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# High lungworm burden in enclosed wild boar from Eastern Austria

Bettina Lechner*[1], Barbara Hinney, Georg Duscher, Anja Joachim

*Institute of Parasitology, Department of Pathobiology Vetmeduni Vienna*

**Corresponding author: Mag.med.vet.Bettina Lechner, Institute of Parasitology, Department of Pathobiology,Vetmeduni Vienna Veterinärplatz 1 A-1210, Vienna, AUSTRIA. Tel: +43 1 25077 2201; Fax: +43 1 25077 2290;*

*Email: bettina.lechner91@gmail.com*

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## Abstract

### Objective
We aimed to investigate the endoparasite status, especially the lungworm burden, of wild boar in an enclosed hunting ground in Eastern Austria.

### Animals and samples
In total, 49 lungs and 47 corresponding faecal samples of animals of different age groups (shoats, young pigs and adults) were examined.

### Methods
Lungs were dissected and adult metastrongylids were counted and determined to species level (n=25/animal). Faecal samples were prepared by sedimentation/flotation and examined qualitatively and also quantitatively (by McMaster counting).

### Results
Adult lungworms were present in 94% of the animals. Eggs of *Metastrongylus* spp. (89%), *Ascaris suum* (8%), *Globocephalus urosubulatus* (96%), *Trichuris suis* (51%), as well as oocysts of coccidia (100%) were detected. Five different species of *Metastrongylus* (*M. apri, M. salmi, M. pudendotectus, M. confusus* and *M. asymmetricus*) were found in the lungs. Oocysts of *E. debliecki, E. scabra, E. perminuta, E. porci, E. polita* and *Cystoisospora suis* could be differentiated. *E. debliecki* was the most common (100 %), *E. porci* (28 %) the rarest species. In most cases, parasite excretion tended to decline with increasing age. In contrast to domestic pigs, *C. suis* could be found in all age groups.

### Conclusions
The high intensities and infection rates indicate a considerable infection pressure which may lead to health problems in enclosed wild boar. Proper habitat conservation and hunting practices are necessary to keep a stable and healthy population in such enclosed environments.

**Keywords:** game animals; nematodes; *Metastrongylus*; *Eimeria*; *Cystoisospora*; *Globocephalus*; *Trichuris, Ascaris*

## Introduction

Besides roe and red deer, wild boar is one of the most important hoofed game species in Central Europe. Due to the difficult hunt and the excessive food supply the populations are constantly increasing. Growing populations in restricted habitats however pose an increasing risk of parasitic infections. Especially in game enclosures it must be assumed that the transmission risk for various pathogens increases inordinately [1, 2].

Coccidial infections are frequently asymptomatic, but *Cystoisospora suis* and rarely *Eimeria* spp. can also cause catarrhal, rarely necrotic enteritis with non-haemorrhagic diarrhoea in young piglets, leading to weight loss and poor performance [3-6].

Little is known about the prevalences in wild boar and the effects on their health. For Austria, so far five species of Eimeria have been described from domestic and wild suids. The latter harboured mostly *Eimeria debliecki* and *Eimeria polita*, as well as C. suis [7].

The large roundworm *Ascaris suum* can be found in the small intestines of domestic and wild suids and can cause reduced growth when present in large numbers [8]. Similarly, the whipworm *Trichuris suis* frequently resides in the large intestines of wild and domestic pigs and can cause enteritis with diarrhoea in intensive infections, as well as hypalbuminaemia and reduced growth [9]. The porcine hookworm *Globocephalus urosubulatus* on the other hand infects primarily wild boar [10].

The porcine lungworms of the genus *Metastrongylus* are rarely found in domestic pigs since they require earthworms as intermediate hosts so only pigs with outdoor access to earthworm habitats can become infected while wild boars frequently harbour these parasites. Especially in young animals the parasite is rather pathogenic, inducing lung damage with dyspnoea, weight loss and even death [11, 12]. Due their pathogenicity they are still considered to be the most important airway pathogens in extensive pig management [13, 14]. In Europe, so far five different species have been described, *Metastrongylus apri* (syn. *M. elongatus*), *M. salmi, M. pudendotectus, M. confusus* and *M. asymmetricus* [12, 15-19].

To evaluate the parasite burden of wild boar from an enclosure in Eastern Austria, we investigated lungs and faecal samples of animals from different age categories for infections with parasites, especially lungworms.

## Material and Methods

### Samples

Samples were provided by hunters and originated from a large enclosure in Eastern Austria. As soon as possible after killing, lungs and faecal samples were kept refrigerated in a cooling chamber at a temperature of 4-8 °C until examination 3-5 days later. The hunters also evaluated age, weight and body condition of the animals. In total 49 animals, 10 male and 23 female shoats (<1 year), two male and six female young animals (1-2 years), four sows and four tuskers were examined. Lungs were available from all of them, faecal samples from all but two shoats (n=47). Lungs were inspected for gross pathological changes, the upper and lower airways were cut open, the lungworms removed and fixed in 70% ethanol.

### Lungworm differentiation

Specimens from each positive lung were counted. A maximum of 25 females per each lung were differentiated according to different keys [12, 18, 20]. The species were differentiated according to their characteristic endings shown in Figure 1.

**Figure 1.** *Metastrongylus* species in wild boar: Posterior ends of females of *M. apri* (A); *M. pudendotectus* (B), *M. asymmetricus* (C), and *M. confusus* (D).


### Coproscopy

Using a combined sedimentation/flotation technique, faecal sample were examined for parasite stages (helminth eggs and coccidian oocysts) using saturated sugar solution. Positive samples were examined by a modified McMaster technique [21]. Coccidia oocysts were microscopically differentiated according to their size and morphology [22].

### Statistical evaluation

To compare the parasite distribution in different age groups data were analysed by nonparametric tests (Kruskal-Wallis and Mann-Whitney U test) in SPSS v. 20 (SPSS Inc., Chicago, USA). Correlations between body mass and parasite burden/excretion and between different species of Metastrongylus were tested calculating Pearson's rank correlation coefficient.

## Results and Discussion

### Body condition of the animals

The body condition was documented for 48 animals, and 38 of these were in very good or good physical condition. Nine shoats were poorly nourished and a male adult animal was emaciated. For nine of the ten animals with a poor condition faecal samples could be examined. No correlation with the burden of adult lungworms or with the excretion of oocysts/nematode eggs could be established (details not shown).

**Lung pathology**

During gross examination purulent areas, enlarged lymph nodes, pulmonary oedema and haemorrhage, emphysema and adult lungworms could be seen in different parts of the lung. Haemorrhage was the most common finding, which could at least partly be attributed to gunshot injuries and was not evaluated further. Emphysema was the second most common alteration, found in 90% of the shoats in different parts of the lung. Young pigs showed mainly signs of purulent pneumonia and enlarged lymph nodes (Fig. 1). Earlier works stated that pathological changes induced by porcine lungworms are irreversible [11], indicating the health importance of metastrongylid infections in wild boar.

**Metastrongylid infections**

In total, 46 animals (94%) harboured adult lungworms. Shoats showed a mean worm burden of 195.5 specimen (SD=251.5, median 109, maximum number of worms: 1020) which was higher than in the other two groups (Table 1).

Overall, five different species of *Metastrongylus* could be differentiated, *M. apri, M. salmi, M. pudendotectus, M. confusus* and *M. asymmetricus* (Fig. 2). M. apri and M. salmi had prevalences of 75-100% and 63-100%, respectively, depending on the age of the animals, whereas *M. asymmetricus* was the rarest with 13-42% (Fig. 3). Differences in species composition between the age groups of the animals were, however, not significant. A significant positive correlation between infections with *M. salmi* and *M. pudendotectus* ($p = 0.000$; Pearson's Rho = 0.493) and an almost significant positive correlation between infections with *M. confusus* and *M. apri* ($p = 0.000$; Rho = 0.564) could be observed.

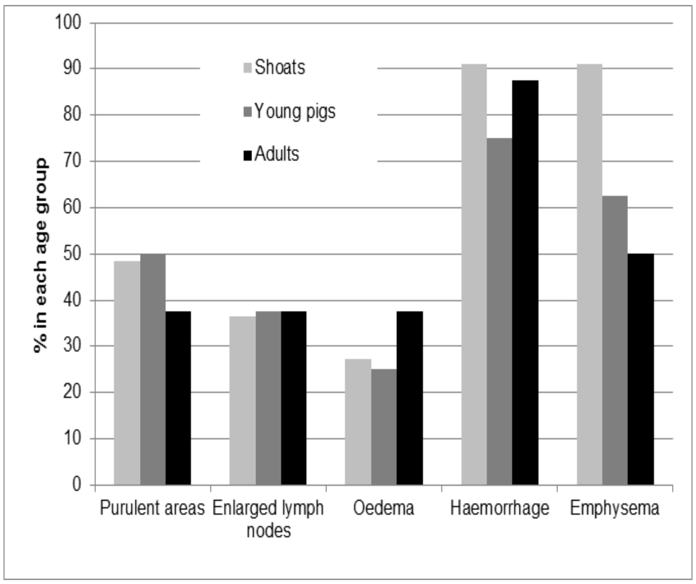
Metastrongylids are of the most important extraintestinal nematode pathogens of wild boar and organic pigs in terms of animal health, due to the wide distribution of the intermediate earthworm host. A high overall prevalence precluded statistically significant differences between age groups, hinting at a continuous reinfection cycle within the enclosure. So far, correlations between infection intensity and body condition could not be stablished, however, a tendency of lower body weight in animals with high infections was observed. Other studies could show a correlation between poor body condition and lungworm infection [27].

**Table 1.** Prevalences and infection intensities for adult *Metastrongylus spp*. and excretion rates for coccidia oocysts and eggs of *Metastrongylus, Trichuris* and *Globocephalus* and (only in shoats) *Ascaris* in different age groups. SD: standard deviation

| Age group | Parasites | *Prevalence (%)* | Excretion rates (eggs/oocysts per gram of faeces) | | | | |
|---|---|---|---|---|---|---|---|
| | | | Minimum | Maximum | Median | Mean | SD |
| **Shoats** | *Metastrongylus* adults | *96.8* | 0 | 1020 | 109 | 195,5 | 251.6 |
| **(<1 year)** | Coccidia oocysts | *100* | 450 | 88,850 | 11,650 | 19,579 | 20,073.8 |
| N=33 (lungs) | *Metastrongylus* eggs | *90.3* | 50 | 400 | 0 | 52 | 103.9 |
| N = 31 (faecal samples) | *Trichuris* eggs | *51.5* | 50 | 100 | 0 | 11 | 28.8 |
| | *Globocephalus* eggs | *93.5* | 50 | 3000 | 450 | 544 | 649.7 |
| | *Ascaris* eggs | *12.9* | 50 | 4950 | 0 | 265 | 955.0 |
| **Young pigs** | *Metastrongylus* adults | *100* | 1 | 44 | 63 | 22,1 | 17.2 |
| **(1-2 years)** | Coccidia oocysts | *100* | 4,500 | 151,150 | 27,025 | 50,244 | 12,667.0 |
| N = 8 | *Metastrongylus* eggs | *87.5* | 50 | 100 | 0 | 20 | 35,0 |
| | *Trichuris* eggs | *62.5* | 50 | 50 | 0 | 10 | 21.1 |
| | *Globocephalus* eggs | *100* | 50 | 1150 | 125 | 305 | 395.4 |
| **Adults** | *Metastrongylus* adults | *87.5* | 0 | 307 | 51,5 | 87,9 | 107.0 |
| **(>2 years)** | Coccidia oocysts | *100* | 1,650 | 37,550 | 11,850 | 14,769 | 57,487.6 |
| N = 8 | *Metastrongylus* eggs | *87.5* | 50 | 100 | 0 | 33 | 51.6 |
| | *Trichuris* eggs | *37.5* | 50 | 50 | 0 | 17 | 25.8 |
| | *Globocephalus* eggs | *100* | 100 | 1650 | 575 | 608 | 590.3 |
| **TOTAL** | *Metastrongylus* adults | *95.8* | 0 | 1020 | 0 | 1020 | 149.6 |
| N= 49 (lungs) | Coccidia oocysts | *100* | 450 | 151,150 | 14,050 | 23,980 | 28,979.5 |
| N = 47 (faecal samples) | *Metastrongylus* eggs | *89.4* | 0 | 400 | 0 | 49 | 88.8 |
| | *Trichuris* eggs | *51.1* | 0 | 100 | 0 | 13 | 26.5 |
| | *Globocephalus* eggs | *95.7* | 0 | 3000 | 400 | 550 | 600.3 |
| | *Ascaris* eggs | *8.0* | 0 | 4950 | 0 | 174 | 781.6 |

This may be due to an influence of age, but irrespective of the risk factors, high worm burdens indicate high infection pressure and in the long run this may lead to serious health problems in the observed herd since in enclosures parasite stages may accumulate (in the environment or in intermediate hosts, depending on the life cycle).

**Figure. 2.** Lung alterations according to age groups.



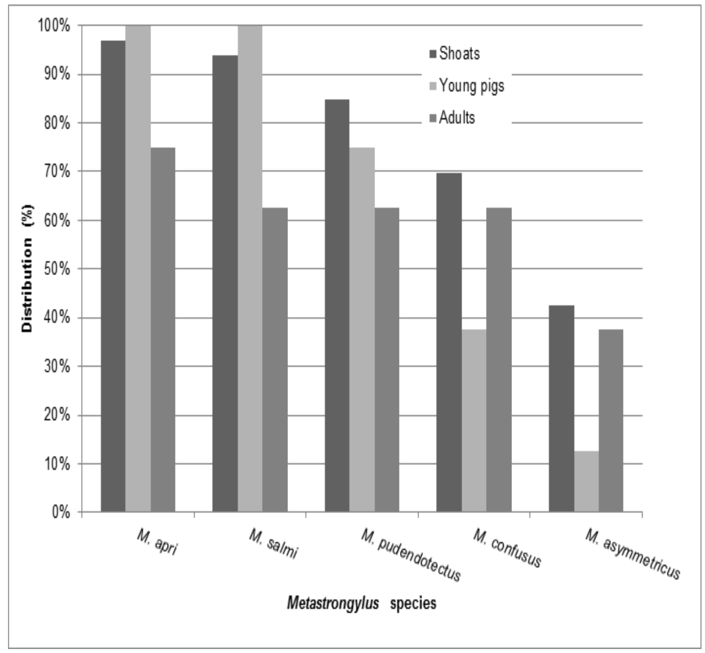

## Coproscopy

Coccidia oocysts could be found in all examined samples (Table 1). Five species of *Eimeria* (*E. debliecki, E. perminuta, E. polita, E. scabra* and *E. porci*) were found in a prevalence of 25-100%, while *Cystoisospora suis* was found in 97.9% of the samples, mostly in shoats (Table 2).

the same time, *E. scabra* excretion rates were also negatively correlated with body weight ($p = 0.007$; Rho = -0.446), which could be an effect of age distribution, although correlations between parasite excretion and age could not be established, probably due to low numbers of animals in some age groups.

In contrast to earlier studies [7, 23] in the present study *E. perminuta* and not *E. suis* was detected.

**Figure 3.** Prevalences of adult *Metastrongylus* species in different age groups.




Interestingly, all age groups shed considerable amounts of *C. suis* oocysts, which is in contrast to observations in domestic pigs where infection is mostly seen in suckling piglets [24].

**Table 2.** Coccidia (*Eimeria spp., Cystoisospora suis*) according to species and age group.

| | Number of samples | *E. debliecki* | *E. perminuta* | *E. polita* | *E. scabra* | *E. porci* | *C. suis* |
|---|---|---|---|---|---|---|---|
| Shoats | 31 | 31 | 30 | 17 | 31 | 8 | 30 |
| Young pigs | 8 | 8 | 8 | 4 | 8 | 2 | 8 |
| Adults | 8 | 8 | 8 | 4 | 6 | 3 | 8 |
| TOTAL | 47 | 47 | 46 | 25 | 45 | 13 | 46 |

Excretion intensities varied between 450 and 151,150 oocysts per gram of faeces (Table 1). *E. scabra* was found significantly more often in shoats than in the older pigs ($p = 0.007$) while no correlation could be found for the other coccidia species. At

Besides eggs of *Metastrongylus*, eggs of *Globocephalus, Trichuris* and *Ascaris* could be detected by flotation. Age-related differences were seen only for *Trichuris* eggs which were found mainly in young pigs (62.5%) and *Ascaris* eggs which were found only in shoats (Table 1). The highest excretion rates were seen for *Ascaris* with 4,950 eggs per gram of faeces (epg) and for *Globocephalus* with 3,000 epg, both in shoats. *Metastrongylus* and *Trichuris* eggs were excreted with a maximum of 400 and 100 epg (Table 1). Quantitative excretion of metastrongylid eggs was positively correlated with the excretion of hookworm eggs ($p = 0.000$; Rho = 0.679).

Ondrejková et al. [25] investigated the effect of endoparasites on the oral vaccination against classical swine fever in wild boars and found that parasitic infections influence the efficacy of oral vaccination against swine fever and support the ability of the virus to reproduce and cause disease, and to infect the surrounding the wild boar populations [25]. It must therefore be assumed that parasitic infections render wild boar more prone to other infections.

## Conclusion

The rate of lungworm infections of the examined animals was very high in all age groups, as were the infection rates for coccidian. The worm burden and oocyst excretion rates especially in shoats indicated a high infection pressure in young animals which was partially reduced in older boars, probably due to frequent reinfection in combination with induction of immunity [19]. High excretion rates for hookworm, ascarid and whipworm eggs in younger animals also indicate a development of immunity; however, this appears to be slow and incomplete except for *A. suum*, which was excreted only by shoats. The lung alterations, especially emphysema and purulent pneumonia, indicated that animals were more or less severely affected by lungworms (and possibly secondary bacterial infections) in all age groups. Under these circumstances both the high extensity and the high parasite burden indicate that animal health is most likely compromised by parasitic infection since animals constantly remain in the same contaminated environment. Contrary to this, Popiolek et al. observed a higher prevalence of *Metastrongylus* in a wild population than in farmed wild boar [26], so management of farmed wild boar may influence the parasite burden. In the longer term, it is expected that animals with reduced pulmonary function will suffer from reduced food intake, poor growth or even weight loss, as indicated by the approximately 20% of the hunted animals which were in poor body condition, with the consequence of a weakened immune system.

Means of improving animal health in a game enclosure are restricted to controlled hunting to reduce population density, while improved hygiene of feeding areas might be more difficult to implement. Navarro et al. [28] showed that it is important to restrict supplemental feeding because of the high density of wild boar in feeding grounds. They also observed that wild boars defecate before entering feeders which lead to an accumulation of parasite stages, and Nagy et al. [29] reported an increased density of earthworms infected with metastrongylids in the feeding area of wild boar, so that an accumulation of parasite stages at such sites (where their final hosts aggregate) must be assumed.

The ultimate aim of all measures must be to achieve a balance between game animals and their enclosed habitat to maintain a functional ecological cycle.

## Acknowledgements and Conflict of Interest

The authors declare that they have no conflict of interest.

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