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# Feline parasites and the emergence of feline lungworm in the Portland metropolitan area, Oregon, USA 2016–2017

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## Abstract

**Objectives** The aim of this study was to determine the prevalence of internal parasites in feral and free-roaming owned cats in the region of Portland, Oregon, USA.

**Methods** Fecal samples from asymptomatic cats were opportunistically collected from feral cats presented for surgical sterilization ( $n = 46$ ), as well as free-roaming owned cats ( $n = 86$ ) presented to primary care clinics. Fecal analysis was performed using the Baermann technique, centrifugal flotation, fluorescent auramine and fluorescent antibody for *Giardia* species.

**Results** Lungworm infection was identified in 24.2% of owned cats and 17.2% of feral cats. At least 11 unique parasite species were identified in this study. *Taenia* species and *Toxocara cati* were identified in higher proportions in feral cats, whereas *Giardia* species were significantly higher in owned cats.

**Conclusions and relevance** The prevalence of lungworm was higher than has been previously documented in other areas of the USA. In addition, feral cats were infected with a higher percentage of *Toxocara* species and *Taenia* but a significantly lower percentage of *Giardia* species.

**Keywords:** Parasites; *Aelurostrongylus*; fecal flotation; lungworm; Baermann; Oregon; USA

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## Introduction

Cats with outdoor access are uniquely at risk for parasitic diseases,<sup>1,2</sup> and the prevalence of these conditions may be increasing.<sup>3</sup> In fact, Chalkowski et al<sup>2</sup> reported that cats with outdoor access were 2.77 times more likely to be infected with parasites than indoor-only cats. There are an estimated 58 million pet cats in the USA, and 790,000 in the state of Oregon.<sup>4</sup> Limited information exists on the exact number of pet cats with outdoor access; however, between 30% and 44% of owned cats in North America are estimated to have some outdoor access.<sup>5,6</sup> In addition, there are an estimated 30–80 million feral cats in the USA.<sup>6</sup> At a minimum, it is reasonable to expect that there is a population of hundreds of thousands of feral and owned cats outdoors, mostly concentrated near urban population centers.

One of the parasitic infections outdoor cats are exposed to is the feline lungworm, *Aelurostrongylus abstrusus*.<sup>7,8</sup> This parasite has a global distribution, with previous studies in the USA showing infection rates

between 6.2% and 18.5%.<sup>9,10</sup> A recent study found a variable distribution of the parasite across the USA, with clusters in the Pacific Northwest,<sup>8</sup> the region where these data were collected. Anecdotally, clinical practitioners and researchers in Oregon, USA, suspect that the incidence of cats with signs compatible with parasitic bronchial pneumonia is increasing (E DeBess, 2021, personal communication).

The feline lungworm has an indirect life cycle that requires invertebrate gastropods as an intermediate host within which the first-stage larvae (L1s) mature to the

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infective third-stage larvae (L3s).<sup>7</sup> After ingestion of the intermediate or paratenic hosts, the larvae migrate to the lungs via the lymphatic vessels and mature into adult stages.<sup>7</sup> Detection of adult *A. abstrusus* can be challenging because of their embedment in the lung parenchyma; different methods and attempts to correlate adult worm burdens with fecal larval count have previously been used with varying success.<sup>8,11,12</sup>

The primary objective of this study was to identify and quantify the presence of feline lungworm infection in the Portland metropolitan area in the state of Oregon. Secondary objectives were the identification of other feline internal parasites and comparison between free-roaming cats and owned cats.

## Materials and methods

Fecal samples were submitted over a 15-month period from June 2016 to September 2017. Samples were collected from two sources: client-owned cats visiting veterinary clinics during an annual examination, and feral cats surgically sterilized by the Feral Cat Coalition of Oregon. To be considered for analysis, the cats had to have outdoor access and not have been treated with a parasiticide in the previous 3 months. Outdoor access was reported by the owners and defined as cats that spend more than 50% of the time outdoors.

Samples were refrigerated and shipped overnight in refrigerated containers to the Oregon Veterinary Diagnostic Laboratory (Corvallis, OR, USA), which is an American Association of Veterinary Laboratory Diagnosticians-accredited diagnostic laboratory, within 48–72 h of collection. If enough fecal material was present, samples were analyzed by the following techniques as described elsewhere: flotation and centrifugation with Sheather's solution at a specific gravity of 1.27; modified Baermann funnel technique; fluorescent auramine for *Cryptosporidium* species; and fluorescent antibody for *Giardia* species.<sup>13–16</sup> Samples prepared with the modified Baermann technique were collected into Petri dishes after overnight incubation at room temperature and examined with a dissecting microscope. Diagnostic results for each analysis were recorded (see the supplementary material).

Statistical analysis was performed using a two-tailed Fisher's exact test with a *P* value <0.05, using open source software (<https://www.graphpad.com/quickcalcs/contingency1.cfm>).

## Results

A total of 126 feline fecal samples were submitted for analysis. The sample population consisted of 49 males, 61 females and 16 cats with no recorded sex. There were no differences in sex between the two groups. There were 95 samples from owned cats and 31 samples from feral cats. Fecal flotation, fluorescent antibody for *Giardia* species and fluorescent auramine for *Cryptosporidium* species were

performed on all samples. Owing to insufficient fecal material, the Baermann funnel technique was only performed on 120 samples, with 91 samples from owned cats and 29 samples from feral cats. In this study, tapeworm eggs that were morphologically identical between *Taenia* species and *Echinococcus* species were identified as *Taenia* species owing to the lack of reported *Echinococcus* species in the region.

On fecal flotation, parasites were detected in 44 (34.9%) samples. The most frequently encountered parasite with this technique was *Toxocara cati*, found in 30 samples (23.8%). There were 28 lungworm positive samples (23.0%) tested by the Baermann funnel technique. All except for one was positively identified as *Aelurostrongylus* species. *Giardia* species were detected in 25 samples (19.8%) via the fluorescent antibody technique and *Cryptosporidium* species were detected in 33 samples (26.2%) via the fluorescent auramine technique. There was a statistically significantly higher prevalence of *Giardia* species in free-roaming owned cats compared with feral cats. Complete results are presented in Table 1.

## Discussion

These data contribute important regional information on lungworm and other parasitic infections in cats allowed outdoor access. This is the first report to compare sympatric populations of feral and owned cats with regard to fecal parasite prevalence, which showed similar prevalence, with the exception of higher numbers of *Giardia* infections in owned cats. Additionally, this report demonstrated a higher incidence of lungworms than has been reported in other regions of the USA.<sup>9,10,17</sup>

Feline lungworm may be under-reported for a variety of reasons. Subclinical or mild infections occur in some cats, other non-infectious diseases can mimic clinical signs of lungworm<sup>7,11</sup> and owners may not have as much opportunity to observe clinical signs in cats that are allowed outdoors. The prevalence of lungworm infections in this population may be higher than previously been reported, owing to differences in regional factors such as paratenic host prevalence. It has also been suggested that climate change may influence the prevalence of *Aelurostrongylus* infection.<sup>7,11</sup>

Direct fecal smears and classical sedimentation and flotation methods are unreliable for diagnosing metastrongyloid infections, because of the unpredictable presence of L1s, inadequate sample size, low sensitivity and larval osmotic damage due to the high specific gravity concentrations.<sup>7,11</sup> No L1s were identified with flotation technique in this study; however, even the Baermann technique, which is the most commonly used diagnostic for clinical lungworm identification, can have false-negative results due to intermittent shedding of the parasite,<sup>7,11,12</sup> and repeated examinations are generally recommended before ruling out parasitism.<sup>7</sup>

**Table 1** Prevalence of internal parasites via different copromicroscopic techniques in feral and owned cats with outdoor access in Portland, Oregon

	Owned (n = 95)	Feral (n = 31)	P value
Fluorescent auramine			
<i>Cryptosporidium</i> species	22 (23.1)	11 (35.4)	0.239
Fluorescent antibody			
<i>Giardia</i> species	24 (25.3)	1 (3.2)	0.008*
Baermann technique			
Unidentified lungworm larvae	1 (1.1)	0 (0)	1.000
<i>Aelurostrongylus</i> species	22 (24.2)	5 (17.2)	0.456
Flotation with sugar centrifugation			
<i>Ancylostoma caninum</i>	0 (0)	1 (3.2)	0.248
<i>Capillaria</i> species	0 (0)	1 (3.2)	0.248
Coccidia	2 (2.1)	0 (0)	1.000
<i>Cystoisospora</i> species	1 (1.1)	2 (6.5)	0.150
Taeniid species	5 (5.3)	3 (9.8)	0.406
<i>Toxocara cati</i>	19 (20)	11 (35.5)	0.092
<i>Trichuris</i> species	1 (1.1)	0 (0)	1.000
<i>Uncinaria</i> species	0 (0)	1 (3.2)	0.248

Data are presented as n (%)

\*Indicates statistical significance using Fisher's exact test using a two-tailed *P* value <0.05

Incidence rates for intestinal parasites vary widely, and our study showed similar incidences compared with previous reports in outdoor cat populations in the USA.<sup>3,8,18–20</sup> Because feline intestinal parasites may be under-reported by fecal flotation alone,<sup>21</sup> it is likely that the true infection rates are higher than has been reported here. A relatively high incidence of *Giardia* and *Cryptosporidium* species was found, which may reflect the more sensitive diagnostic techniques used. The identification of *Ancylostoma caninum* is surprising, as there are no previous reports of this parasite in cats, and it may, in fact, have been a misidentification of *Ancylostoma tubaeforme*.

There are a number of important limitations to this study. Very limited clinical information was available from the sampled population, making inferences about asymptomatic incidence difficult. This is important given the intermittent shedding that occurs in some parasite species, which could lead to artificially lowered prevalences. Similarly, important information that could contribute to disease transmission, such as hunting behavior, percentage of time spent outside and whether any raw diet was fed, was not collected. Unfortunately, reliable data about age in the feral population was not recorded. It is possible that significant differences in age between the feral and owned population could explain the findings. Despite these limitations, this study contributes important information regarding the prevalence of feline and zoonotic parasites in the Pacific Northwest.

## Conclusions

The increased identification of *Aelurostrongylus* species in feline samples and its distribution continues to be of great

interest in feline medicine. Implementation of the Baermann funnel technique in routine fecal testing can significantly improve knowledge on the current epidemiology of this parasitosis. Cats presenting to veterinary clinics with respiratory signs should be assessed with a Baermann fecal test. Feline aelurostrongylosis is an important parasitic disease that is likely to continue to threaten feline health. It is crucial that veterinary practitioners are aware of this disease and the appropriate diagnostic technique.

**Conflict of interest** The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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**Ethical approval** The work described in this manuscript involved the use of non-experimental (owned or unowned) animals. Established internationally recognised high standards ('best practice') of veterinary clinical care for the individual patient were always followed and/or this work involved the use of cadavers. Ethical approval from a committee was therefore not specifically required for publication in *JFMS Open Reports*. Although not required, where ethical approval was still obtained it is stated in the manuscript.

**Informed consent** Informed consent (verbal or written) was obtained from the owner or legal custodian of all animal(s) described in this work (experimental or non-experimental animals, including cadavers) for all procedure(s) undertaken (prospective or retrospective studies). No animals or people are identifiable within this publication, and therefore additional informed consent for publication was not required.

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**Supplementary material** The following file is available online: Sample description and results of feline fecal analyses of various methodologies.

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