EFFECT OF BREEDING CONDITIONS, PHENOLOGY, AND AGE ON THE OCCURRENCE OF HELMINTHS IN PIGS. A PRELIMINARY STUDY

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Abstract

Comparative faecal analysis-based research on the occurrence of helminths in pigs was conducted in two farms, which differ in their breeding system; in one, the pigs were kept indoors, while the pigs reared on the other had access to outdoor facilities. An examination of 118 faecal samples revealed the presence of the following four helminth species: Ascaris suum, Trichuris suis, Strongyloides ransomi, and Oesophagostomum sp. The helminth prevalence was very low (14.41%) and the mean number of eggs per sample being low as well (8.91%). The values of the basic parasitological indicators, and the richness of the species in the free-ranging herd proved significantly (P<0.007) higher than in the stock lacking access to outdoor facilities. The differences between the two pig farming systems compared were also found to be related to the age and phenology of the pigs studied.

Key words: pigs, helminths, breeding conditions, Poland.

The cost efficiency of pig farming depends primarily on the pig’s health. Country-wide, invasive pig diseases pose an important economic problem, the losses produced by parasitic diseases being higher than the losses inflicted by bacterial and viral diseases. The majority of parasite-inflicted diseases, even symptomless ones, are detrimental to the organism. Parasite-infected weaners show poorer body weight gains; the feed consumption is higher in infected pigs, compared to healthy ones, which extends the duration of the fattening (6, 11, 17, 24, 31, 32). Other consequences of parasitoses include a lack of rut activity, low litter size, and the poor viability of suckling pigs (11, 24). Parasitoses precede bacterial and viral diseases, enhanced by the deteriorating condition of the pigs (14). Moreover, the domestic pig is an epizootically important reservoir and vector of parasites, which are dangerous for other animals and for humans.

Tarczyński (26) published one of the first Polish reports on the parasitic fauna of domestic and wild suids. His country-wide research revealed 19 helminth species. Subsequently, faecal-analysis-based studies on pigs kept in state-owned farms, carried out in 1972-1974 in Western Pomeranian (29), showed almost half of the pigs to have been infected by gastrointestinal nematodes.

Comparative research, prompted by a switch from rearing pigs on small farms to the emergence of large-scale pig farming, is exemplified by studies by Romaniuk (23) on pig farms in Warmia-Masuria, by Połozowski et al. (18) on selected pig farms in Wielkopolska, and Nosal and Eckert (14) in the environs of Cracow. Data on the parasites and parasitoses of pigs have also been reported from the Czech Republic (10, 31), Germany (7), Spain (2, 20), Scandinavia and Iceland (21), China (1, 28), Kenya (13), and many others. The effects of the breeding conditions on the occurrence of gastrointestinal parasites in pigs were studied by Ropestorff and Nansen (22), Nansen and Ropestorff (12), and, recently, by Eijck and Borgsteede (4).

The amount of information on internal pig parasites, in both Polish and foreign literature, seems to be sufficient. However, exploratory parasitological studies on pig herds are still rare in Poland. Without earlier knowledge of the presence or absence of parasitic infections, pig breeders apply deworming medication and coccidiostatics in a routine manner, or only treat their pigs when they develop clinical parasitose symptoms, while the rearing conditions, which underpin the spread of the infection, remain unchanged (14). As a result, non-infected pigs are unnecessarily treated with medication, the overuse of which frequently leads to the emergence of drug resistance in parasites (15). Therefore, it is important to identify the species composition of the parasitic fauna characteristic of the different environmental conditions, to study the pathogenicity of the...
parasitic assemblage revealed, and to develop measures to prevent or limit the spread and invasiveness of the parasites. Also of importance for the prophylaxis of the infection is an analysis, from the parasitological standpoint, of the pig breeding technologies used in Poland. This paper is aimed at evaluating the effects of the pig breeding system on the spread and the parameters of internal parasite invasions, with particular reference to the effects of the pig’s age and phenology.

Material and Methods

Venue of study. The study was carried out on two pig farms located in the South-East of Poland. These farms apply different pig breeding systems: while the farm A pigs do not have access to outdoor facilities, the pigs kept at farm B can use the paddocks at will. At the farm A (Group A), most of the pigs are kept in stalls having fully or partially gridded floors. Non-gestating and early gestating sows are kept in groups of four-six in stalls with a small amount of bedding on a concrete floor. The concrete floor of the stall is durable and easy to clean. It is tilted to about 8% (6). The manure is reycled every other day and is replaced by a lining of clean straw. The straw lining provides soft and warm flooring. Each of the gestating sows, as well as the farrowing ones, are kept in a separate pen with a grill flooring. The pigs are fed standard feed mixes. The piggery is equipped with a semi-automatic feed dispenser. The pigs have constant access to drinking water from sucker-type dispensers. When they attain 30 kg of body weight, the weaners from the same litter are kept in group pens placed on a slotted grill flooring. The floors are made of plastic; they are thus warm and have no sharp edges.

The width of the slits is adjusted to the animals’ age. At the farm B (Group B), the pigs are kept in a free-range system, i.e., the pigs are not restricted in their use of outdoor paddocks. During inclement weather, the pigs can find shelter in the stall. The free-range breeding system is appropriate for keeping male pigs, non-gestating, and early-gestating sows (8). The paddock surface has a natural ground (dirt) cover, the cover in some parts being hardened. The natural ground part allows the pigs to fulfil their behavioural needs, mainly wallowing, which contributes to their wellbeing. The hardened part adjoins the stall and is equipped with rainwater and manure drainage systems. The paddock is fenced to prevent the pigs from escaping. Exits from the stalls onto the paddock are through flap doors, which automatically close the opening, thus preventing excessive heat loss from the stall. Inside the stall, the pigs are kept on a hardened floor lined with a thin layer of bedding. Weaners are kept in groups on a thin layer of bedding; like the sows, they have access to the outdoor facilities. The pigs are fed standard compound feeds. The farm has no automated feed dispensing system. Drinking water is constantly available.

At the farm A, the sows were dewormed 3 weeks prior to delivery, while the weaners were dewormed in early autumn and early spring; the pigs were treated with Ivomec. At the farm B, the sows were dewormed 3 weeks prior to delivery, while the weaners were treated just before weaning, when 28-d-old. The pigs were treated with Ivomec and Ivermectine. In both farms faecal samples were collected not earlier than eight weeks after the termination of deworming.

Collection of samples and laboratory procedures. The study was based on faecal examinations. Faecal samples were collected twice from each farm: in autumn 2006 and in spring 2007. A total of 118 samples were collected: 56 at the farm A (33 and 23 from sows and weaners, respectively) and 62 at the farm B (30 and 32 from sows and weaners, respectively). At both farms, the faecal samples were collected from the Polish white droopy-eared (pbz), great Polish white (wbp), and F1 (wbp x pbz hybrid) pigs. The weaners yielding the faecal samples were aged 1.5-3 months (about 10-30 kg of individual weight). About 5 g of faecal samples were collected. The fresh faecal samples, collected directly from the litter, were placed in labelled plastic containers and frozen at -18 to -20°C (25). In case of sows, the samples were collected from animals kept individually in separate boxes, in case of weaners – from animals kept in different collective boxes. The eggs and larval stages of parasites were isolated by using the standard (direct) flotation technique (27), a saturated NaCl solution being used as the flotation liquid. Egg identification was based on morphological characteristics (shape and structure of the shell), and measurements (5, 27, 30).

Statistics. Two types of parasitological indicators were used to assess the levels of infection in the two groups of pigs: (1) range and mean number of parasite eggs or larvae in a given sample; and (2) prevalence, i.e., the proportion (percentage) of infected samples relative to the total number of samples examined. The significance of the differences in the infection level (overall, in individual seasons, and in relation to the pig’s age) between the groups was tested using the non-parametric Mann-Whitney U test. The normality of distribution was checked using the Shapiro-Wilk W test. The species accumulation curve was used to calculate the species richness of the entire parasite assemblage, and at each pig farm separately; the results were estimated using the bootstrap non-parametric species richness estimator based on a formula provided by Colwell (3). The estimator used allows the calculation of species richness irrespective of the proportion of rare and accessory species, based on the presence (1) or absence (0) of data (9, 19). All calculations were performed using EstimateS 7.0 and Statistica 7.0 PL software packages.

Results

Overall prevalence and intensity of parasitic infection. Of the total of the 118 samples collected from both piggeries, as few as 17 were found to contain parasite eggs. Thus, the egg prevalence was very low (14.41%), as was the mean number of eggs per sample (8.91). The eggs of four parasitic nematodes (Ascaris suum, Trichuris suis, Strongyloides ransomi, and Oesophagostomum sp.) were isolated and identified. The
species accumulation curve for the samples examined did not reach the asymptote, which makes it possible for additional helminth species to be present (Fig. 1). The bootstrap estimated species richness (4.39 ±0.19) was not, however, markedly different from the species richness observed (4). This may be taken as an indication that the study yielded most of the coproposcopically detectable parasitic species, and that the examination of additional samples would not significantly change the final result. The list of species found, as well as the values of the basic parasitological indicators, is provided in Table 1. The highest prevalence was observed in T. suis, the eggs of which were represented in the smallest numbers. A. suum showed a slightly lower prevalence. The prevalence of Oesophagostomum sp. was 3.4%, the eggs of the nematode being second in abundance among all the eggs found in the samples (a mean of 7.89%). The rarest parasite was S. ransomi, found only once in the samples examined.

An analysis of the infection in relation to the pig’s age showed the prevalence in sows to be more than twice as high as in the weaners (Table 1). Among the 63 samples collected from the sows, 12 proved to be infected, while as few as five out of the 55 samples obtained from the weaners contained parasite eggs. The mean number of eggs per sample, however, was similar in the sows and weaners. No significant age-related differences were found.

As shown by the data in Table 1, the prevalence of infection was found to change with the season. The highest and the lowest prevalences were recorded in autumn and spring, respectively, a reverse pattern being observed in the mean number of eggs per sample. The autumn and spring prevalences of A. suum were similar. The autumn prevalence of T. suis was 7.27%, and dropped by almost half (to 4.76%) in the spring. The two remaining species, S. ransomi and Oesophagostomum sp., were recorded only in the autumn. The differences observed were not significant.

As many as 101 samples, i.e. 85.59% of the total number of samples examined, were parasite-free. The presence of one parasitic species was found in 16 samples (13.56% of the total number of samples). Coinvasion was recorded in a single sample only (0.85% of the total number of samples).

**Comparison of the kind of parasitic species and infection indicators in relation to age and phenology in farms A and B.** The two groups of pigs were found to differ in terms of the basic indicators of infection. The prevalence in the Group B (22.58%) was almost four times as high as that in the Group A (5.36%), while the groups did not particularly differ in terms of their respective mean numbers of eggs per sample (B: 10.89 ±17.53 vs. A: 6.33 ±6.80). Not all of the parasitic species were present in the two groups compared. The Group A was found to support two parasites: A. suum and Oesophagostomum sp. On the other hand, the pigs of the Group B were hosts to all the parasites listed, whose prevalence was higher than in the Group A (Fig. 2).

The parasite assemblages present in the two groups compared appeared to be explored sufficiently well (Fig. 1), as demonstrated by only small differences existing between the observed species richness (Group A - 2; Group B - 4) and the bootstrap-estimated values (Group A - 2.5 ±0.06; Group B - 4.43 ±0.18); sufficient knowledge of the parasites present in the two groups is also evidenced by the shape and form of the species accumulation curves (Fig. 1). In neither of the groups would an examination of additional samples yield a significantly higher number of helminth species. The highest prevalence in the Group B was typical of T. suis, a parasite absent in the Group A. The second highest prevalence (6.45%) was that of A. suum, a parasite with the highest mean number of eggs per sample (23.50%). The prevalence and mean number of eggs per sample shown by the species in the Group A were lower by as much as half, but were still the highest infection indicators recorded in that group. The third highest prevalence (4.84%) in the Group B was revealed by the nematode Oesophagostomum sp., the rarest helminth species in the Group A (1.79%; mean number of eggs per sample = 1).

The lowest prevalence in the Group B (1.61%) was characteristic of S. ransomi, a parasite absent in the Group A. As shown by the normality test, the distribution of the species richness deviated markedly from the normal distribution. The differences in species richness between the two groups proved to be highly significant (P<0.007; Mann-Whitney U Test; Z= -1.056, n1= 56, n2= 62), T. suis being the species with the highest contribution to the difference between the two groups (P<0.01, Mann-Whitney U Test; Z= -1.056, n1= 56, n2= 62).

Differences in the parasitic infection between the two pig groups were evident also with respect to the age. In the Group B, the parasites were almost three times as prevalent in the sows as in the weaners, while the latter showed the highest mean number of eggs per sample (19.25 versus 5.55 in the sows). On the other hand, differences between sows and weaners of the Group A were not as pronounced (Table 2). The mean number of eggs in the sow faecal samples averaged nine eggs, with only one egg being recorded in the weaners. The Group A sows only supported A. suum, occurring at a prevalence and mean number of eggs per sample similar to those in the Group B sows (Fig. 3). The Group A weaners, too, supported a single species, Oesophagostomum sp., the prevalence of which was the lowest in the Group A (4.34%). The Group B sows, on the other hand, carried all the parasitic species found in this study. The Group B weaners yielded two parasites only: A. suum and T. suis, which occurred at identical prevalences (6.25%), but differed markedly in their number of eggs: from 16 to 59 A. suum per sample (a mean of 37.5) versus one egg of T. suis per sample (Fig. 3).

As seen in Fig. 4, the differences between the two pig groups compared were also season-dependent. In the autumn, the prevalence in the Group B was almost twice as high as in the Group A.
Table 1  
Prevalence of infection and mean number of helminth eggs in relation to the season and age of the pigs

<table>
<thead>
<tr>
<th>Species of parasite</th>
<th>Total (n=118)</th>
<th>sows (n=63)</th>
<th>weaners (n=55)</th>
<th>spring 2007 (n=63)</th>
<th>autumn 2006 (n=55)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>number of eggs*</td>
<td>%</td>
<td>number of eggs*</td>
<td>%</td>
</tr>
<tr>
<td>Ascaris suum</td>
<td>5.08</td>
<td>18.66 ±14.10</td>
<td>6.34</td>
<td>9.25 ±8.05</td>
<td>3.63</td>
</tr>
<tr>
<td>Trichuris suis</td>
<td>5.93</td>
<td>1.07 ±0.18</td>
<td>7.93</td>
<td>1.1 ±0.22</td>
<td>3.63</td>
</tr>
<tr>
<td>Strongyloides ransomi</td>
<td>0.85</td>
<td>1</td>
<td>1.58</td>
<td>1</td>
<td>nd</td>
</tr>
<tr>
<td>Oesophagostomum sp.</td>
<td>3.40</td>
<td>7.87 ±10.41</td>
<td>4.76</td>
<td>10.16 ±11.44</td>
<td>1.81</td>
</tr>
<tr>
<td>Total</td>
<td>14.41</td>
<td>8.91 ±14.10</td>
<td>19.05</td>
<td>6.12 ±7.91</td>
<td>9.09</td>
</tr>
</tbody>
</table>

% - prevalence of infection; nd – not detected; n – number of samples examined; SD – standard deviation; * – per sample

Table 2  
Prevalence of infection and mean number of helminth eggs in relation to the age of pigs

<table>
<thead>
<tr>
<th>Farms/pig’s age</th>
<th>Prevalence (%)</th>
<th>number of eggs* mean ±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm A</td>
<td>sows</td>
<td>6.06</td>
</tr>
<tr>
<td></td>
<td>weaners</td>
<td>4.35</td>
</tr>
<tr>
<td>Farm B</td>
<td>sows</td>
<td>33.33</td>
</tr>
<tr>
<td></td>
<td>weaners</td>
<td>12.5</td>
</tr>
</tbody>
</table>

% - prevalence of infection; SD – standard deviation; * – per sample

Table 3  
Prevalence and mean number of eggs of particular helminth species in two farms compared in relation to the season

<table>
<thead>
<tr>
<th>Species of parasite</th>
<th>Farm A</th>
<th>Farm B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>spring 2007 (n=31)</td>
<td>autumn 2006 (n=25)</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>number of eggs*</td>
</tr>
<tr>
<td>Ascaris suum</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>Trichuris suis</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>Strongyloides ransomi</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>Oesophagostomum sp.</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>Total</td>
<td>nd</td>
<td>nd</td>
</tr>
</tbody>
</table>

% - prevalence of infection; nd – not detected; n – number of samples examined; SD – standard deviation; * – per sample
**Fig. 1.** Species richness estimates predicted for helminth assemblages: black points - both combined farms, white - farm A, grey- farm B; the lower curves (triangulars) are based on the number of species observed, the upper curves (squares) show the results of the Bootstrap non-parametric estimators of species richness.

**Fig. 2.** Prevalence (A) and mean number of eggs of particular helminth species per sample (B) in two compared farms. As – *Ascaris suum*, Ts – *Trichiuris suis*, Sr – *Strongyloides ransomi*, Oe – *Oesophagostomum* sp.
Fig. 3. Prevalence (A) and mean number of eggs of particular helminth species per sample (B) in two farms compared in relation to the age. Explanations as on Fig. 2.

Fig. 4. Prevalence (A) and mean number of helminths eggs per sample (B) in two farms compared in relation to the season.
The mean number of eggs per sample in the two groups was similar. In spring, the Group A proved to be parasite-free, while the Group B was affected by a prevalence of 18.75% (Fig. 4). In autumn, as shown by the data in Table 3, Group A carried the eggs of two parasitic species only: *A. suum* and *Oesophagostomum* sp., the prevalences of which were 8 and 4, respectively. On the other hand, the Group A proved parasite-free in spring. In autumn, the Group B supported all the parasitic species found in this work, while two species only (*A. suum* and *T. suis*) were recorded in spring and occurred at identical prevalences (9.37%). In autumn, *T. suis* was most prevalent in the Group B, the lowest prevalence being shown by *A. suum* and *Oesophagostomum* sp.

**Discussion**

The helminth fauna of pigs from the two farms proved species-poor and sparse. The samples examined were found to contain as few as four nematode species: *Ascaris suum*, *Trichuris suis*, Strongyloides ransomi, and *Oesophagostomum* sp. The species diversity was low, but the same species were recorded by, among others, Nosal and Eckert (14), and Połozowski et al. (18). Research carried out in other European countries has shown the gastrointestinal parasites of pigs to have a similar species richness. Roepstorff et al. (21) reported an identical composition of pig helminth fauna in five Scandinavian countries. Eijck and Borgsteede (4) in the Netherlands, and Joachim et al. (7) in Germany, listed three species (*A. suum*, *T. suis*, and *Oesophagostomum* sp.) out of the four found in this study. Those nematodes were also reported by Krivanec et al. (10) from pigs in the Czech Republic and, recently, by Bornay-Llinares et al. (2) and Weng et al. (28) from pigs in Spain and in the Guangdong province in China, respectively.

*T. suis* was the most frequent parasite. The results reported by Nosal and Eckert (14) were similar to the data obtained in this study. They revealed no *T. suis* eggs in the indoor pigs, while the free-range pigs showed a prevalence of 11.2% (11.29% in this study). However, the authors quoted found no *T. suis* in the sows, while the pigs of both ages, belonging to both groups examined in this study, proved to be infected with the parasite. The *T. suis* prevalence reported by Eijck and Borgsteede (4) from the free-range herds in the Netherlands was 21%, *i.e.* higher than that found in this study. The nematode was also recorded in adult pigs belonging to herds reared in the conventional way (a prevalence of 3.22%). The parasite was absent in suckling pigs. *T. suis* has also been reported from other European countries, *i.e.* from the Czech Republic (10) and Scandinavia (12, 21). A low prevalence of *T. suis* was recorded by Joachim et al. (7) in pigs in Germany, while the pigs reared in Iceland proved free of the parasite (21).

*A. suum* was the second most prevalent species (5.08%) and the one occurring at the highest abundance in the samples (a mean of 18.66). The two groups of pigs differed in both the prevalence and mean number of eggs per sample of the parasite’s infection, both indicators being higher in the Group B (A - 3.57%; 9 vs. B - 6.45%; 23.50). A lower prevalence was reported by Nosal and Eckert (14): 0.6 and 1.1% in the indoor and free-range pigs, respectively. The aforementioned authors failed to find *A. suum* in the weaners of either group, as opposed to this study in which the parasite’s eggs were absent only in the Group A weaners. Eijck and Borgsteede (4) identified the parasite in 21% of the free-ranging pigs, as opposed to as few as 3.22% pigs of the conventional group. They, however, found no *A. suum* eggs in the faeces of the free-ranging pigs. *A. suum* was also commonly reported from other European countries, *i.e.* from the Czech Republic (4, 31) Scandinavia, and Iceland (12, 21).

*Oesophagostomum* sp. was another genus recorded in both groups. Although its overall prevalence was 3.40%, the prevalence in the indoor pigs was lower (1.79%) than that found in the free-ranging pigs (4.84%). The mean number of eggs per sample was lower, too, in the Group A (1) than in the Group B (17.5). Among the indoor pigs, the eggs of *Oesophagostomum* sp. were found in the weaners only, the sows being the only carriers among the free-ranging pigs. A higher prevalence was reported by Nosal and Eckert (14). It was 3.7% in the indoor pigs, *O. dentatum* eggs being found only in the sows. On the other hand, 7.8% of the free-range pigs were affected, the nematode being, again, supported only by the sows. The study described by Eijck and Borgsteede (4) showed that the prevalence in the pigs with access to outdoor facilities and those kept indoors amounted to 18.4% and 12.9%, respectively. *Oesophagostomum* sp. was present in almost all the age groups, irrespective of the farm type. The prevalence of this parasite was also reported by Roepstorff et al. (21) from all the Scandinavian countries, except for Iceland.

Strongyloides ransomi proved to be the rarest parasite. It was recorded only in the Group B in the free-ranging pigs; its the prevalence was 1.61%. *S. ransomi* eggs were also the rarest in the samples examined; they were found only in the faeces of the sows, which showed 3.33% prevalence. Almost identical results were reported by Nosal and Eckert (14), who found no *S. ransomi* in the indoor herd, and recorded the parasite’s presence only in sows, showing 3.4% prevalence. *S. ransomi* is very rare in Europe; it was not reported from the Czech Republic (10), Finland, Norway (21), and the Netherlands (4).

An analysis of the differences between the two groups of pigs revealed pronounced differences in the species composition of the helminth fauna, and in the values of the basic parasitological indicators. The prevalence, mean number of eggs per sample, and number of parasitic species in the free-ranging group were higher than in those pigs having no access to outdoor facilities, which confirms the findings reported by Nosal and Eckert (14) and by Eijck and Borgsteede (4). The low level of infection in the indoor group resulted from the restricted contact of those pigs with faeces, achieved by, *e.g.* grill floors and no outdoor facilities. In the opinion of Nosal and Eckert (14), the invasion of *T. suis* is facilitated by access to dirt-covered paddocks, as also shown in this study. The prevalence was found to increase with age, as demonstrated earlier by Eijck and Borgsteede (4)
and by Nosal and Eckert (14). This was also confirmed by Pejsak and Tarasiuk (16), who found sows to be the main helminth vectors and egg dispersers. This study showed no clear-cut pattern with respect to phenology, particularly in the parasite species richness. Similar conclusions were drawn by Eijck and Borgsteede (4). Moreover, they put forth the theory that access to outdoor facilities is of only minor importance in the epidemiology of parasitic species such as *A. suum, T. suis,* and *Oesophagostomum* sp. whose life cycle can be easily completed within a pigsty. The conclusions reached by Nosal and Eckert (14) were, however, different: in the free-range pig herds they observed parasites to be more prevalent in autumn and the intensity of infections to increase in summer, while indoor herds showed no clear seasonal infection pattern.

The study presented allows us to accept the hypothesis that the helminth fauna occurs at a higher species richness and diversity in the pigs kept at farms with outdoor facilities, the prevalence and mean number of eggs per sample being higher in those pigs as well. The results presented reflect the effects of the rearing conditions on the pigs’ susceptibility to parasitic invasions.

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