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The presence of *Alaria alata* fluke in the red fox (*Vulpes vulpes*) in north-western Poland

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Abstract

The aim of the study was to evaluate the occurrence of *Alaria alata* in red foxes in NW Poland. The extensity of infection with *Alaria alata* was 54.7%, and the mean intensity of infection was 72 individuals per host, ranging in number from one to 769 individuals. The fluke was found in the three parts of the small intestine, but more often in the jejunum and duodenum than the ileum. Statistically significant differences in fluke number were found between the duodenum and ileum and between the jejunum and ileum. The presence of *Alaria alata* was observed more in the western districts, large surfaces of which are covered by water reservoirs: these allow *Alaria alata* flukes to complete their developmental circle.

Key Words: *Alaria alata*, red fox, Poland

Alaria alata (Goeze, 1782) is capable of parasitizing a range of common hosts. This lack of specificity assists the parasite in completing its developmental circle and contributes to its distribution in the environment. Some reports indicate that it may also represent a potential threat to humans, who can act as paratenic hosts for *Alaria alata* after consuming poorly-cooked food of animal origin containing mesocercaria, such as frogs' legs, wild boar or venison. Following infection, alariosis can develop; despite its rarity in humans, the condition may represent a severe threat to health, with potentially fatal consequences. The parasites penetrate from the intestines into the surrounding tissues and become located in the liver, kidneys, brain, lungs and adipose tissue[15,16,28)].

The final hosts for *Alaria alata* are common species of predators, including foxes[13)]. The growth in the red fox population observed recently in European countries[9,14,17,23,25,27)] has increased the risk of human infection with alariosis, especially

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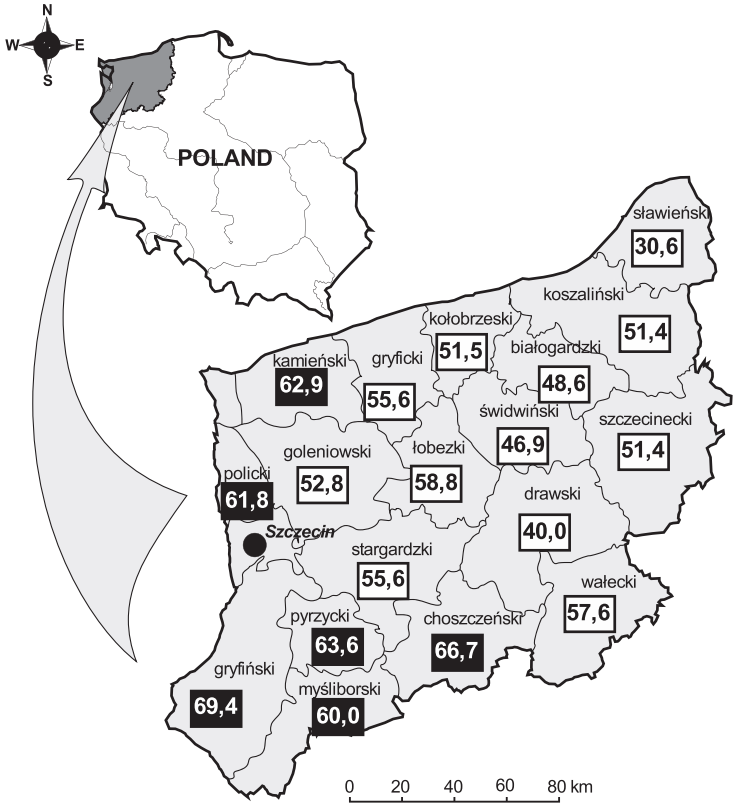

Fig. 1. Extensity of infection with *Alaria alata* in red fox in particular districts of the Zachodniopomorskie (West Pomerania) voivodeship: extensity of infection (%) shown in frames; districts with the highest extensity of infection in foxes are indicated in black. Tylkowska *et al.*

as the fox population is increasingly encroaching upon human neighborhoods in its search for food. Such close contact with foxes, which act as parasite reservoirs, represents a potentially severe threat to public health. Therefore, it is recommended that studies on fox parasite fauna should be updated to better evaluate the risk of alariosis infection for humans.

The aim of the study was, therefore, to determine the presence of *Alaria alata* in the red fox (*Vulpes vulpes*) in north-western Poland.

The study was performed in the West Pomerania voivodeship (NW Poland). The total area of the voivodeship is more than 22,892 km^2, with forests covering 35.4% of its total area and water reservoirs almost 2.9%. West Pomerania is characterized by considerable biodiversity and its climate is highly variable due to the intersection of maritime and continental climates. The combination of the sea, water reservoirs and large forest surface in such close proximity form a temperate climate with an mean annual rainfall of 500–800 mm, average annual temperature between 7°C and 9°C and high air humidity.

The study material included 620 red foxes (*Vulpes vulpes*) (236 females, 384 males) obtained by the reduction culling in 2008–2011 in 18 districts of West Pomerania (Fig. 1). According to Polish law[24], the collection of tissues and organs from animals killed for other than scientific and didactic reasons is not classified as experimental work on animals and therefore does not require ethics committee approval.

Post mortem examinations were performed according to Eckert *et al.* (1991, 1992)[11,12] and Deplazes and Eckert (1996)[7]. During the examination, the small intestines of the foxes were removed and divided into three sections (duodenum, jejunum and ileum) and the sex of the individual was identified based on the

Table 1. Occurrence of *Alaria alata* in red fox

Sex	Number of parasites	Number of infected/examined foxes	Prevalence (%)	U Mann-Whitney test	Intensity of infection			Relative density
					Mean	Range	U Mann-Whitney test	
♂	12832	213/384	55.5	$Z = -0.82$	60.2	2–441	$Z = -0.08$	33.4
♀	11587	126/236	53.4	$P = 0.414$	92.0	1–769	$P = 0.934$	49.1
Total	24419	339/620	54.7	–	72.0	(1–769)	–	39.4

gonads. The flukes were identified according to the parasite identification key by Ziomko and Cencek (1995)[31]. The flukes were preserved in 70% alcohol.

The results were analyzed with Statistica 10.0 software. To evaluate the significance of differences in fluke number in relation to sex, the U Mann-Whitney test was used. To assess the significance of the presence of flukes in particular sections of the digestive tract, and in particular districts of the West Pomerania voivodeship, the Kruskal-Wallis test was used.

In our study, the extensity of fox infection with *Alaria alata* in north-western Poland was 54.7% (Tab. 1). A lower extensity of infection (39.2%) was previously reported by Bieńko (2000)[3] in the same area. Similarly, a lower extensity of fox infection (31.6%) was also reported by Ramisz *et al.* (2004)[22] in western Poland. Hence, there appears to have been a systematic increase in the presence of this parasite in north-western Poland over the past 17 years. Balicka-Ramisz *et al.* (2003)[2] reported the mean extensity of fox infection with *Alaria alata* in Poland to be 21.8%. In contrast, Murphy *et al.* (2012)[19] reported a much lower extensity of fox infection with *Alaria alata* (21–26%) in Ireland in a study group of 500 individuals. The intensity of infection was diverse: mostly it ranged from one to 10 parasites, however, it was higher than 200 in 12% of foxes and more than 500 in 6%. In one fox, the authors found 981 flukes.

Two factors could be responsible for such a high occurrence of *Alaria alata* in north-western Poland. The first is the contribution of paratenic hosts available in the area which play a role in the developmental cycle of flukes: wild boar, mustelids, rodents, birds and lizards[15,28,30]. In Poland, since 2000, a threefold increase in the fox population has also been observed. This wide range of paratenic hosts and the commonness of their presence favors the completion of the developmental cycle of the parasite, thus increasing its distribution through the environment.

The second factor is the environment, more specifically, the availability of water reservoirs. As many animals associated with water habitats act as intermediate hosts for *Alaria alata*, the fluke is better able to complete its developmental cycle in regions with large areas of water reservoirs; the West Pomeranian voivodeship is such a region, with surface waters covering 2.9% of its total area. The parasite tended to be found in greater numbers in the western districts of the voivodeship, where water reservoirs are more plentiful.

Many authors have also noted the effect of availability of water reservoirs on the extensity of fox infections with *Alaria alata*[2,4,18,20]. The prevalence of *Alaria alata* was found to be lower in the south of Poland than the north[2], which correlates with a greater surface area of water reservoirs in the northern part of the country. In addition, a greater extensity of fox infections with *Alaria alata* has been reported in the North of Europe, i.e. 94.8% in Lithuania, 42.6% in Belarus and 27.3% in Ireland[5,26,29], than in the South: 1.2% in Slovakia, 1.5% in Spain and 4.7% in Croatia[6,17,21]. This can be attributed to the fact that more water reservoirs are located in the northern part of the continent than the southern part.

Table 2. Occurrence of *Alaria alata* in red fox in particular parts of small intestine

Part of a small intestine	Number of parasites	Number of infected/examined foxes	Prevalence (%)	Kruskal-Wallis test	Intensity of infection			Relative density
						Range	Kruskal-Wallis test	
Duodenum	4955	308/620	49.7^{A}	$H = 166$ $P < 0.001$	16.1^{A}	1–256	$H = 179.9$ $P < 0.001$	8.0
Jejunum	17281	328/620	52.9^{A}		52.7^{B}	1–527		27.9
Ileum	2183	125/620	20.2^{B}		17.5^{A}	1–152		3.5

The different capital letters indicate statistically significant differences at $P \leq 0.01$

The extensity of fox infections with *Alaria alata* is higher in wild animals (final and paratenic hosts) living in moist areas colonized by snails and amphibians. Studies by Murphy *et al.* (2012)[19] in Spain have shown the fluke to be present in foxes living in the well-irrigated valley of the Jarama river, but not in the desert regions of southern Spain. Also, Alagaili *et al.* (2011)[1] did not identify any flukes in foxes in Saudi Arabia; they attribute this absence to the dry, desert climate and limited number of water reservoirs, which impeded the completion of the fluke developmental cycle due to a lack of intermediate hosts.

The presence of *Alaria alata* in male and female foxes was found to be similar, which has previously been noted by other authors[4,10,8,25,27]. Vervaeke *et al.* (2005)[27] attributes this similarity in numbers to the fact that both females and males consume a similar diet.

In this study, the mean intensity of infection was 72 individuals per host animal (range 1–769). The mean intensity of infection was higher in female foxes than in males (92.0 and 60.2 individuals, respectively), however, again, these differences were not statistically significant.

Although *Alaria alata* flukes were found in every single section of small intestine, our findings indicate that it prefers the initial sections of the small intestine (duodenum and jejunum) as a living habitat (Tab. 2). Unfortunately, it is not possible to compare these findings with those of other studies as no such literature data is available concerning the location of flukes in the digestive tract.

The mean intensity of fox infection was higher in the jejunum (52.7 individuals) than the duodenum (16.1 individuals) and the ileum (17.5 individuals). Statistically significant differences in mean intensity were noted between the jejunum and the duodenum, and between the jejunum and the ileum (Kruskal-Wallis test; $H = 179.9$; $P = 0.000$).

The presence of *Alaria alata* was noted in all West Pomerania voivodeship districts and no significant differences in its presence were observed between particular districts. However, it was more commonly observed in the districts of the western part of the voivodeship (Fig. 1). During the last few years, the extensity of fox infections with *Alaria alata* in north-western Poland has grown, with greater numbers being observed in foxes in districts where large areas of land are covered by water reservoirs.

Conflict of Interest

We confirm that there is no conflict of interest with any people or organizations that could prejudice or bias the content of this research paper.

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