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Case Report

First detection of *Crenosoma vulpis* in Red Foxes *Vulpes vulpes* in Western Poland

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Summary

Crenosoma vulpis is a nematode from the superfamily Metastrongylidea, which parasitizes the respiratory tracts of carnivores, primarily red foxes (*Vulpes vulpes*), and occasionally domestic dogs (*Canis familiaris*). This study aimed to assess the presence of *C. vulpis* in red foxes in western Poland, an area where its occurrence had not been previously documented. We examined lung tissue from 47 red foxes obtained during the regular hunting season (2017 – 2018) using the Baermann method to detect the presence of nematode larvae. Larvae, identified based on morphology as *C. vulpis*, were found in 12.8 % of the foxes (6/47; 95 % CL = 4.8 – 25.7 %). This is the first confirmed report of *Crenosoma vulpis* in red foxes in Poland, highlighting the potential need for further epidemiological studies on its distribution and impact on both wildlife and domestic animals.
Keywords: *Crenosoma vulpis*; Carnivores; Red fox; Poland

Introduction

Crenosoma vulpis, commonly referred to as the lung nematode of foxes, is a parasite from the family Metastrongylidae that plays a crucial role in the epidemiology of respiratory diseases among wild carnivores. This helminth is particularly significant in forest ecosystems, where it affects the health of fox populations (*Vulpes vulpes*) and occasionally infects other species, including domestic dogs (*Canis familiaris*) and other carnivorous or omnivorous species, such as badgers (*Meles meles*) (Popiołek *et al*., 2009). The parasite resides in the bronchioles, bronchi, and trachea of its definitive hosts, therefore infections caused by *C. vulpis* can lead to severe respiratory conditions, such as bronchitis and pneumonia, which have a negative impact on the overall fitness, reproductive success, and long-term viability of affected populations of canids (Bihr & Conboy, 1999; Unterer *et al*. 2002). Furthermore, the parasite's ability to infect multiple species highlights its broader ecological impact. The life cycle of *C. vulpis* is complex and involves both intermediate and definitive hosts, demonstrating the parasite's adaptability and resilience in various environments. The intermediate hosts include gastropods, such as slugs and snails (species of *Helix*, *Cepaea*, *Arianta*, *Agriolimax*, and *Arion*), which play a critical role in the transmission of the parasite to final hosts. Larvae in the first stage (L1) are expelled in the feces of infected carnivores after being coughed up and swallowed. These L1 larvae then infect gastropods by penetrating their foot tissue, where they undergo development into the invasive third-stage larvae (L3). Final hosts, such as foxes and domestic dogs, become infected when they consume gastropods harboring the L3 larvae. Once ingested, the larvae migrate through the intestinal wall, travel via the bloodstream through the liver and heart, and reach the lungs approximately 20 hours post-infection, where they undergo maturation (Anderson, 2000; Sréter *et al*., 2003; Saeed *et al*., 2006; Bagrade *et al*., 2009; Colella *et al*., 2016). The intricate life cycle

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of *C. vulpis* demonstrates the interplay between terrestrial ecosystems and carnivore populations, which facilitates the transmission and persistence of this nematode in the wild. Numerous epidemiological studies have documented the presence of *C. vulpis* in fox populations across various geographic regions, emphasizing the parasite's widespread distribution and its role as a significant factor in the health dynamics of wild carnivores (Nevárez *et al*., 2005; Barutzki *et al*., 2017; Schug *et al*., 2018). In addition to its ecological importance, *C. vulpis* poses potential risks for domestic animals, particularly in areas where wildlife and pets overlap, highlighting the need for further research into its transmission and management strategies.

In this short note, based on an analysis of red foxes culled during the hunting season in Poland, we document the first confirmed occurrence of *Crenosoma vulpis* in Western Poland. Additionally, we provide data on the prevalence of this parasite in the local fox population, contributing to the understanding of its geographic distribution and potential impact on wildlife health.

Material and Methods

The study was conducted on 47 red foxes (*Vulpes vulpes*) obtained during the regular hunting season (2017–2018) from Western Poland. After collection, each carcass was stored in a labelled plastic bag at −20 °C until it was transferred to the Department of Zoology at Poznań University of Life Sciences for further analysis. A complete parasitological necropsy was performed, and data on the sex and sexual maturity of each animal were recorded. The lungs were kept frozen at −20 °C for 1 year, until processing. Prior to analysis, the lung samples were thawed at room temperature. The lungs were dissected and bronchi and bronchiole carefully inspected under a stereomicroscope, to find adult worms. Then the lung tissue was chopped into small pieces (approximately 5 mm) and examined for the presence of first-stage larvae (L1) using the Baermann method, as described by Lacorcia *et al*. (2009). Larvae were recovered and identification was based on their size and morphology. The L1 larvae were measured under a stereomicroscope using 0.63 × 10.0× magnification, with special attention to the morphology of their tails, which were examined under an oil immersion lens and photographed.

All microscopic images and measurements were captured using the NIS-Elements D 4.10.01 64-bit software image processing system. The identification of larvae was conducted according to the morphological keys provided by Zajac and Conboy (2006).

Ethical Approval and/or Informed Consent

For this study, formal consent is not required.

Results

Sex and age information was available for all collected foxes: 27 males (7 juveniles and 20 adults) and 20 females (7 juveniles and 13 adults). Metastrongyloid first-stage larvae (L1) were recovered from the lungs of 6 foxes, resulting in a prevalence of 12.8 % with estimated 95 % confidence limits (95 % CL = 4.8–25.7 %). While many of the larvae appeared to be dead, the majority were recovered alive, exhibiting vigorous motility. The larvae were morphologically identified as *Crenosoma vulpis* (Fig. 1). When analyzing prevalence by sex, L1 larvae were detected in 4 out of 27 males (14.8 %) and 2 out of 20 females (10 %). With respect to age, L1 larvae were detected in 4 out of 14 juveniles (28.6 %) and in 2 out of 33 adults (6 %). However, the sample size was too small to conduct exact statistical tests.

Discussion

This is the first evidence of the presence of *Crenosoma vulpis* in red foxes in Western Poland. This lungworm species has previously been reported in other parts of Europe, as well as in North and South America, Africa, and Asia (Reilly *et al*., 2000; Conboy, 2004; Barutzki & Schaper, 2009; Popiołek *et al*., 2009; Taubert *et al*., 2009; Simin *et al*., 2012; Choi *et al*., 2014; Latrofa *et al*., 2015; Tolnai *et al*., 2015; Hajnalova *et al*., 2017; Cabanova *et al*., 2018; Rice, 2018; Morandi *et al*., 2019; Penagos-Tabares *et al*., 2019; Deak *et al*., 2020; Pohly *et al*., 2022; Mechouk *et al*., 2023). One noteworthy observation in this study is that many larvae survived despite being frozen at −20°C for over a year. This resilience could point to the nematode's ability to endure colder climates, like reports of *C. vulpis* thriving in areas like Prince Edward Island (Conboy *et al*., 2017) and Newfoundland (Jeffery *et al*., 2004). The ability of C. vulpis to survive freezing conditions suggests potential implications for its spread in temperate regions where cold winters could otherwise reduce parasitic load in the environment. Moreover, Conboy *et al*. (2017) discovered that frozen *C. vulpis* L1 larvae, retrieved from fox carcasses stored at -20°C for four months, remained infective to *L. maximus* slugs and successfully developed into L3. While the survival of L1 larvae from various metastrongyloid species after freezing has been documented, the underlying mechanisms enabling this resilience remain unexplored (Conboy *et al*., 2017; Ferdushy & Hasan, 2010; Kafle *et al*., 2018; Lorentzen & Halvorsen, 1986; Robbins, 2018; Shostak & Samuel, 1984; Snyder, 1985).

Interestingly, *C. vulpis* was more frequently detected in juvenile foxes compared to adults. This trend is consistent with previous studies, suggesting that young animals, with their still-developing immune systems, are more vulnerable to nematode infections (Jeffery *et al*., 2004). A comparable decline in adult *C. vulpis* numbers with age has been documented in both dogs and red foxes (Watkins & Harvey, 1942; Bihr & Conboy, 1999). This trend may be attributed to younger animals, such as red fox kits and puppies, being more inclined to consume snails and slugs, increasing their exposure to infective larvae (Richards, 1977). Additionally, young red foxes may develop partial immunity after their initial exposure,

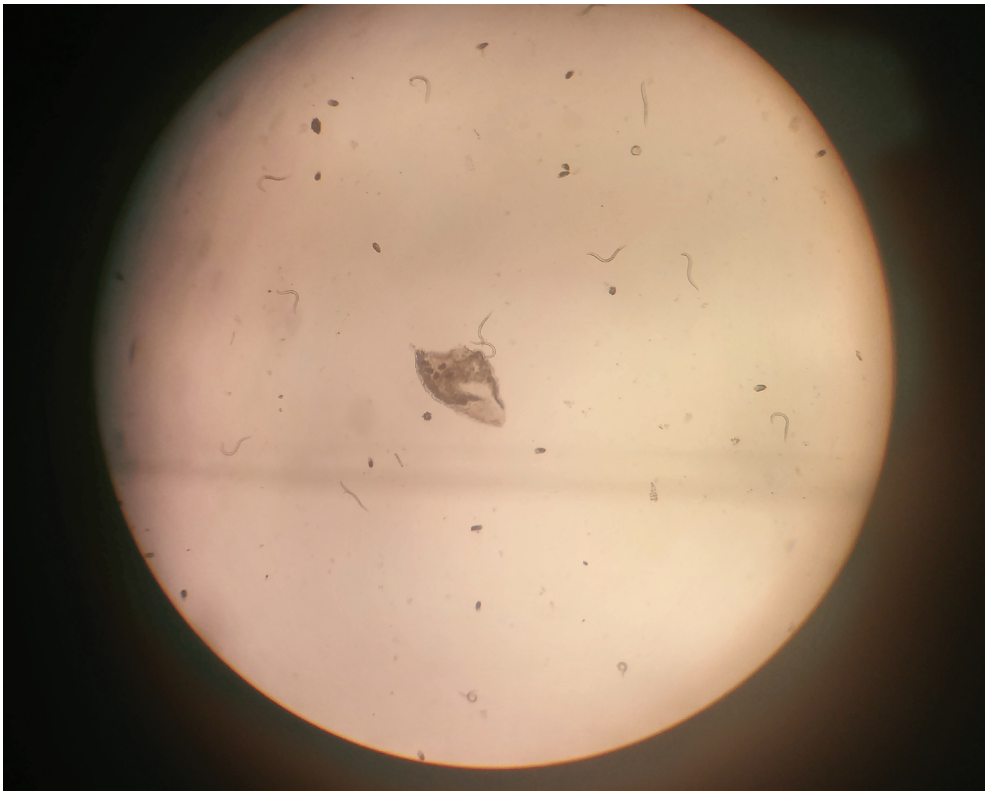

Fig. 1. *Crenosoma vulpis* larvae.

as experimentally infected individuals exhibit milder infections upon reinfection (Jeffery *et al*., 2004). Furthermore, *C. vulpis* has a relatively short lifespan, surviving approximately 33 weeks in red foxes (Jeffery *et al*., 2004). Thus, the lower parasite burden in older red foxes may result from both dietary shifts and acquired immunity.

In Poland, interest in research on *C. vulpis* and other parasites of wild animals is increasing, especially in the context of wildlife health monitoring and the effects of environmental changes. Factors such as climate change, urbanization, and habitat fragmentation could contribute to an increase in the populations of intermediate hosts, such as slugs and snails, thereby facilitating the spread of *C. vulpis* among fox populations (Nevárez *et al*., 2005; Barutzki *et al*., 2017; Schug *et al*., 2018). Additionally, concerns are rising about respiratory infections in wild canids, highlighting the need for more in-depth research on the prevalence of *C. vulpis* in Poland (Popiołek *et al*., 2009). Studies like these could provide valuable insights into the broader dynamics of parasitic spread, its impact on ecosystem health, and its implications for both wildlife and potentially domestic animals, such as dogs. So far, only one case of *C. vulpis* has been described in dogs in Poland (Spuzak *et al*., 2018). However, it is the first documented evidence of *C. vulpis* in red foxes in Poland, although its real prevalence, ecological impact, and role in ecosystem health remain largely unexplored. Further research is needed to assess the full distribution of this parasite within Poland and to evaluate its effect on fox populations and their role as hosts in spreading the infection to domestic animals. Monitoring programs that track the health of wild carnivore populations, combined with assessments of environmental changes, would be beneficial for identifying trends and potential future outbreaks of *C. vulpis*.

In conclusion, documenting the presence of *C. vulpis* in Poland not only fills an important gap in the understanding of this parasite's distribution but also emphasizes the need for continued surveillance. Considering the growing pressures on wildlife due to environmental changes, it is crucial to understand how such parasites could impact not only individual species but also broader ecosystem health.

Conflict of Interest

Authors state no conflict of interest.

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