Emerging Eyeworm Infections Caused by *Thelazia callipaeda* in Companion Animals in North America

Caroline Sobotyk, DVM, MSc, PhD

KEYWORDS

• *Thelazia* eyeworm • Thelaziosis • Zoonosis • Dog • Cat • Eye • Vector • Fruit fly

KEY POINTS

- *Thelazia callipaeda* is a zoonotic vector-borne nematode transmitted by *Phortica* fruit flies.
- *T callipaeda* cases have increased in companion animals in the United States.
- Infections in companion animals may be subclinical or associated with mild to severe ocular clinical signs.
- Effective diagnosis, treatment, and control measures are critical to limit the spread of this zoonotic parasite.

INTRODUCTION

Thelazia callipaeda (Spirurida, Thelaziidae) is a zoonotic vector-borne nematode transmitted by drosophilid flies of the genus *Phortica*. Following its original description in Asia by Railliet and Henry in 1910, the parasite has been reported in animals and humans, predominantly in South and East Asia, where it was historically referred to as *the oriental eyeworm*.[1,2] This nomenclature is no longer appropriate, as *T callipaeda* was first identified in Italy in the late 1980s and has since undergone substantial geographic expansion, with reports from at least 20 European countries and, more recently, North America.[3–5]

In the United States, *T callipaeda* was first described in a domestic dog (*Canis lupus familiaris*) in New York (NY), and a few years later, several more autochthonous cases were reported in domestic dogs and cats (*Felis catus*), including 8 cases in NY, 3 in New Jersey (NJ), and 1 case in Connecticut (CT) and Nevada.[3,6] The existence of a sylvatic transmission cycle of *T callipaeda* was recently documented in American black bear (*Ursus americanus*) in Pennsylvania (PA), highlighting the potential role of

Department of Pathobiology, School of Veterinary Medicine, University of Pennsylvania, 3900 Delancey Street, Philadelphia, PA 19104, USA
E-mail address: csobotyk@vet.upenn.edu

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Abbreviations	
mtDNA	mitochondrial genome
NG	first-stage larvae
NJ	New Jersey
NY	New York
PA	Pennsylvania

these wild carnivore hosts in the epidemiology of the disease in North America.[7] Since then, a significant number of new cases have been identified by veterinary clinicians in domestic dogs, cats, and wild carnivores (not published), raising concerns about the parasite's emergence, fast geographic expansion, and establishment in the United States, particularly in the northeastern region. Phylogenetic analyses have demonstrated that all eyeworm cases identified in domestic and wild animals in the United States are identical to the single *T callipaeda* haplotype 1 reported in Europe. These findings support the hypotheses that *T callipaeda* was recently introduced in North America from Europe, likely via animal movement resulting from human-mediated translocation and is now established and spreading in the United States.

The emergence and rapid spread of *T callipaeda* in North America is driven by complex interactions among environmental, parasitic, host, and anthropogenic factors. Although the determinants of canine and feline thelaziosis in the United States remain poorly understood, early detection and intervention may mitigate the risk of pathogen exposure in companion animals and humans. In this review, we synthesize current knowledge on the biological and clinical aspects of infection in companion animals, outline the current recommendations for diagnosis, treatment, and prevention in domestic dogs and cats, and discuss the epidemiologic dynamics and preventive strategies associated with this emerging zoonotic vector-borne disease in the United States.

Life Cycle

Adult *T calliapeda* worms are primarily located in the conjunctival sac and under the nictitating membrane, but can also be found in the lacrimal apparatus, retina, vitreous cavity, and periocular tissues of domestic dogs, cats, lagomorphs, wild carnivores, and humans.[8–12]

Transmission occurs when *Phortica* fruit flies, which are zoophilic secretophagous vectors, ingest *T callipaeda* first-stage larvae (L1) from the lachrymal secretions of an infected vertebrate host (**Fig. 1**). In the vector, L1 develops into the infective third-stage larva (L3) in the testes and body cavity, and subsequently migrates to the mouthparts over approximately 3 weeks. The infective L3 is transmitted during feeding by infected male fruit flies on ocular secretions of a susceptible host. In the definitive host, the L3 differentiates into adult worms in the orbital cavity and surrounding tissues in approximately 35 days.[13]

Clinical Signs

T callipaeda infections can persist for prolonged periods and are associated with variable clinical presentations, infection intensity, and outcomes. While most infections in animals produce no overt clinical signs (subclinical infection), clinical manifestations can vary across a wide range of clinical signs. When clinical signs do occur unilaterally or bilaterally, they may range from nonspecific mild ocular lesions, such as inflammation, edema, hyperemia, conjunctivitis, epiphora, ocular discharge, and photophobia, to more severe pathologic changes, including keratitis, corneal opacity and ulceration, secondary bacterial infections, and blindness.[4,14,15] While *T callipaeda* infections

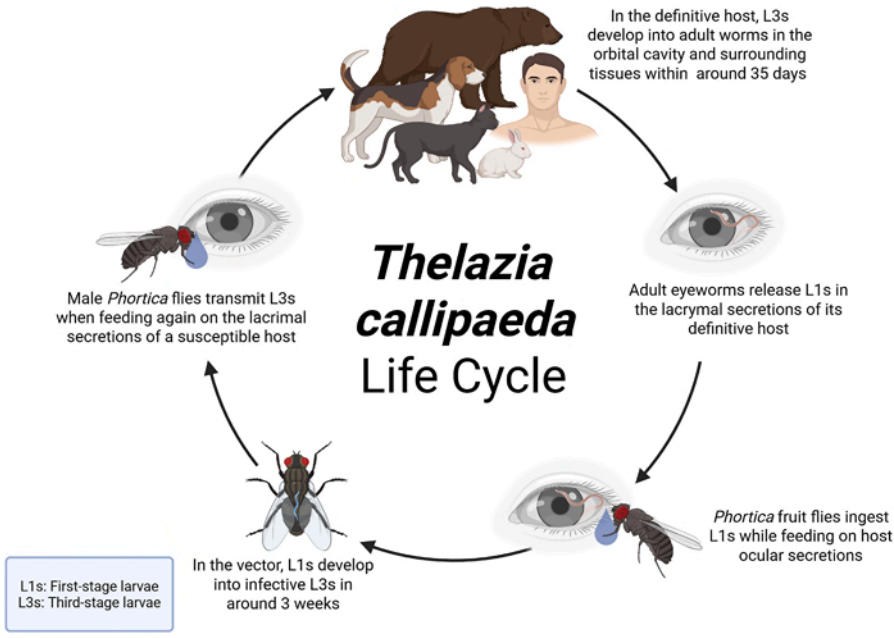


Fig. 1. Life cycle of *Thelazia callipaeda*. (*Created in* BioRender. Sobotyk, C. (2026) https://BioRender.com/2344ggr.)

generally do not impact the systemic health of affected animals, veterinarians and owners may observe behavioral changes, including anxiety, head shaking, and decreased appetite.[14]

Although the severity of canine thelaziosis does not appear to correlate with parasite burden, the presence of *Thelazia* gravid female and larval stages has been associated with more pronounced clinical manifestations in affected animals.[16,17] Additionally, the serrated cuticular morphology of adult worms can induce mechanical damage to the conjunctival and corneal epithelium, resulting in epiphora and ocular discharge and potentially increasing the risk of *T callipaeda* transmission by attracting the vector to host lacrimal secretions.[16] Other factors influencing disease severity include bacterial secondary infection, host immune response, and parasite location.[12]

RISK FACTORS

As with most vector-borne diseases, the risk and prevalence of thelaziosis are directly associated with the vector density and distribution. Although vector biology and epidemiology depend heavily on regional environmental factors and microhabitats, *T callipaeda* cases have been primarily reported in peri-urban and rural areas,[12,18,19] reflecting increased exposure of humans and animals to vector flies. Vector exposure is reported to be occasionally seasonal, with increased transmission risk from July to October in endemic regions of Europe.[20,21] However, this pattern likely varies with environmental conditions and geographic location, and clinical *T callipaeda* cases may occur at any time of year. Therefore, routine clinical examinations and preventive measures should be applied throughout the year in dogs and cats.

Epidemiologic data suggest that young and small-sized animals are less likely to be infected with *T callipaeda* compared to medium-to large-breed dogs over 3 years of

age.[4,22] The higher occurrence of thelaziosis in adult animals is likely attributable to differences in behavior, lifestyle, and body size. Lifestyle represents an important risk factor, with animals housed predominantly or exclusively outdoors, or those with regular outdoor access, being at increased risk of *T callipaeda* infection. Compared with dogs, feline thelaziosis is reported less frequently, which may reflect reduced exposure to *T callipaeda* vector, intensive grooming behavior, and underdiagnosis due to the inherent difficulty of performing thorough ocular examinations in feline patients.[4] Although male dogs and cats are more frequently reported as eyeworm-positive, no statistically significant association has been found between sex or breed and predisposition *T callipaeda* infection in companion animals from endemic areas.[4,11,17]

In Europe, wild carnivores, particularly red foxes (*Vulpes vulpes*), are recognized as important reservoir hosts contributing to the maintenance of the sylvatic cycle, with concomitant reports of eyeworm infections across human, domestic, and wild host populations within the same geographic region.[11,23] Similarly in the United States, the occurrence of canine thelaziosis overlaps with recently published and unpublished reports of *T callipaeda* cases in wild carnivores in PA and NJ. American black bears are implicated in the maintenance of the sylvatic cycle in the United States (C. Sobotyk, unpublished data, 2026).[7] These hosts inhabit dense woodland ecosystems that favor the presence of *Phortica* spp. and facilitate parasite transmission. American black bears are widely distributed across forested regions of Canada, the United States, and northern Mexico, and also frequent urban-wildland interfaces, particularly in the Mid-Atlantic region.[24,25] This combination of ecological suitability and host adaptability likely promotes their role as reservoirs and contributes to the persistence and geographic expansion of *T callipaeda* in the country.

DIAGNOSIS

Suspicion of thelaziosis is established based on clinical signs, clinical and travel history, and epidemiologic factors. Animals with a history of ocular disease should undergo a complete ophthalmologic examination, and both eyes should always be evaluated. In endemic areas, comprehensive ophthalmic assessment should be integrated into routine clinical examinations of companion animals. A definitive diagnosis of *T callipaeda* infection is achieved through direct visualization of the parasite within the orbital cavity and surrounding tissues (**Fig. 2**), followed by parasite species identification.



Fig. 2. Eye of a domestic dog (*Canis lupus familiaris*) infected with adult *Thelazia callipaeda*. (*Image Courtesy* This image is the courtesy of Dr Sara A. Adelman, DVM, MS.)

A comprehensive evaluation of the ocular apparatus is best performed in a quiet, well-illuminated room that can be darkened, with topical anesthesia used as needed for specific procedures. The examination may include: (i) gross assessment of the ocular adnexa and globe; (ii) baseline diagnostic testing; (iii) detailed anterior segment evaluation, including third eyelid eversion and inspection of the conjunctival fornix; (iv) neuroophthalmic and visual function assessment; and (v) posterior segment examination, including the lens, vitreous, and fundus, using direct and indirect ophthalmoscopy.[26] Additional diagnostic procedures may be indicated in cases of secondary bacterial infection or severe ocular pathology.

Visualization of adult worms within the ocular apparatus is considered pathognomonic of thelaziosis, but definitive diagnosis is achieved through morphologic and/or molecular analysis. *T callipaeda* can be collected mechanically using a cotton swab or fine forceps, or by flushing the conjunctival sac with sterile saline solution (0.9% NaCl). The use of a topical anesthetic is recommended.[12] Adult worms are elongated, white to cream-colored, thread-like parasites that are typically highly motile and readily observed during a careful ophthalmologic examination. All parasite specimens should be stored in 70% alcohol and submitted to a veterinary diagnostic laboratory for identification. Adult worms can be identified to the species level based on key morphologic features, including a cup-shaped buccal capsule at the anterior end, the number of cuticular transverse striations ranging from 160 to 400 per mm (**Fig. 3**), and the location of the vulvar opening anterior to the esophageal-intestinal junction in female worms.[27,28] *T callipaeda* larvae can be identified in the tears of infected animals through microscopic examination.

Species confirmation can also be performed using molecular assays. Compared to traditional microscopy, these molecular tools offer greater sensitivity and specificity, enabling detection of low-level, mixed, or subclinical eyeworm infections. They provide rapid and accurate species differentiation, inference of phylogenetic relationships, and can be applied to a variety of sample types, enhancing both clinical diagnosis and large-scale surveillance.[7,23,29] Most molecular assays have targeted the mitochondrial cytochrome c oxidase subunit 1 (*cox1*) gene, which has proven particularly useful for characterizing regional genetic variation and phylogeographic structures, especially in endemic areas and emerging transmission foci.[2,30] Serologic assays for the diagnosis of thelaziosis have not yet been developed.

Establishing a presumptive or confirmatory clinical diagnosis may be challenging in early-stage infections, in cases of low parasite burden, or when adult worms are

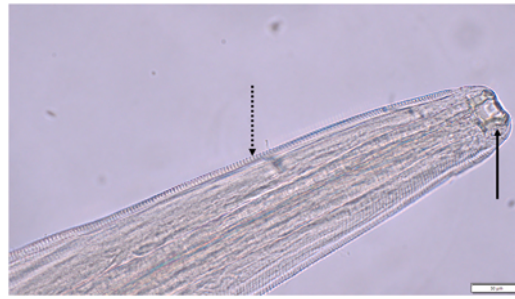


Fig. 3. Morphologic features of the anterior end of an adult female *Thelazia callipaeda* eyeworm. The solid black arrow indicates the large, deep, cup-shaped buccal cavity. The dashed black arrow indicates the thin transverse cuticular striations pattern. Scale bar indicates 50 μm.

located in atypical or concealed ocular structures. These factors, together with the nonspecific clinical presentation of canine and feline thelaziosis, may contribute to misdiagnosis or delayed diagnosis, potentially leading to unnecessary antimicrobial or other therapeutic interventions.[12,31] A range of ocular diseases should be considered as differential diagnoses, including infectious and allergic conjunctivitis, dacryocystitis, keratitis, and ocular infections caused by other nematode species such as *Dirofilaria* spp., *Onchocerca lupi*, and *Thelazia californiensis*.

Treatment

In Europe, several macrocyclic lactone-based formulations containing moxidectin or milbemycin oxime are approved for the treatment of thelaziosis in companion animals at the recommended minimum dose. Previous studies have shown a high efficacy with only one or two monthly doses of a spot-on formulation containing 10% imidacloprid and 2.5% moxidectin for both therapy and prevention of canine and feline thelaziosis in naturally infected animals.[32,33] The lack of activity of imidacloprid against *T callipaeda* confirms that the therapeutic and prophylactic efficacy derives exclusively from the anthelmintic action of 2.5% moxidectin.[32] Other macrocyclic lactone formulations have also demonstrated over 90% efficacy against *T callipaeda* (**Table 1**), including oral milbemycin oxime combined with praziquantel, a topical eprinomectin with fipronil/(S)-methoprene/praziquantel, subcutaneous moxidectin, and moxidectin or ivermectin eye drops.[34,35,39,40] The latter should be avoided in veterinary practice, as it may cause ocular irritation.[34]

In contrast, no standardized therapeutic regimen has yet been established, and no Food and Drug Administration (FDA)-approved drug is currently available in the United States. However, studies from Europe, as well as published and unpublished case reports, indicate that mechanical removal of adult worms under ophthalmologic care using eye flushes, cotton swabs, or fine forceps, followed by anthelmintic therapy, provides rapid and highly effective resolution of ocular clinical signs associated with *T callipaeda* infections. Comparable therapeutic strategies have also been described for other ocular nematode infections, including those caused by *O lupi* and *T californiensis*.[41–43] Infected animals may require supportive treatment based on their clinical presentation. The administration of anti-inflammatory therapy and topical antibiotics may also be necessary, especially in cases of severe ocular clinical signs and secondary bacterial infections.

Prevention

In endemic areas, products containing milbemycin oxime or moxidectin have been used to prevent thelaziosis in companion animals (**Table 2**). These heartworm preventatives have also been shown to effectively limit *T callipaeda* reinfection, prevent the development of severe ocular disease, and reduce the incidence of canine thelaziosis.[34,40] In Europe, only the monthly oral combinations milbemycin oxime/afoxolaner and moxidectin/sarolaner/pyrantel are currently registered for preventing the establishment of adult *T callipaeda* infections in dogs. In contrast, repellents and flea and tick preventives seem to have little to no effect on the fruit fly vector and are considered ineffective in preventing *T callipaeda* transmission.[45] To date, no vaccine has been developed for the prevention of thelaziosis.

Integrated approaches combining chemical and nonchemical vector control, systematic surveillance of vectors and parasites, and continuous education for owners, veterinarians, and technicians are critical to reducing *T callipaeda* exposure and transmission. Further research is required to clarify vector competency, geographic distribution, and prevalence in North America to guide targeted interventions. Although

Table 1
Current anthelmintic therapies used in the treatment of *Thelazia callipaeda* infections in domestic dogs and cats

Anthelmintic Drug	Treatment Regimen	Route of Application	References
Domestic dog (*Canis lupus familiaris*)			
Ivermectin 10 mg/mL diluted to 10% in propylene glycol	1–3 doses within a month	Eye drops	Marino et al,[34] 2021
Milbemycin oxime 0.5 mg/kg + Praziquantel 5 mg/kg[a]	2 doses at a weekly interval[b]	PO	Bianciardi et al,[34] 2005; Marino et al,[35] 2021
Milbemycin oxime 0.5 mg/kg	1–2 doses at a weekly interval	PO	Ferroglio et al,[36] 2008
Moxidectin 2.5% + Imidacloprid 10%[a]	1–2 doses at a monthly interval	Topical	Bianciardi et al,[33] 2005; Marino et al,[34] 2021
Moxidectin 10%	1 single dose	SQ	Marino et al,[34] 2021; Rossi et al,[37] 2008
Moxidectin 1%	1 single dose	Eye drops	Lia et al,[38] 2004
Domestic cat (*Felis catus*)			
Eprinomectin 0.4% + Fipronil 8.3% + (S)-methoprene 10% + Praziquantel 8.3%	1 single dose	Topical	Zanet et al,[39] 2021
Ivermectin 10 mg/mL diluted to 10% in propylene glycol	1–3 doses within a month	Eye drops	Marino et al,[40] 2021
Milbemycin oxime 2 mg/kg + Praziquantel 5 mg/kg	2 doses at a weekly interval[b]	PO	Motta et al,[35] 2021
Moxidectin 1.0% + Imidacloprid 10%[a]	1 single dose	Topical	Otranto et al,[32] 2019

Abbreviation: PO: orally; SQ: subcutaneous.
[a] Currently registered for treatment of adult *T callipaeda* infections in Europe.
[b] An additional dose or mechanical removal of adult *T callipaeda* worms may be required if parasites persist at the end of the treatment regimen.

transmission dynamics and key biological parameters remain poorly defined in the United States, proactive preventive measures against this zoonotic vector-borne disease are warranted and may reduce the risk of pets and human exposure.

PUBLIC HEALTH CONSIDERATIONS

Human thelaziasis has been identified as an emerging neglected zoonotic disease. It is more commonly reported in low-income populations with limited access to adequate healthcare. Additionally, the disease is often overlooked and underdiagnosed due to its diverse clinical presentations and limited investment in research and epidemiologic surveillance.[12]

In Asia, *Thelazia* infections in humans are more prevalent in rural areas, where infection rates in animals and parasite burden are often high.[12,47] Although domestic and

Table 2
Anthelmintic options for the prevention of thelaziosis caused by *Thelazia callipaeda* in domestic dogs and cats

Anthelmintic Drug	Indications for Use	Route of Application	References
Domestic dog (*Canis lupus familiaris*)			
Milbemycin oxime 0.5 mg/kg + Afoxolaner 2.5 mg/kg[a]	Monthly	PO	Lebon et al,[44] 2019
Milbemycin oxime 0.5 mg/kg	Monthly	PO	Ferroglio et al,[36] 2008
Moxidectin 2.5% + Imidacloprid 10%	Monthly	Topical	Marino et al,[34] 2021; Lechat et al,[45] 2015
Moxidectin 10%	Every 6 mo	SQ	Rossi et al,[37] 2008
Moxidectin 24 μg/kg + Sarolaner 1.2 mg/kg + Pyrantel 5 mg/kg[a]	Monthly	PO	Bezerra-Santos et al,[46] 2022
Domestic cat (*Felis catus*)			
Moxidectin 1.0% + Imidacloprid 10%	Monthly	Topical	Marino et al,[40] 2021

Abbreviation: PO, orally; SQ, subcutaneous.
[a] Currently registered in Europe for the prevention of the establishment of adult *Thelazia callipaeda* infections.

wild carnivores can act as reservoirs, *T callipaeda* is transmitted exclusively by *Phortica* fly vectors. Despite the absence of direct transmission from infected animals to humans, prevention of human thelaziasis relies on appropriate veterinary care and routine prophylactic treatment of pets, along with reducing vector exposure and improving public health education.

INNOVATIVE INSIGHTS

Despite the availability of advanced sequencing and bioinformatic approaches, epidemiologic and biological studies of nematodes have traditionally relied on morphologic characteristics, ecological traits, and phylogenetic analysis using partial genome sequences. Over the past decades, considerable effort has been made to elucidate transmission patterns and genetic variability of *T callipaeda* worldwide. Molecular tools targeting specific regions of the mitochondrial genome (mtDNA) have confirmed the presence of a single haplotype in Europe, and recently, in North America (Haplotype 1), and have identified at least 20 different haplotypes in Asia.[2,7,30] These genetic variation analyses have been instrumental in understanding the lack of host specificity of *T callipaeda* and in evaluating its epidemiology and geographic distribution across different regions. Moreover, few studies have focused on the characterization of the complete mtDNA of *T callipaeda*, enriching the mtDNA database of Spirurid nematodes.[48,49] Complete mtDNA datasets are essential for resolving taxonomic relationships and understanding genome evolution within this parasite suborder, as well as for providing robust markers for molecular epidemiology, population genetics, and analyses of gene rearrangements, and for the identification of potential biomarkers associated with disease severity and host susceptibility.

CLINICS CARE POINTS

- Include Thelazia callipaeda in the differential diagnosis of ocular disease in dogs and cats, particularly in endemic or emerging regions of the northeastern United States.
- Perform a thorough ophthalmic examination of both eyes, including eversion of the third eyelid and inspection of the conjunctival fornices.
- Definitive diagnosis relies on direct visualization and removal of adult worms, followed by morphologic and/or molecular identification.
- Mechanical removal of eyeworms combined with macrocyclic lactone therapy is currently the most effective treatment approach.
- Transmission risk may occur throughout the year and standard flea/tick preventives do not reliably prevent infection.

DISCLOSURE

The author declares no conflicts of interest.

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