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First identification of *Echinococcus multilocularis* in rodent intermediate hosts in Sweden



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ABSTRACT

Echinococcus multilocularis is a zoonotic tapeworm with a sylvatic lifecycle and an expanding range in Europe. Monitoring efforts following its first identification in 2011 in Sweden have focused on the parasite's definitive host, the red fox (*Vulpes vulpes*). However, identifying rodent intermediate hosts is important to recognize opportunities for parasite transmission. During 2013–2015, livers from a total of 1566 rodents from four regions in Sweden were examined for *E. multilocularis* metacestode lesions. Species identity of suspect parasite lesions was confirmed by PCR and sequencing. *E. multilocularis* positive lesions >6 mm in diameter were also examined histologically. One *Microtus agrestis* out of 187 (0.5%, 95%CI: 0–2.9%), 8/439 (1.8%, 95%CI: 0.8–3.6%) *Arvicola amphibius*, 0/655 (0%, 95%CI: 0–0.6%) *Myodes glareolus*, and 0/285 (0%, 95%CI: 0–1.3%) *Apodemus* spp. contained *E. multilocularis* metacestode lesions. Presence of protoscoleces was confirmed in the infected *M. agrestis* and in three of eight infected *A. amphibius*. Six of the nine positive rodents were captured from the same field. This is the first report of *E. multilocularis* in intermediate hosts in Sweden. The cluster of positive rodents in one field shows that local parasite prevalence can be high in Sweden despite overall low national prevalence in foxes (<0.1%). The presence of protoscoleces in infected *M. agrestis* and *A. amphibius* indicate these species can serve as competent intermediate hosts in Sweden. However, their relative importance for *E. multilocularis* transmission in the Swedish environment is not yet possible to assess. In contrast, the negative findings in all *M. glareolus* and *Apodemus* spp. suggest that these species are of no importance.

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1. Introduction

Echinococcus multilocularis is a tapeworm with a sylvatic life-cycle between canids and rodents. In humans, *E. multilocularis* causes alveolar echinococcosis, which is a highly fatal disease without treatment (Torgerson et al., 2008). The known geographic range of *E. multilocularis* has been expanding from its high endemic areas in central Europe in recent decades, and it is now considered an emerging disease throughout Europe (Romig et al., 2006; Torgerson et al., 2010). To better understand risk for human

exposure, there is an increased need for understanding of the transmission dynamics of this parasite in the wild. This is particularly true in areas, such as Sweden, where the parasite has only recently been detected in red foxes (*Vulpes vulpes*) (Osterman Lind et al., 2011).

Although host species vary throughout the parasite's range globally, suitable intermediate hosts in Europe are rodent species mainly within the subfamily Arvicolinae (Eckert and Deplazes, 2004). The importance of a particular rodent species as an intermediate host for *E. multilocularis* transmission is dependent on such physiological and ecological factors as species susceptibility, species abundance, and predator preferences (Giraudoux et al., 2003). In central Europe, the common vole (*Microtus arvalis*) and the water vole (*Arvicola terrestris*) are considered the most important

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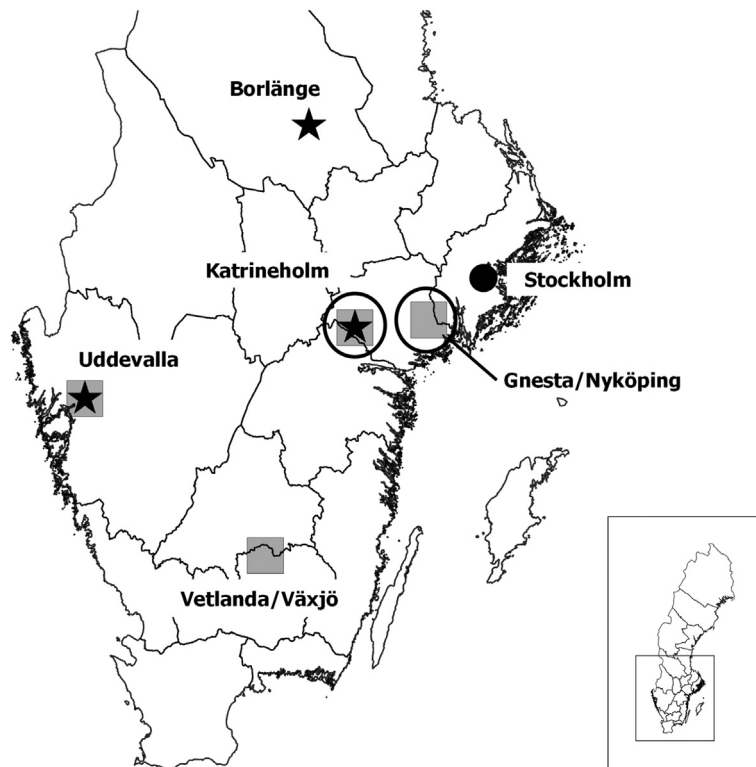


Fig. 1. Study areas and positive findings of *E. multilocularis* in southern Sweden at the beginning of the study, 2013. Boxes show study areas and stars indicate where positive foxes/fox fecal samples had been found. Circles encompass the study areas where rodents positive for *E. multilocularis* were captured. The lines are county boundaries. (CRS: WGS 84, QGIS 2.12.3).

intermediate hosts with the bank vole (*Myodes glareolus*) of lesser importance (Stieger et al., 2002; Romig et al., 2006). In high endemic areas in Switzerland, prevalence in *A. terrestris* has been reported up to 39% (11/28 voles examined) and 23% (12/52 voles examined) in *M. arvalis* (Gottstein et al., 2001). Both *M. arvalis* and *A. terrestris* are important prey items of the red fox, the most common definitive host for *E. multilocularis* in central Europe. During cyclic peaks of *A. terrestris* in France, the red fox may feed almost exclusively on this species (Viel et al., 1999). Although a generalist predator, some studies have also shown that the red fox prefers to feed on *Microtus* spp. even in areas of low *Microtus* spp. densities (Guislain et al., 2008; Raoul et al., 2010). In contrast to *M. arvalis* and *A. terrestris*, *M. glareolus* is not heavily preyed upon by foxes (Dell'Arte et al., 2007; Raoul et al., 2010) and prevalence of *E. multilocularis* in *M. glareolus* is usually low even in high endemic areas (Stieger et al., 2002; Hanosset et al., 2008).

E. multilocularis was first identified in Sweden in a red fox shot December 2010 in the municipality of Uddevalla (Osterman Lind et al., 2011) (Fig. 1). Increased nationwide monitoring during 2011 identified three infected areas in Sweden, and prevalence in foxes

on a country level was estimated to be approximately 0.1% (Wahlstrom et al., 2012) (Fig. 1). This low prevalence has remained and is intriguing as in large parts of Sweden conditions for the existence of the parasite are considered to be favorable. These conditions include presence of the red fox and a cool, moist environment ideal for survival of tapeworm eggs (Veit et al., 1995; Eckert and Deplazes, 2004). Nevertheless, the absence of Europe's most important intermediate hosts could be a limiting factor for the presence of the parasite in the Swedish environment. The common vole (*M. arvalis*) does not exist in Sweden (Wilson and Reeder, 2005). Furthermore, *A. terrestris* has recently been recognized as two species, *Arvicola scherman* and *Arvicola amphibius* (Wilson and Reeder, 2005). Of the two, only *A. amphibius* exists in Sweden (Wilson and Reeder, 2005). In the absence of *M. arvalis* and *A. scherman*, the intermediate hosts most likely to maintain the *E. multilocularis* lifecycle in Sweden are *A. amphibius*, *Microtus agrestis* and *M. glareolus* (Wahlstrom et al., 2012).

Thus far, there have been no reports of *E. multilocularis* in intermediate hosts in Sweden. Monitoring of rodents around Uddevalla where the parasite was first detected red foxes, included

Table 1

Results of 1566 rodents captured in four different regions in Sweden during 2013–2015 and examined for *Echinococcus multilocularis*. Number of examined rodents (*n*), number of positive rodents (*N*), percent positive (%), and 95% confidence interval (95 CI) are given for each region and for each species.

	Uddevalla			Katrineholm			Gnesta/Nyköping			Vetlanda/Växjö		
	<i>n</i>	<i>N</i>	% (95 CI)	<i>n</i>	<i>N</i>	% (95 CI)	<i>n</i>	<i>N</i>	% (95 CI)	<i>n</i>	<i>N</i>	% (95 CI)
<i>Arvicola amphibius</i>	147	0	0 (≤2.5)	159	3	1.9 (0.4–5.4)	131	5	3.8 (1.3–8.7)	2	0	0 (≤84.2)
<i>Microtus agrestis</i>	60	0	0 (≤6.0)	73	0	0 (≤5.0)	44	1	2.3 (0.1–12.0)	10	0	0 (≤30.8)
<i>Myodes glareolus</i>	205	0	0 (≤1.8)	166	0	0 (≤2.2)	124	0	0 (≤2.9)	160	0	0 (≤2.3)
<i>Apodemus</i> spp.	78	0	0 (≤4.6)	84	0	0 (≤4.3)	36	0	0 (≤9.7)	87	0	0 (≤4.2)
TOTAL	490	0		482	3		335	6		259	0	

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