 3A](#) and [B](#).

Table 1. Occurrence of *Toxocara cati* in seven felines run over on highways in the mountainous region, Santa Catarina, Brazil

| Specie | Specie | | | Total |
|----------------------|--------------------|--------------------|-------------------------|-------|
| | <i>P. concolor</i> | <i>L. tigrinus</i> | <i>P. yagouaroundsi</i> | |
| <i>Toxocara cati</i> | 111 | 42 | 44 | 197 |

The study about run-over felines showed that 55.84% (110/197) *T. cati* were females and 44.16% (87/197) males.

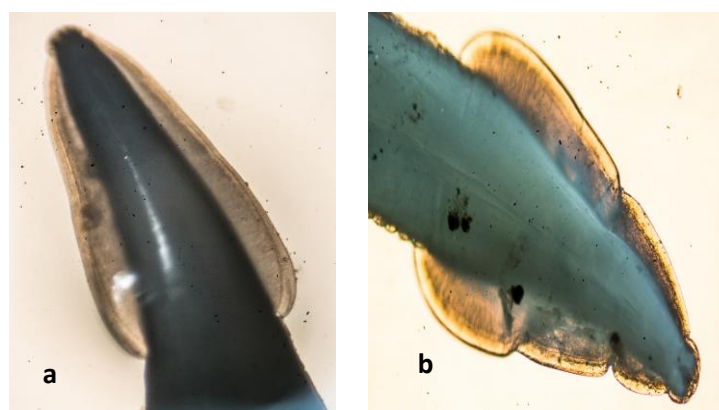


Figure 3. Representation of the cervical wing from *T. cati* (a, b).

Discussion

The conservation of the environment is a global priority, and animal health is critical to preserving wild species ([Deem & Emmons, 2005](#)). However, habitat loss, fragmentation, and the exploitation of many species constitute a growing trend that exposes problems arising from biodiversity conservation ([Jorge et al., 2010](#)).

The infections depend on the parasite species, load, nutritional status, physiological conditions, and host-immune response. Such animals are present in nature. Therefore, their health status cannot be accurately estimated. However, the presence of pathogenic organisms can have adverse effects on the host that can lead to population decline and often generate disastrous consequences for wildlife ([Pedersen et al., 2007](#)).

Wild felines need large areas for movement and survival due to territorial habits. Therefore, they may contact domestic dogs when they move to human use or when dogs enter natural areas. Thus, the transmission of parasites from domestic dogs to wild animals can constitute an anthropogenic effect that affects populations that should be protected ([Woodroffe et al., 2004](#)). Furthermore, stray domestic dogs can also compete with wild canids for food ([Ritche et al., 2013](#)). Regarding the probability of human infection, [Artois et al. \(2001\)](#) mention that increasing human occupation often favors contact with wildlife. This contact can spread infectious diseases to wild animals.

Among the different groups of parasites with zoonotic characteristics, the genus *Toxocara* spp. stands out due to its zoonotic element and wide distribution among domestic and wild animals. The nematodes of the Ascarididae family of the genera *Toxocara* and *Toxascaris* are of significant epizootic relevance among predatory mammals of the Canidae and Felidae families. The location of these parasites in the definitive hosts, their morphology, and the measurements of eggs and adult parasites are similar. Furthermore, many studies indicate a mixed occurrence between *T. canis* and *T. leonina* in domestic and wild canids, such as in *T. cati* and *T. leonina* in felids. Although human infections with *T. canis* and *T. cati* are common worldwide, *T. leonina* larvae can cause human diseases such as emerging zoonoses ([Okulewicz et al., 2012](#)).

Host habitat is the factor that appears to significantly impact the incidence of infection by carnivores by the genera *Toxocara* and *Toxascaris*. For example, [Reperant et al. \(2007\)](#) demonstrated in their study

in Switzerland that up to 59.6% of foxes in rural areas were infected with *T. leonina*, whereas in urban areas, only 8%, which indicates that the diagnosis of this species decreases due to urbanization, which is not observed on *Toxocara* genus. Also, soil contamination by *Toxocara* eggs has been found in more urban than rural areas due to the higher density of domestic carnivores ([Mizgajska, 1997](#)).

The occurrence of *Toxocara* spp. and *T. leonina* in definitive hosts is highly variable and depends on several factors: climate, environmental conditions, age of hosts, and time of year. This applies to infected wildlife as well as domestic animals ([Okulewicz et al., 2012](#)). [Morgan \(2000\)](#) cites the existence of mixed infections of *T. canis* and *T. leonina* in dogs and *T. cati* and *T. leonina* in cats.

Climatic conditions such as temperature, humidity, and soil type also influence the survival of eggs in the environment ([Parsons, 1987](#)). However, ascarid eggs are highly resistant and can survive for years in the background ([Gillespie et al., 1991](#)). The degree of soil contamination reflects the prevalence of ascarids in dogs and the density of the dog population in a given area ([Glickman & Schantz, 1981](#)).

Although *T. cati* has a worldwide distribution, especially causing affections in dogs and cats, the epidemiological occurrence in dogs is discussed. Knowing the importance of paratenic hosts would provide knowledge about the transmission routes for the definitive hosts, especially in different environments, whether wild or urban. Still, little information exists about the species of paratenic hosts that infect wild carnivores ([Vega et al., 2018](#)). Although *T. leonina* is described in feral cats, these species that were necropsied and analyzed did not find this ascarid.

The consumption of raw or undercooked viscera and tissues from infected animals can be an important source of infection ([Lim, 2012](#)). For example, [Taira et al. \(2004\)](#) verified that in chicken meat experimentally infected with *T. cati* larvae, they were infected for up to 28 days, even when kept at a temperature of 4° C. In human infection, the parasite can affect various organs such as the liver, lungs, kidneys, heart, striated muscle, nervous system, and eyeball ([Von Söhsten & Silva, 2015](#)).

[Kayes \(1997\)](#) states that the socioeconomic pattern is not significant as a risk factor for toxocariasis. Still, for some authors, there is a significant association between positive serology and socioeconomic indicators. So, therefore, is a high prevalence in regions with low purchasing power, low rate of urbanization, and part of the population without access to sanitary conditions ([Kanafani et al., 2006](#)).

Analyzes of parasite biodiversity in wild animals inside conservation areas can be significant health indicators of these ecosystems, reflecting the phylogeny, parasite versus host conditions, and evolutionary pressures on both in the environment. On the other hand, it can also enable the observation of migrations, know the diet of species, habits, and behavior of hosts. Therefore, it is of extreme importance to understand the parasitic fauna in wild carnivores, especially for the maintenance of preserved environments, and to ensure the environmental health of the populations that divide the area, especially those that involve conservation efforts because of the risk situation, such as the case of *P. concolor* and *P. yagouarondi*, considered endangered species in Brazil ([Wrublewski et al., 2018](#)).

Conclusion

The study of ascarids in wild cats brings essential contributions to ecology, allowing to observe the relationship between parasites, prey, and predators. The study also shows the importance of a loss of environmental fragmentation since these species need large extensions for their displacement and search of food and thus may present a threat to domestic carnivores, to human health and, above all, a severe threat to felids at risk of extinction such as those shown in this work.

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