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Paper



Helminths of small carnivores (Mammalia: Carnivora) from a Tropical Dry Forest in the Colombian Caribbean

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Abstract

Among the least explored yet highly relevant aspects of wildlife health are host–endoparasite interactions, particularly those involving helminths with zoonotic potential. Carnivores are known reservoirs of several such parasites. This study investigates the diversity of gastrointestinal helminths in small carnivores (Mammalia: Carnivora) inhabiting a tropical dry forest ecosystem in the Colombian Caribbean. A total of 60 fecal samples were collected from five species—*Cerdocyon thous*, *Leopardus pardalis*, *Procyon* spp., *Eira barbara*, and *Puma yagouaroundi*—within the Sanguaré Natural Reserve (Sucre, Colombia) and subjected to parasitological analysis. Eleven nematode taxa, two trematode taxa, and three forms morphologically consistent with cestodes were identified. Overall, 56.7% of the samples tested positive for at least one helminth species. The most prevalent parasite was *Spirometra* sp. (20%), followed by *Strongyloides* sp. (18%) and *Toxocara* sp. (13%). Notably, this study constitutes the first report of gastrointestinal helminths in *Procyon* spp. and *Eira barbara* in wild populations in Colombia. The detection of *Spirometra* sp. and *Toxocara* sp.—both genera with known zoonotic representatives—underscores the importance of monitoring parasitic infections in wild carnivores to better evaluate the potential risk of spillover to domestic animals and humans.

Keywords

Gastrointestinal endoparasites, Nematoda, Platyhelminthes, Zoonoses

Introduction

Among the least explored yet highly relevant aspects of wildlife health is the presence of endoparasites and their interaction with potential hosts—an issue of growing importance in the context of public health. Carnivores, in particular, have been identified as key reservoirs for helminths with zoonotic potential (Han et al., 2021; Veronesi et al., 2023). In the face of global environmental change and increased interface between wildlife, domestic animals, and humans, characterizing the diversity and presence of parasitic species is essential for monitoring host population health and mitigating the risk of cross-species transmission (Barroso & Pelayo, 2021).

Such analyses enable early detection of pathogens shared with domestic animals and can support timely intervention in the event of outbreaks. Disruptions in these host-parasite dynamics can have substantial implications not only for wildlife but also for livestock and human communities living in proximity to natural ecosystems (Vallat, 2008).

In Neotropical carnivores, the presence of endoparasites has predominantly been studied in captive individuals (Aranda et al., 2013; Acosta et al., 2015; Beltrán-Saavedra et al., 2008; Vieira et al., 2021) or through the inspection of carcasses, particularly roadkill (Gallas & Fraga, 2011; Lima et al., 2013). While necropsy-based methods generally offer higher taxonomic resolution for parasite identification (Rojas et al., 2024), fecal analysis remains a widely employed, noninvasive technique that facilitates long-term monitoring of both parasite presence and host-parasite interaction dynamics (Barroso & Pelayo, 2021).

In Colombia, research on endoparasites in wild carnivores remains limited and fragmented. Existing studies have focused on a few species, with findings derived mostly from fecal analysis, including the neotropical river otter (*Lontra longicaudis*) (Jaramillo, 2015), ocelot (*Leopardus pardalis*), jaguar (*Panthera onca*), puma (*Puma concolor*), jaguarundi (*Puma yagouaroundi*) (Uribe et al., 2021), crab-eating fox (*Cerdocyon thous*), bush dog (*Speothos venaticus*) (Uribe et al., 2023), and spectacled bear (*Tremarctos ornatus*) (Zárate et al., 2022). Additional insights have been obtained from necropsy studies of ocelots (Muñoz-Rodríguez et al., 2021). Despite these contributions, significant gaps remain regarding the diversity, prevalence, and ecological roles of endoparasites in many carnivore species throughout Colombia.

In this context, the present study aimed to: (1) identify and characterize gastrointestinal helminths in wild carnivorous mammals inhabiting a small fragment of tropical dry forest in Sucre, Colombia; and (2) evaluate the feasibility and reliability of noninvasive fecal sampling for assessing endoparasite prevalence in wild carnivore populations in the region.

Methods

Study area

This study was conducted in the Sanguaré Natural Reserve, located north of the Gulf of Morrosquillo (9.72017° N, 75.67592° W), within the municipality of San Onofre, Sucre Department, Colombia (Figure 1). The reserve encompasses an area of 598 hectares and is part of a Tropical Dry Forest ecosystem characterized by marked seasonality. The climate includes two dry seasons (December–April and July–September) and two rainy periods (April–May and October–November), with an annual average rainfall of approximately 1,000 mm and an average temperature of 27°C (Pizano & García, 2014).

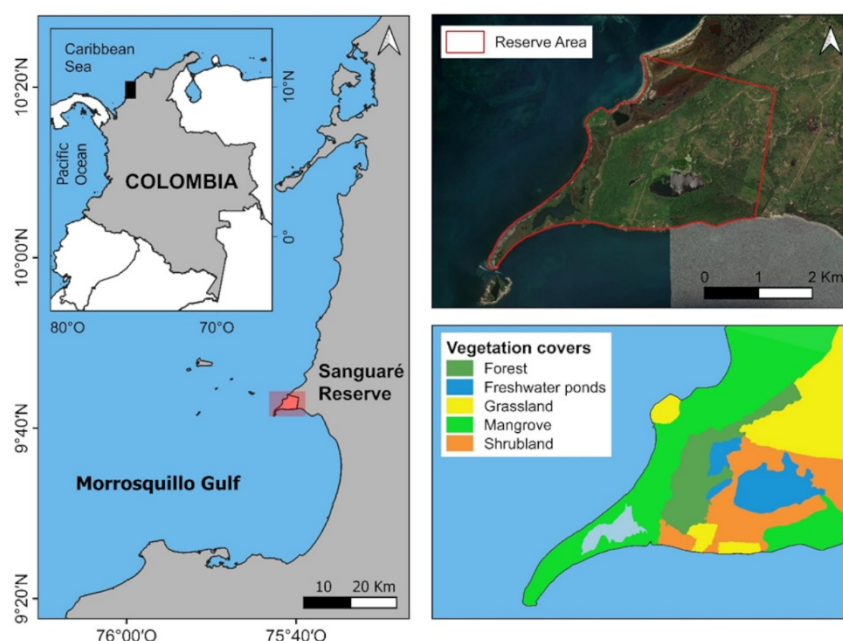


Figure 1. Location of Study site Sanguaré Natural Reserve at Colombian Caribbean coast.

Prior to its designation as a protected area, the land was used for traditional extensive cattle ranching, which involved the removal of native tree cover. Currently, about half of the reserve continues to support sustainable cattle ranching on spontaneously regenerated pastures and tall grasslands. The remaining area comprises 110 hectares of secondary forest, 80 hectares of lagoon systems, and 70 hectares of former grazing land undergoing active forest restoration. The reserve provides habitat for a community of at least 17 species of medium-sized mammals (Díaz-Pulido et al., 2014), offering a valuable setting for ecological and parasitological studies in wildlife.

Collection of excrement and parasitological analysis

Three field expeditions were conducted between April 2019 and February 2020, each lasting seven days. These campaigns corresponded climatically to the dry season (February and June) and the transitional period between the dry and rainy seasons (April). During each expedition, systematic surveys were carried out through four-hour morning walks along various trails within the reserve. To ensure representative sampling, each of the three available habitat types—forest, shrubland, and grassland—was visited twice per session.

Fresh fecal samples were collected daily and identified based on their strong odor and characteristic viscous or liquid consistency. Each sample was assigned to a carnivore species based on morphological traits and contextual field evidence (e.g., tracks and other signs), following identification guides by Aranda (2012) and Borges & Tomás (2008). To avoid contamination with geo-helminths, the portion of each sample in direct contact with the ground was discarded (Beltrán-Saavedra & González, 2008). Samples were placed in plastic containers, labeled with the date and presumptive species of origin, and processed on-site using the spontaneous sedimentation method in 300 mL of water.

Between three to five cycles of resuspension, sedimentation, and supernatant removal were performed until the supernatant appeared clear. The final sediment was transferred using a Pasteur pipette into a 2 mL Eppendorf tube and preserved in 2% glutaraldehyde at a 1:1 ratio. This fixative ensured morphological preservation of parasitic structures across different developmental stages until laboratory examination.

Samples were stored at room temperature and transported to the Study and Control of Tropical Diseases Program (PECET) at the Parasitology Laboratory of the Universidad de Antioquia, Medellín, Colombia. Microscopic examination was conducted within one to three weeks of collection. Parasitic forms were observed under 40× magnification, photographed, and measured. Morphological identification of helminth eggs, larvae, and cysts was performed using established diagnostic keys and descriptions (Gressler et al., 2016; Dib et al., 2020; Vieira et al., 2021; Lignon et al., 2023).

Ethical considerations

This study did not involve the capture or manipulation of animals. The Veterinary Ethics Committee of Corporación Universitaria Remington, in Minutes 007, approved the sampling protocol of February 2019.

Results

A total of 60 fecal samples were collected from five wild carnivore species, including *Cerdocyon thous* (n = 33), *Leopardus pardalis* (n = 11), raccoons (*Procyon* spp.) (n = 14), *Eira barbara* (n = 1), and *Puma yagouaroundi* (n = 1). Due to the difficulty in morphologically distinguishing between the feces of the two raccoon species present in the study area (*Procyon lotor* and *Procyon cancrivorus*), all findings are reported under the genus *Procyon* spp.

Parasitic helminths were detected in 34 of the 60 samples, corresponding to a prevalence of 56.7%. Across the host assemblage, a total of 11 nematode taxa, 2 trematode taxa, and 3 forms morphologically compatible with cestodes were identified (Table I, Figure 2). The most frequently detected parasitic form was *Spirometra* sp. eggs, found in 12 samples (20%), followed by Strongylida-type larvae and eggs in 11 samples (18%), and *Toxocara* sp. eggs in 8 samples (13%).

Helminths (Phylum, Class, Order)	Family	Genus	Carnivore species				
			<i>C. thous</i> (n=33)	<i>L. pardalis</i> (n=11)	<i>Procyon</i> spp. (n=14)	<i>E. barbara</i> (n=1)	<i>P. yagoarou ndi</i> (n=1)
Frequency (number of positive samples)							
Nematoda							
Secernentea							
Ascaridida	Ascarididae	<i>Ascaris</i> sp.	0.09(3)				
		Ascaridid-Type 1 egg		0.09(1)			
		<i>Toxocara</i> sp.	0.09(3)	0.45(5)			1
Rhabditida	Strongylidae	Strongylida-Type egg and larvae	0.21(7)	0.18(2)	0.14(2)	1	
	Oxyuridae	Oxyurid-Type 1 egg	0.06(2)				
		Oxyurid-Type 2 egg		0.09(1)			
Araeolaimida	Trichuridae	<i>Trichuris</i> sp.	0.03(1)		0.07(1)		
		Nematode unidentified egg 1	0.03(1)				
		Nematode unidentified egg 2	0.03(1)				
		Nematode unidentified egg 3	0.06(2)				
		Nematode unidentified larvae	0.03(1)		0.07(1)		
Platyhelminthes							
Trematodes							
Plagiorchiida	Heterophyidae/ Plagiorchiidae		0.03(1)				
		Trematode unidentified egg	0.03(1)				
Cestodes							
Diphylobothriidea	Hymenolepididae	<i>Spirometra</i> sp.	0.24(8)	0.18(2)	0.14(2)		
Ciclophyllidea		Hymenolepid- Type unidentified cyst	0.03(1)				
Cestode unidentified		Cestode unidentified cyst	0.06(2)				

Table 1. Frequency distribution of helminths detected in fecal samples of small carnivores in a Tropical Dry Forest ecosystem, Sanguaré Natural Reserve, Sucre, C.

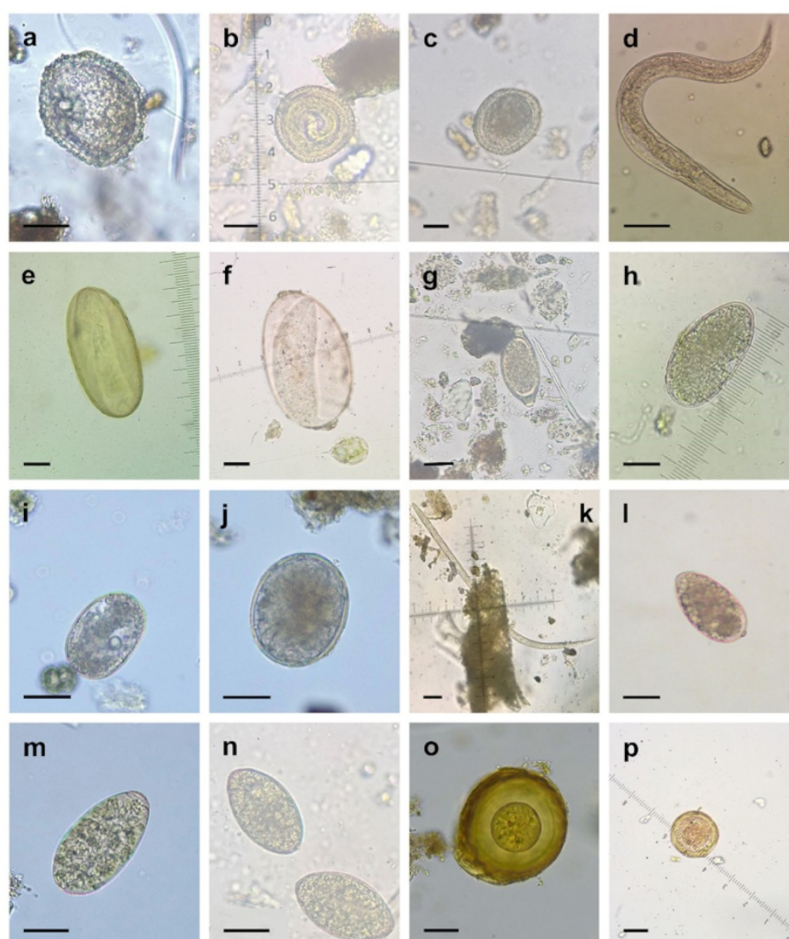


Figure 2. Morphotypes of helminths eggs 400× detected in fecal samples of small carnivores (Mammalia: Carnivora) from a Tropical Dry Forest in the Colombian Caribbean. (a) *Ascaris* sp., (b) Ascaridid-Type 1 egg, (c) *Toxocara* sp., (d) Strongylida-Type larvae, (e) Oxyurid-Type 1 egg, (f) Oxyurid-Type 2 egg, (g) *Trichuris* sp., (h) Nematode unidentified egg 1, (i) Nematode unidentified egg 2, (j) Nematode unidentified egg 3, (k) Nematode unidentified larvae, (l) Heterophyidae/Plagiorchiidae egg, (m) Trematode egg, (n) *Spirometra* sp., (o) Hymenolepid-Type cyst, (p) Cestode unidentified cyst. Scale bar 25 µm.

In terms of parasite richness and infection frequency by host species, *C. thous* exhibited the highest parasite diversity, with 14 distinct parasitic forms identified in 22 out of 33 samples (66.7%). *L. pardalis* followed, with 5 helminth types identified in 5 of 11 samples (45.5%). In *Procyon* spp., 4 helminth forms were found in 5 of 14 samples (35.7%). For both *E. barbara* and *P. yagouaroundi*, one nematode form was identified in each of the single samples collected for those species.

Discussion

This study documents the presence of gastrointestinal helminths in four wild carnivore species inhabiting a tropical dry forest ecosystem in the Colombian Caribbean, using noninvasive fecal sampling. An overall infection frequency of 56.7% was recorded, with 16 helminth taxa identified. Notably, the presence of parasites with zoonotic potential, such as *Spirometra* sp. and *Toxocara* sp., underscores the importance of continued morphological and molecular surveillance of parasitic fauna in wild carnivores, particularly in ecosystems where contact with domestic animals and human populations is frequent.

The carnivore assemblage studied included representatives of the families Canidae, Felidae, Mustelidae, and Procyonidae—mesocarnivores widely distributed across the Neotropics and known to play key roles in ecosystem dynamics (Roemer et al., 2009). Their involvement in pathogen transmission is especially relevant in fragmented habitats (Hollings et al., 2013). To date, no previous study has evaluated endoparasite infection across such a taxonomically diverse assemblage of wild carnivores in the Neotropics. Most available data are derived from isolated records or necropsy-based surveys, often without specific host association (Dib et al., 2020).

The observed infection frequency (56.7%) aligns with previous reports for similar taxa in the region, with prevalences ranging from 37% in Costa Rica (Chinchilla et al., 2020) to 100% in Brazil (Ruas et al., 2008). Seasonal patterns may have influenced transmission, as sampling occurred during dry and transitional periods, when wildlife tend to aggregate around water sources—conditions that increase the likelihood of contact with contaminated environments or intermediate hosts (Gómez-Ruiz et al., 2020). Future investigations should aim to compare infection dynamics across seasons.

In Colombia, studies on gastrointestinal helminths in wild carnivores remain limited and are mostly derived from necropsy data (Muñoz-Rodríguez et al., 2021; Uribe et al., 2021, 2023). While valuable, such approaches preclude calculation of ecological indicators such as prevalence. The present study provides the first noninvasive evidence of helminth infection in *Procyon* spp. and *Eira barbara* in Colombia, offering a critical baseline for long-term monitoring in a highly threatened ecosystem.

In *Cerdocyon thous*, for which a relatively large body of literature exists (e.g., Fiorello et al., 2006; Lima et al., 2013; Uribe et al., 2023), our findings confirm previous records of *Trichuris* spp., *Toxocara* sp., *Strongyloides* sp., and *Spirometra* sp. Additionally, we document the presence of nematodes from the family Oxyuridae, trematodes resembling *Heterophyidae* / *Plagiorchiidae*, and cestodes from the *Hymenolepididae* family—representing new records in this host in Colombia.

In *Leopardus pardalis*, 14 helminth taxa have been previously reported (Patton et al., 1986; Muñoz-Rodríguez et al., 2021; Uribe et al., 2021). Our findings confirm the presence of *Toxocara*, *Strongyloides*, and *Spirometra* sp., consistent with past studies. The *Toxocara* eggs likely correspond to *T. cati*, previously confirmed via necropsy in Colombian ocelots (Muñoz-Rodríguez et al., 2021). However, the Oxyuridae forms observed differ from previously recorded genera (e.g., *Syphacia*), suggesting the potential presence of undescribed taxa that merit further morphological or molecular analysis, possibly using roadkill specimens.

Data on *Procyon* spp. helminths in the Neotropics remain scarce. Previous reports in *P. cancrivorus* include Strongylida-type eggs in captive animals (Vieira et al., 2021; Lima et al., 2021) and *Chandleronema longigutturata* in deceased individuals (Rodríguez et al., 2015). In *P. lotor*, *Baylisascaris procyonis* and other nematodes and trematodes have been reported in Central America (Baldi et al., 2016; García-Prieto et al., 2012). Our study adds *Trichuris* sp. and *Spirometra* sp. as new records for *Procyon* spp. in South America.

This is only the second report of helminths in *Eira barbara*, expanding the known parasitic fauna beyond *Molineus* sp., *Angiostrongylus vasorum*, and *Physalopterinae* gen. sp. (Panti-May et al., 2021) to include Strongylida-type larvae. In *Puma yagouaroundi*, our detection of *Toxocara* sp. and *Spirometra* sp. aligns with findings from wild and captive individuals in Brazil and Peru (Wrublewski et al., 2018; Villena, 2015).

Infection frequencies for *C. thous* and *L. pardalis* were lower than those reported in necropsy-based studies (e.g.,

Ruas et al., 2008; Fiorello et al., 2006), likely reflecting methodological differences, as fecal examination tends to detect fewer parasite taxa than necropsy (Jorge et al., 2013; Miller et al., 2018). For *Procyon* spp., *E. barbara*, and *P. yagouaroundi*, the lack of comparative data limits broader interpretation.

Of particular concern is the detection of *Spirometra* sp., a genus responsible for sparganosis—a zoonotic disease prevalent in Asia (Liu et al., 2022). Human infection typically occurs through ingestion of contaminated water or intermediate hosts such as frogs or fish. Wild carnivores act as definitive hosts, shedding eggs into the environment (Liu et al., 2015). In Colombia, only *S. mansoni* has been confirmed (Brabec et al., 2022). Given the environmental overlap between humans and wildlife in dry forest ecosystems—especially near limited water sources—further characterization of *Spirometra* species is warranted. Infection rates reported in Latin American wild canids and felids range from 45% to 65.8% (Fiorello et al., 2006; Dib et al., 2018), consistent with our observations.

Finally, the detection of *Toxocara* sp. in both felid (*L. pardalis*, *P. yagouaroundi*) and canid (*C. thous*) hosts suggests the likely presence of *T. cati* and *T. canis*, respectively (Muñoz-Rodríguez et al., 2021; Lima et al., 2013). Both are recognized zoonotic agents, capable of environmental contamination through the release of long-surviving infective eggs (Nijse et al., 2020). The ocelot's hypercarnivorous diet and frequent ingestion of paratenic hosts such as rodents may predispose it to reinfection (Gómez-Ruiz et al., 2020), whereas *C. thous* may be more exposed to direct environmental transmission routes, possibly resulting in lower reinfection rates (Lima et al., 2013).

Overall, this study demonstrates the value of noninvasive parasitological monitoring in wild carnivores from a threatened tropical dry forest ecosystem. By integrating ecological and public health perspectives, it highlights the importance of continuous surveillance at the wildlife-domestic animal-human interface. Further efforts, including molecular characterization and broader temporal sampling, are essential to deepen our understanding of parasite transmission dynamics and inform prevention strategies in similar high-risk environments.

Ethical approval

The Veterinary Ethics Committee of Corporación Universitaria Remington, in Minutes 007, approved the sampling protocol of February 2019.

Author contributions

Conceptualization: DAG; Methodology: CLV; Investigation: DAG, CLV; Writing original draft: DAG; Writing, review and editing: CLV; Visualization: CLV; Supervision: DAG. All authors have read and approved the manuscript.

Conflict of interest

The authors declare that they have conflict of interest.

Data availability

The data are stored in the Office of the Vice-Rector of Research of Corporación Universitaria Remington and must be requested from the correspondence author.

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