

## Epidemiologic Study of Lung Parasites (*Metastrongylus* spp.) in Wild Boar (*Sus scrofa*) in Southwestern Spain

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**ABSTRACT:** We analyzed 927 wild boars (*Sus scrofa*) in southwestern Spain during the hunting seasons of 2004/2005 to 2008/2009. Respiratory tracts were examined for lung nematodes (*Metastrongylus* spp.). The prevalence of *Metastrongylus* spp. was 41.1%. The most frequently isolated species were *Metastrongylus apri* (71.4%), *Metastrongylus puledotectus* (28.0%), and *Metastrongylus salmi* (0.6%). Prevalence and infection intensity were greater in young animals (<1 yr old) than in older animals. There were no significant differences in prevalence between sexes. Prevalence and intensity of infection were higher in areas of high altitude and high rainfall.

**Key words:** Helminths, *Metastrongylus*, southwestern Spain, wild boar.

Metastrongylosis is an important parasitic respiratory disease affecting domestic pigs and wild boars (*Sus scrofa*). Because earthworms are required for their transmission (Hobmaier and Hobmaier, 1929), parasitism is less frequent in indoor pig-rearing facilities. Because of the increase of indoor pig rearing in Europe, metastrongylosis has been neglected. In outdoor farms that remain, however, interaction between domestic pigs and wild animals is common. Wildlife is a reservoir for several diseases and epizootiologic surveys are needed, especially in large wild boar populations (Gortázar et al., 2000; Santos et al., 2006).

The typical Mediterranean forest ecosystem of southwestern Spain supports two overlapping economic activities—game and extensive pig husbandry—carried out in very close areas, even sharing estates (Fig. 1). Their co-occurrence in time and space facilitates interactions between domestic pigs and wild boars.

We examined the prevalence of *Metastrongylus* spp. in the wild boars from

southwestern Spain and analyzed the association of this lung nematode with sex and age of wild boars and with environmental conditions (climate, altitude, and rainfall) of this region. We sampled 927 hunter-shot wild boars during five hunting seasons (October to February) from 2004/2005 to 2008/2009. Age was estimated according to Saéñz de Buruaga et al. (1991) and four age groups were established on the basis of tooth development.

Postmortem examinations of wild boars were conducted immediately after official health inspection. Lungs were collected, placed into plastic bags, labeled, and preserved in refrigerators. Lungs were opened with dissection scissors following the bronchial tree, from the main bronchi to the terminal bronchioles; all nematodes were collected and fixed in 70% ethanol for counting and identification by sex and species according to Soulsby (1986) and Morita et al. (2007).

The study was conducted in Extremadura, southwestern Spain (41° to 37°N, 7° to 3°W; Fig. 1). Rainfall occurs mainly in spring and autumn; winters are mild and dry, and summer is long, hot, and extremely dry. Three climate types—Mediterranean, continental, and mountain-like—are distinguished in this area. The Mediterranean climate is characterized by average temperatures of 18 C and rainfall of 400–700 mm. The values for continental climate are 22 C and 300–650 mm and for mountain climate, 10 C and 1,000 mm. Climate data were taken from the Spanish Meteorological Agency.

Data were compared using analysis of variance (ANOVA) and Student's *t*-test in SPSS 15.0 software. Correlations between

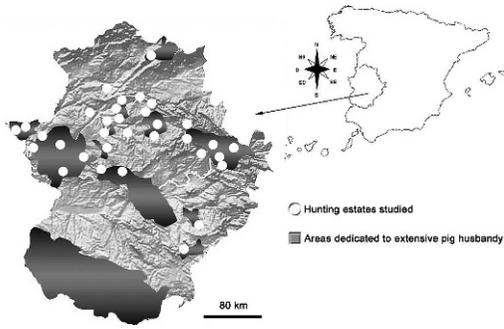


FIGURE 1. Areas of outdoor domestic pig production and hunting estates surveyed for lung nematodes (*Metastrongylus* spp.) in wild boars (*Sus scrofa*) in southwestern Spain.

variables were estimated using Pearson's linear correlation coefficient; values of  $P < 0.05$  were considered statistically significant.

*Metastrongylus* spp. were found in 381 (41.1%) of 927 wild boars examined (Table 1). The number of nematodes in bronchi and bronchioles was 10,315, but only 6,421 parasites could be identified. The mean intensity of infection was 27 helminths per infected animal. Of the nematodes examined, 22.5% ( $n = 2,324$ ) were male and 77.5% ( $n = 7,992$ ) were female.

Three species of lung nematodes were identified: *Metastrongylus apri* (71.4%), *Metastrongylus pudendotectus* (28.0%), and *Metastrongylus salmi* (0.6%); 92.9% of infected boars had a pure infection with *M. apri*, 57.7% with *M. pudendotectus*, and 5% with *M. salmi*. Mixed infections occurred in 55.4% of infected animals. The prevalence of *Metastrongylus* spp. infection was higher in young wild boars ( $\leq 2$  yr old) than older animals ( $> 2$  yr old;  $P < 0.005$ ). There were no significant differences between sexes of wild boar.

The intensity of *Metastrongylus* spp. infection was higher in areas with high average altitude ( $> 451$  m) than low average altitude ( $P = 0.005$ ), and the number of lungworms was higher in mountain-like than other kinds of weather ( $P = 0.005$ ). The most heavily infected animals

were shot in areas with high rainfall ( $> 501$  L/m<sup>2</sup>;  $P = 0.001$ ). The correlation between the *Metastrongylus*-infected animals and the climatic condition was significant for mountain-like weather ( $r = 0.97$ ;  $P = 0.005$ ), altitude ( $> 451$  m;  $r = 0.98$ ;  $P = 0.005$ ), and rainfall ( $> 501$  L/m<sup>2</sup>;  $r = 1$ ;  $P = 0.001$ ). Similarly, higher prevalences of *Metastrongylus* spp. in wild boar were found in areas with high average altitude (56.4%), high rainfall (53.0%), and mountain-like weather (71.9%; Table 2).

The prevalence of metastrongylids detected in southwestern Spain was distinct from that found in the eastern Spanish province of Valencia by de la Muela et al. (2001), who examined 47 wild boars and found a prevalence of 85%. Prevalences in other European countries were also higher than that found in our study. Humbert and Henry (1989) reported 92% prevalence in France. In Germany, Barutzki et al. (1991) observed 91, 88, and 87% prevalences for *M. salmi*, *M. apri*, and *M. pudendotectus*, respectively; Järvis et al. (2007) found 82% prevalence in Estonia.

García-Vallejo (1999) reported that 24% of 689 domestic pigs examined in southwestern Spain were positive for *Metastrongylus* spp. Thus, prevalence seems to be lower in domestic pigs than in wild boars. Differences are probably due to a combination of factors: wild boars have easier access to intermediate hosts (earthworms), do not have nose-rings, and undergo no deworming treatment. Moreover, wild boars live longer (32 mo in this survey) than domestic pigs (slaughtered at 12–14 mo) in southwestern Spain. Thus, wild boars could develop an effective immune response in older age. However, no studies have been conducted to demonstrate that wild boars are more sensitive than domestic pigs to infection with these parasites. The biased sex ratio in favor of female worms (3.4) was also recorded by Calero-Bernal et al. (2007). This bias leads to an increased prolificacy ensuring reproductive success and dispersal. The intensity

TABLE 1. Prevalence, abundance, and characterization of lung nematodes (*Metastrongylus* spp.) in wild boar (*Sus scrofa*) in southwestern Spain according to age and sex.

Variable	Sampled animals (n)	Positive animals (n)	Prevalence (%)	Infection intensity <sup>a</sup> (SD)	Wild boars infected by each species (%)			Total nematodes studied		
					<i>M. apri</i>	<i>M. pudendotectus</i>	<i>M. salmi</i>	Mixed infections	(n)	Sex ratio <sup>b</sup>
Age <sup>c</sup> of animal (yr)										
0-1	155	92	59.4	35.1 (31.0)	92.4	75.0	9.7	69.5	3,232	3.45
1-2	138	79	57.2	26.7 (28.5)	91.1	54.4	3.8	50.6	2,111	2.96
2-3	236	73	30.9	19.9 (16.0)	97.2	52.0	0.0	52.0	1,456	3.56
>3	167	54	32.3	19.1 (13.8)	87.0	38.8	5.5	37.0	1,033	4.64
Gender <sup>d</sup> of the animal										
Male	442	180	41.4	28.7 (24.1)	93.3	63.8	5.5	61.1	5,158	3.78
Female	457	189	40.7	24.6 (22.4)	92.0	51.3	4.7	49.2	4,641	3.19
Total	927	381	41.1	27.0 (32.4)	92.9	57.7	5.0	55.4	10,316	3.43

<sup>a</sup> Helminths per infected animal.

<sup>b</sup> Sex ratio = female worms/male worms.

<sup>c</sup> Data recorded from 696 animals.

<sup>d</sup> Data recorded from 899 animals.

TABLE 2. Prevalence, abundance, and characterization of lung nematodes (*Metastrongylus* spp.) in wild boar (*Sus scrofa*) in southwestern Spain according to environmental variables.

Variable	Sampled animals (n)	Positive animals (n)	Prevalence (%)	Infection intensity <sup>a</sup> (SD)	Wild boars infected by each species (%)			Total nematodes studied		
					<i>M. apri</i>	<i>M. pudendotectus</i>	<i>M. salmi</i>	Mixed infections	n	Sex ratio <sup>b</sup>
Altitude of the estate (m)										
<300	325	77	23.7	28.9 (23.0)	90.9	51.9	3.8	46.7	2,228	3.09
301–450	272	118	43.4	26.5 (21.4)	45.5	29.4	2.5	29.0	3,127	3.55
>451	330	186	56.4	11.3 (28.1)	86.0	53.7	4.8	51.6	2,106	3.54
Climate of the estate										
Continental	572	259	45.3	25.9 (25.5)	93.4	57.9	5.4	55.9	6,701	3.54
Mediterranean	266	58	21.8	26.0 (18.3)	89.6	60.3	3.4	55.2	1,509	3.37
Mountain	89	64	71.9	32.9 (30.4)	93.7	54.6	4.7	53.1	2,106	3.18
Rainfall of the estate (L/m <sup>2</sup> )										
<500	448	127	28.3	29.1 (24.0)	94.4	62.2	4.7	60.6	3,699	3.15
>501	479	254	53.0	26.1 (24.9)	92.1	55.5	5.1	52.7	6,617	3.68
Total	927	381	41.1	27.0 (32.4)	92.9	57.7	5.0	55.4	10,316	3.43

<sup>a</sup> Helminths per infected animal.

<sup>b</sup> Sex ratio=female worms/male worms.

of *Metastrongylus* spp. infections was higher in wild boars <1 yr old than in older animals (de la Muela et al., 2001; Jarvis et al., 2007). Dunn (1956) reported that young domestic pigs were more susceptible, perhaps because repeated contact with *Metastrongylus* spp. causes the establishment of an effective immune response (Alcaide Alonso, 2005). Humbert and Henry (1989) reported that the intensity of infection was higher in young animals because of their requirement for proteins during growth. Earthworms have a high nutritional value for wild boars, especially the high lysine content, an essential amino acid for growth in pigs (Mauget, 1982; Henry, 1987). Young wild boars are thought to ingest a higher number of earthworms than adults and therefore may have a higher level of parasitism.

The highest prevalence of *Metastrongylus* spp. was observed in areas with high altitude (>451 m), areas of mountain-like weather, and high rainfall. These climatic conditions are favorable for the resistance of eggs of *Metastrongylus* spp. (Rose, 1959) and survival of the intermediate host (Bouché et al., 1984). The presence of earthworms in the soil surface is higher after heavy rains (MacDonald, 1980; Baubet et al. 2003).

Our findings confirm that *Metastrongylus* spp. are distributed in mountain areas with high altitude and abundant rainfall in southwestern Spain. The numerous populations of wild boar, widespread in areas where outdoor pig farms are present, result in the mingling of wild boars and domestic pigs. Wild boars may serve as a propagator of forms of dissemination (eggs) of *Metastrongylus* spp. on southern Mediterranean pig farms.

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