Research Article

Toxocara spp. Prevalence and Risk Factors in Cats from Mexico

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Abstract |Information regarding infection and risk factors for endoparasites, such as helminths like *Toxocara*, is crucial for implementing effective control programs. The objective of this study was to assess the current prevalence and risk factors for *Toxocara* spp. in cats. A total of 3695 fecal samples from cats of all ages, genders, breeds, clinical conditions, and origins, representing 31 out of the 32 states of the Mexican Republic, were included. *Toxocara* presence was assessed using the direct smear technique and Faust centrifugation-flotation with a 33% saturated solution of zinc sulfate. The overall prevalence of *Toxocara* was 33.09%. A significant association was observed (Chi2= 73.22, p= 0.0001) between age and positivity for this nematode. Access to the outdoors exhibited a strong association (Chi2= 48.31, p= 0.0001) with *Toxocara* spp. prevalence and was identified as a risk factor (OR= 1.63, p= 0.0001). Additionally, farm-raised cats also showed an association (Chi2= 15.26, p= 0.001) with *Toxocara* prevalence in feces. Younger cats exhibited an association with *Toxocara* spp. (Chi2= 6.31, p= 0.04) and were identified as a risk factor (OR= 1.20, p= 0.01), indicating a higher likelihood of *Toxocara* spp. presence in feces. Cats with soft feces were 1.78 times more likely to test positive, and the presence of parasites in feces was strongly associated with *Toxocara* spp. prevalence (Chi2= 67.97, p=0.0001) and identified as a risk factor (OR= 2.12, p=0.0001). It is crucial to implement effective therapeutic and environmental management strategies, along with hygiene procedures, for the proper control of this parasite.

Keywords | Cats, Zoonosis, Risk factors, Parasite

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INTRODUCTION

Cats (*Felis catus*) have been one of the most widespread and beloved companion animals, with a history of association with humans dating back approximately 8,000 to 10,000 years ago (Merola et al., 2015). The interest in acquiring these animals has grown, with the adoption of street animals becoming common. Additionally, there has been an increasing trend of humanization of pets, which has facilitated the transmission of anthropozoonotic and zooanthroponotic diseases (Fantinatti, 2019). Felines play a crucial role in the epidemiology of zoonotic parasites (Beigi et al., 2017), with *Toxocara cati* being the most common gastrointestinal helminth in cats globally (Coati *et al.*, 2004). It is closely related to *T. canis*, the intestinal worm of dogs, and more distantly to *Toxocaris leonina*, which affects both cats and dogs (Fisher et al., 2003).

Toxocara spp. generally do not cause pathological changes in the definitive host species (Macpherson, 2013). In dogs, *Toxocara canis* is considered by public health authorities as

a dangerous zoonosis (Fisher et al., 2003). While *Toxocara* in cats has been suggested to play an important role in human health (Yagoob et al., 2015). *T. cati* has rarely been associated with human cases due to cats' defecation habits (Sommerfelt et al., 2006). The primary source of *Toxocara cati* infection is the eggs passed into the environment by infected cats. However, since the eggs are resistant to degradation and sterilization, the environment serves as a reservoir of infection (Pezeshki et al., 2013).

Infection by ingestion of larval eggs of the genus *Toxocara* spp. in humans is known as Toxocariasis, which is considered an accidental or aberrant host. Therefore, *Toxocara* larvae cannot develop into adult worms inside the human body (Benavides et al., 2017; Chen et al., 2018). The presence of a few larvae can cause well-characterized syndromes, including visceral larva migrans (VLM), ocular larva migrans (OLM), and covert toxocariasis (CT) (Bakhshani et al., 2019). Infection in humans can be acquired by ingesting embryonated/larvated eggs present in contaminated sources such as soil, food, or cat fur. It can also occur by ingesting encysted larvae of this nematode in undercooked or raw meat from paratenic hosts. Close contact with animals, habits such as onychophagia, and geophagia can favor the accidental ingestion of *Toxocara* eggs (Yagoob et al., 2015; Chen et al., 2018; Bakhshani et al., 2019; Barrios et al., 2020).

Martínez-Barbosa et al. (2003) evaluated the prevalence of *T. cati* in cats in Mexico City, finding it to be 42.5% in 2003. The global prevalence of *Toxocara* infection in cats has been estimated at 17%, with the African region showing the highest prevalence (43.3%), while the South American region the lowest (12.6%) (Rostami et al., 2020). In North American countries, a *Toxocara* prevalence of 18.3% has been found, with Mexico accounting for an estimated 24.5% of *Toxocara* infections in cats (Rostami et al., 2020). Two recommended measures to control this parasite are regular anthelmintic treatment or coproparasitoscopic monitoring (Fahrion et al., 2011). In areas where climatic and environmental conditions are conducive to the survival of *Toxocara* eggs in the soil, such as adequate humidity and temperature, the parasite load in the environment can be high (Symeonidou et al., 2018). On the other hand, in places where the population of stray or uncontrolled cats is high, there is a greater probability of spread of parasites such as *Toxocara* due to the lack of control and management measures for cat populations Nijsse et al. (2016). Also, in some areas, there may be a lack of awareness or limited access to cat deworming medications, resulting in a low frequency of deworming and a higher prevalence of *Toxocara* infections (Borji et al., 2011; Beugnet et al., 2014). In environments where cats have close contact with humans, such as in densely populated urban areas or where cats are common household pets, there is an increased risk of transmission of *Toxocara* to humans. Some studies reveal that the lack of adequate hygiene practices, both in cats and in the people around them, can increase the likelihood of environmental contamination with *Toxocara* eggs and subsequent infection (Takeuchi-Storm et al., 2014; Genchi et al., 2021). In the present study, we aimed to assess the current prevalence and risk factors for *Toxocara* spp. in cats of the Mexican Republic, as they represent a potential zoonotic reservoir. Thus, effective prevention of infection in humans and cats is possible.

MATERIAL AND METHODS

A total of 3695 samples from felines of any age, gender, breed, clinical condition, and origin, representing 31 of the 32 states of the Mexican Republic, were collected between June and December 2019. The collection involved 337 veterinary doctors from 195 veterinary offices, clinics, and hospitals. Samples were directly obtained from the rectum, litter boxes, and feline housing, then placed in plastic bags and processed promptly. The samples underwent analysis using the direct smear technique (Hooshyar et al., 2019) and Faust centrifugation-flotation using a 33% saturated zinc sulfate solution (SG 1.18) (Faust et al., 1938).

Statistic Analysis

The data were analyzed using the statistical software JMP 8.0, the variables, being categorical with two or more levels, were analyzed using the chi-square test to determine the level of association between the variables and the prevalence of *Toxocara*. The test of Odds Ratio to establish risk factors related to *Toxocara* in felines.

RESULTS

The prevalence of eggs of *Toxocara* spp. in feces of domestic felines was 33.09%, of the total samples, 2472 were negative and 1223 were positive, a total of 1937 females and 1758 males were registered, of which 1206 were puppies (1 to 6 months), 727 young (7 to 12 months) and 1762 adults (> 13 months), of the 31 sampled states, 25 had *Toxocara* prevalence; Mexico City, Colima, Nuevo León, State of Mexico, Tamaulipas, Querétaro, Aguascalientes, Puebla, Guanajuato, Michoacán, Jalisco, Baja California, Campeche, Tamaulipas, Oaxaca, Nayarit, Hidalgo, Coahuila, Sonora, San Luis Potosí, Yucatán, Guerrero, Chiapas, Tabasco and Chihuahua.

In the result of the association analysis between age and prevalence of *Toxocara* spp. an association was found (Chi2= 73.22 p= 0.0001) between the "puppy" age and being positive for this nematode and, on the contrary, adult age is a protection factor (OR= 0.54 P= 0.0001) as shown

Table 1: Risk factor and association of the prevalence of *Toxocara* with the age and gender of the cats

	Positives n= 1223	%	Negatives n= 2472	%	Chi²	P	OR	P	IC
Age									
≤6 months	486	13.15	720	19.49	73.22	0.0001			
7 a 12 months	275	7.44	452	12.23					
≥13 months	462	12.50	1300	35.18			0.54	0.0001	0.47-0.62
Sex									
Female	652	17.65	1285	34.78	0.58	0.44	0.94	0.49	0.82-1.08
Male	571	15.45	1187	32.12					

Chi-square, OR, Odds ratio, 95% CI, 95% confidence interval, * Significant

Table 2: Habits and their association with the presence of *Toxocara* and risk factors in cats

	Positives n= 1223	%	Negatives n= 2472	%	Chi²	P	OR	P	IC
Lives with other cats									
Yes	898	24.30	1765	47.77	1.66	0.19	1.10	0.19	0.94-1.29
No	325	8.80	707	19.13					
Live with other animals									
Yes	518	14.08	1078	29.31	0.22	0.63	0.96	0.22	0.84-1.11
No	6.91	18.79	1391	37.82					
Hunting habit									
Yes	267	7.31	499	13.66	1.00	0.31	1.08	0.31	0.92-1.28
No	951	26.03	1936	53.00					
Access to the outside									
Yes	563	15.24	847	22.93	48.31	0.0001*	1.63	0.0001*	1.42-1.88
No	659	17.84	1625	43.99					
Brushed									
Daoly	63	1.71	180	4.87					
Weekly	167	4.52	614	16.62	91.36	0.0001*	----	------	---
Monthly	112	3.03	286	7.74					
Never	881	23.84	1392	37.67					

Chi-square, OR, odds ratio, 95% CI, 95% confidence interval * Significant

Table 3: Variables associated with the presence of *Toxocara* and risk factors in cats

	Positives n= 1223	%	Negatives n= 2472	%	Chi²	P	OR	P	IC
Origin									
Adopted	1173	31.76	2339	63.34					
Bought	28	0.76	40	1.08					
Cattery	11	0.30	68	1.84	15.26	0.001*	---	---	---
Unknown	11	0.30	23	0.62					

Chi-square, OR, odds ratio, 95% CI, 95% confidence interval * Significant

Table 4: Stool characteristics and association with *Toxocara* prevalence and risk factor

	Positives n= 1223	%	Negatives n= 2472	%	Chi²	P	OR	P	CI
Color									
Yellow	123	3.33	228	6.17	1.34	0.71	1.10	0.41	0.87-1.38
Light brown	720	19.50	1501	40.64					
Dark brown	269	7.28	530	14.35					
Dark	110	2.98	212	5.74					
Consistency									
Liquid	111	3.00	126	3.41					
Soft	529	14.32	738	19.98	104.64	0.0001*	1.78	0.0001*	1.55-2.06
Firm	509	13.78	1399	37.87					
Hard and dry	74	2.00	208	5.63					
Findings									
Mucus	209	5.66	283	7.67					
Parasites	140	3.79	142	3.85	67.97	0.0001*	2.12	0.0001*	1.66-2.71
Blood	39	1.06	90	2.44					
No findings	833	22.57	1955	52.97					

Chi-square, OR, odds ratio, 95% CI, 95% confidence interval * Significant

in Table 1, the data obtained for gender did not show an association or probability of being a risk factor (Table 1).

Coexistence with other cats and other animals, as well as hunting habits were not associated with prevalence and were not risk factors, on the other hand, having access to the outside did present a strong association (Chi2= 48.31 P= 0.0001) with prevalence of *Toxocara* spp. and it was a risk factor (OR= 1.63 P= 0.0001), as shown in Table 2.

In Table 3 we can see that the farmed felines show an association (Chi2= 15.26 P= 0.001) with the prevalence of *Toxocara* in feces, the type of hair did not present an association, in contrast, the small-sized cats were associated with *Toxocara* spp. (Chi2= 6.31 P= 0.04) and height was a risk factor (OR= 1.20 P= 0.01) having a higher probability of presenting *Toxocara* spp eggs in feces.

The analysis of the characteristics of the feces was carried out, finding that the color had no association, on the contrary, the soft consistency in the feces had a strong association (Chi2= 104.64 P= 0.0001) with the presence of *Toxocara* spp. in feline feces and we consider it a risk factor (OR=1.78 P=0.0001) since felines with soft feces will be 1.78 times more likely to be positive (Table 4), the presence of parasites in feces was highly associated with prevalence of *Toxocara* spp. (Chi2= 67.97 P=0.0001) and having parasites that are observed macroscopically in feces will be a risk factor (OR= 2.12 P=0.0001).

DISCUSSION

Cats from the Mexican Republic seem to be among the high *Toxocara* infections, since in this study it was found that the general prevalence was 33.09%. There is variation in the prevalence of *Toxocara* according to different factors such as the age of the cats, sociodemographic status of the cat owners, location, population size, and various other factors. For example, Cats that have access to the outdoors, especially those that roam freely in areas where other animals defecate, are at greater risk of coming into contact with *Toxocara* eggs present in soil and vegetation, in addition, the lack of regular deworming programs or Low adherence to deworming recommendations may contribute to a higher prevalence of *Toxocara* in cats. Cats that do not receive regular deworming treatment are more likely to harbor and spread parasites. It is important to see that in urban or rural areas with a significant population of stray or uncontrolled cats, the lack of control of the feline population can increase the parasite load in the environment and the prevalence of *Toxocara*. Cat defecation habits, such as disposing of feces in common areas or failure to bury feces, can increase contamination of the environment with *Toxocara* eggs, leading to a higher prevalence of infection. In homes or environments where several cats live together in a small space or in unsanitary conditions, there is a greater risk of parasite transmission between animals, which may contribute to a higher prevalence of *Toxocara*. Interaction with other animals, such as dogs infected with *Toxocara*, can also increase the risk of infection in cats by exposing them to a greater parasite load in their environment (Rostami et al., 2020; Loftin et al., 2019). To our knowledge, this is the first study conducted in 31 states of the Mexican Republic that includes a representative geographic distribution of the general cat population.

Age is a known risk factor for roundworm infections in dogs and cats, with younger animals being more susceptible, which may be partly explained by their inability to mount a sufficient immune response (Nijsse et al., 2016; Ramos et al., 2019) and, consequently, develop more severe clinical signs than older cats (Symeonidou et al., 2018), in addition their mothers can infect them through vertical transmission during pregnancy and lactation (Ramos et al., 2019). Our results confirm this assertion since an association was found to be positive for this nematode in kittens (Nagamori et al., 2018; Tull et al., 2021). However, cats older than 6 years have also been found to be infested by *T. cati*, so immunity is not absolute, and one should be surprised to see roundworms in adult or even old cats (Chalkowski et al., 2019).

In this study it was identified that access to the outside has a significant influence and is a risk factor for *Toxocara* infection. Which coincides with (Symeonidou et al., 2018; Chalkowski et al., 2019; Genchi et al., 2021, Nijsse et al., 2016). However, the hunting habit was not a risk factor for the presence of *Toxocara* in this study.

It has been seen that the coexistence of one or two cats is not a risk factor for the finding of *Toxocara*, instead the high densities of cat populations (more than 3 other cats in the house) can increase the risk of infestation by *Toxocara* (Beugnet et al., 2014). However, in this study, although the prevalence of *Toxocara* was higher (24.3%) in cats that lived with another cat, no significant difference was found even when living with other animals. As in other studies (Nagamori et al., 2018; Hoggard et al., 2019), an effect of gender on the risk of infection by these parasites was not observed either.

Although in this study the type of cat's hair (long or short) did not show to be a risk factor for the presence of *Toxocara*, the weekly brushing habit did show a significant difference (P= 0.0001), for the finding of *Toxocara*. The fur of pets, such as cats, has been mentioned as another important source of embryonated *Toxocara* eggs. The finding of *Toxocara* eggs in cat hair has been variable, with prevalences ranging from 3.4% (Overgaauw et al., 2009) to 22%. However, embryonated eggs are not always found (Öge et al., 2014; Glade et al., 2003; Bissett et al., 2009; Ito et al., 2016).

Soft stool consistency was found to be strongly associated with the presence of *Toxocara* spp. and it was considered a risk factor, so felines with soft feces will have a 1.78 times greater probability of being positive for this nematode, in addition, the presence of parasites in feces was also highly associated with the prevalence of *Toxocara* spp. and finding parasites that are observed macroscopically in feces will be a risk factor. A study by Zanzani *et al.* (Zanzani et al., 2014; Öge et al., 2014; Ramos et al., 2019; Ito et al., 2016), found that dogs and cats that presented gastrointestinal signs presented a prevalence of intestinal parasites close to 45%, however, no significant association was found. Other studies also found no association (Hill et al., 2000; Queen et al., 2011; Sabshin et al., 2012). Even so, it is suggested to carry out a differential diagnosis and periodic stool examination, since there is evidence that anthelmintic treatment can have a positive effect in reducing diarrhea (Zanzani et al., 2014; Kostopoulou et al., 2017; Rostami et al., 2020).

CONCLUSION

Cats can represent an important source of *Toxocara* spp. they can contaminate the environment with parasitic elements and represent a potential threat to other pets and people that share the same habitat. The data presented in this study show that the Mexican Republic is among the highest prevalences of *Toxocara* in cats. Cats with access to the outside, from a cattery and under one month are associated with the presence of *Toxocara* in feces. It is essential to emphasize the importance of performing fecal diagnosis in all cases for the detection of intestinal parasites in cats and to be able to implement effective therapeutic and environmental management and hygiene procedures for the adequate control of this parasite.

CONFLICT OF INTEREST

The authors declares that there is no conflict of interests regarding the publication of this article.

AUTHORS CONTRIBUTION

Camilo RM: Investigation; Project administration; Supervision; Validation; Writing-review & editing; Laura MC: Conceptualization; Resources; Supervision; Validation. Rafael HC: Conceptualization; Project administration; Supervision; Writing-original draft; Validation. Ariadna FO: Conceptualization; Methodology; Writing-original draft; Validation.

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