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Simulation of the economic impact of Lawsonia intracellularis infection

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Introduction

Proliferative enteropathy (PE) is an enteric disease of pigs caused by the obligate intracellular bacterium Lawsonia intracellularis.¹ Results of economic modelling conducted using the AUSPIG decision support system in 1996 estimated that PE cost pork producers up to $7.00 per pig, with most of the cost attributed to using antibiotics in the pig diets to treat and control PE.²,³ This model did not take into account the economic impact of subclinical PE in a herd, and the potential for reduced antibiotic costs through the use of vaccine (Enterisol® Ileitis, Boehringer Ingelheim) to aid in the control of disease. This paper reports on recent simulations on the economic impact of L. intracellularis infection.

Materials and Methods

Growth and carcass data were from an experiment where 36 entire male pigs (18 challenged, 18 controls) were challenged at 63 days of age with 5.85 x 10⁹ L. intracellularis bacteria. Feed intake was measured on 2 consecutive days every week from 2 weeks before inoculation until 6 weeks after. Pigs were weighed each week from the day they arrived until slaughter at 106 days of age. Carcass composition data, including P2 backfat were sourced from CT scans conducted on pigs at 52, 85 and 106 days of age. Data on PE treatment and control costs were from 5 L. intracellularis-infected farms of varying health status. The AUSPIG simulations were based on a 1000-sow farm with commercial Large White X Landrace genotype. Three infection categories (controls (non-challenged), sub-clinically and clinically affected) were modelled. It was assumed that pigs were sold at a constant liveweight (approximately 104 kg). The impact of infection at the herd level was modelled by altering the proportion of control, subclinical and clinical pigs in three simulations and including 50% females and 50% castrates. These proportions were based on a recent serological survey, where an average of 84.2% of pigs within herds in Australia had antibodies to L. intracellularis.⁴ The “subclinical” simulation included 20% control and 80% subclinical pigs. The “clinical” simulation included 10% control, 74% subclinical, 16% clinical and an increase in grower pig mortality of 0.5%.

Results

The growth performance of pigs for the three infection herd categories is presented in Table 1. Profit (net revenue) in the control, non-infected herd was modelled at $25.31AUD per pig. Subclinical L. intracellularis infection reduced net revenue by $8.33AUD, whilst clinical infection reduced net revenue by $13.00AUD, relative to the non-infected “herd”. The cost of controlling PE was $2.70AUD per pig.

Table 1: Results from the AUSPIG growth simulation for control (C), subclinical (SI) and clinical (CI) pigs infected with L. intracellularis.

<table>
<thead>
<tr>
<th></th>
<th>Castrates C</th>
<th>Castrates SI</th>
<th>Castrates CI</th>
<th>Females C</th>
<th>Females SI</th>
<th>Females CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slaughter age (d)</td>
<td>147</td>
<td>147</td>
<td>192</td>
<td>147</td>
<td>147</td>
<td>189</td>
</tr>
<tr>
<td>Livewt. (kg)</td>
<td>104.3</td>
<td>102.6</td>
<td>104.4</td>
<td>104.6</td>
<td>102.9</td>
<td>104</td>
</tr>
<tr>
<td>P2 (mm)</td>
<td>12.1</td>
<td>12.2</td>
<td>14</td>
<td>12.6</td>
<td>12.8</td>
<td>14</td>
</tr>
<tr>
<td>FCR</td>
<td>2.37</td>
<td>2.44</td>
<td>2.95</td>
<td>2.4</td>
<td>2.47</td>
<td>2.92</td>
</tr>
</tbody>
</table>

Discussion

We used the AUSPIG decision support system to estimate the economic impact of L. intracellularis infection. This is similar to a previous estimate of subclinical PE costs.⁵ The impact of infection on growth and P2 backfat greatly outweighed the PE control costs. Costs will vary among herds depending on the proportion of pigs infected, disease severity, treatment/control costs and effects on farm flow. Research is currently underway to refine the results of these simulations, including the growth response of pigs to vaccination/medication.

References
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Acknowledgements

Financial and academic support was provided by the Australian Research Council, Boehringer Ingelheim, University of Sydney and Industry and Investment NSW.
Reduced muscle growth in pigs sub-clinically affected with proliferative enteropathy

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Introduction

Pigs clinically affected with proliferative enteropathy (PE) suffer diarrhoea, reduced growth and poor feed efficiency, which can cost Australian producers as much as A$7 per pig¹. These costs do not include changes to body composition such as muscle growth. The impact of sub-clinical PE is difficult to estimate because many producers are unaware of the problem. In this study we examined the impact of sub-clinical PE in real time on body composition, muscle growth and P2 backfat depth.

Materials and Methods

Thirty six male hybrid weaner pigs (Large White x Landrace) were randomly allocated at 13.8 ± 1.0kg into 2 treatments: pigs infected with L. intracellularis, and a cohort of uninfected pigs. Pigs were housed in individual pens, with strict quarantine between treatments (separate rooms). Serology and faecal PCR monitoring of pigs prior to challenge indicated that all pigs were naïve to L. intracellularis. At 9 weeks of age, one group of 18 pigs was orally challenged with 5.9 x 10⁹ viable L. intracellularis extracted from a PE-affected mucosa, and the control group was inoculated with phosphate buffered saline. The consistency of pig's faeces was scored daily as either normal or diarrhoeic. Blood collected at 0, 28 and 38 days post inoculation (pi) was tested for L. intracellularis-specific IgG using an indirect fluorescent antibody test (IFAT). Faeces collected twice per week from 0 to 35 days pi was tested for L. intracellularis DNA by a conventional PCR. The body composition of pigs was determined at 14 days pre-inoculation and 21 and 42 days pi, using a Picker spiral CT scanner (Model PQ2000). Pigs were anaesthetized and cross-sectional images of the whole pig in 10mm sections (reconstructed in 3 dimensions) were analysed to calculate tissue volumes of bone, muscle, fat, skin and water using described CT densities². Muscle growth was defined as the difference in muscle volume divided by the number of days between CT scans. Tissue volumes were converted into a mass, using described tissue densities and calculated as a proportion of the total mass of the pig². The P2 backfat was measured from the 42 days pi CT image².

Results

L. intracellularis infection was demonstrated by faecal PCR and IFAT between 14 and 42 days pi in all pigs challenged with L. intracellularis. The majority of infected pigs (>80%) were sub-clinically affected, but pigs inoculated with L. intracellularis had a significantly higher probability of diarrhoea than control pigs between day 22 and 26 pi. L. intracellularis infection did not significantly alter the mean tissue weights or proportion of tissue types. However, L. intracellularis infection did significantly reduce the muscle growth in the late infection period.

The totals of CT tissue weights were accurate compared with the actual body weights of the pigs (±1%). Muscle growth was highly correlated with feed intake and weight gains of pigs (r>0.80) and with the absence of diarrhoea (r>0.72) throughout the trial. L. intracellularis infection did not significantly alter the P2 backfat depth.

Discussion

While sub-clinical PE did not affect body composition or P2 backfat depth, it did reduce muscle growth in experimentally challenged pigs. Animal genetics, gender, diet and pig weight all play a significant role in muscle growth. However, L. intracellularis-specific changes to the digestive and absorptive capacity of the intestine may also explain changes in muscle growth. Reduced amino acid absorption³ and reduced digestive enzyme activity⁴ have been described in pigs with PE.

Acknowledgments

Financial and academic support was provided by the Australian Research Council, Boehringer Ingelheim, the University of Sydney and NSW Department of Industry and Investment.

References

Intestinal absorption and histomorphometry of Syrian hamsters (Mesocricetus auratus) experimentally infected with Lawsonia intracellularis

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Introduction

L. intracellularis is an obligate intracellular bacterium and causative agent of porcine proliferative enteropathy (PPE) (1). PE has been experimentally reproduced in pigs and hamsters, and similar lesions have been observed in both species (2). So far, the physiopathological mechanisms responsible for diarrhea in PE are unclear (3). The aim of this study was to experimentally reproduce PE in hamsters (M. auratus), evaluate the intestinal absorption and histomorphometric changes in infected animals.

Materials and Methods

Sixty Syrian hamsters were divided into two groups, inoculated (n=30) and control (n=30). The inoculum was prepared from segments of porcine intestines with PE lesions (1). Each hamster was intragastrically inoculated with 1.0 mL of inoculum using a gavage. On day 26 p.i., all animals were submitted to surgical procedures for evaluation of intestinal absorption. Two cannulae were introduced in the small intestine and Tyrode solution containing twice the concentration of glucose, Na+, K+ and Cl⁻ was infused. Intestinal absorption was calculated by the difference among influx and efflux content for each 10-min interval. Gross and histological lesions were evaluated and one section was stained by IHC (1). The amount of positive antigen labeled in the sections was graded according to Table 1. Additionally, intact and well oriented intestinal villi were selected for morphometric evaluation.

Results

IHC results are summarized in Table 1. Five control and two inoculated hamsters died during the surgical procedure. Furthermore, three animals had no demonstrated positive antigen labeling and were excluded from the statistical analysis. The relevant results of intestinal absorption are demonstrated in Figure 1. There was no difference of villous height or crypt depth between groups. However, the infected group demonstrated positive correlation (p<0.02) between the intensity of positive antigen label by IHC stain and crypt depth.

Table 1: Intensity of positive antigen label of L. intracellularis, in hamsters experimentally infected.

<table>
<thead>
<tr>
<th>Group</th>
<th>Grade 0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Total +</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Infected</td>
<td>3</td>
<td>10</td>
<td>13</td>
<td>2</td>
<td>1</td>
<td>27</td>
</tr>
</tbody>
</table>

Grade 0= no positive antigen labeled; (1) = up to 25% of intestinal mucosa labeled; (2) = 25 to 50% of intestinal mucosa; (3) = 50 to 75% of intestinal mucosa and (4) = more than 75% of intestinal mucosa.

Discussion

This study described experimental reproduction of PE in hamsters which had significant reduction of intestinal absorption of glucose and electrolytes (K+ and Cl⁻). We believe these findings are relevant for the understanding of L. intracellularis pathogenesis. The poor intestinal absorption seems to be the main explanation for the lower performance of hamsters and pigs naturally affected with subclinical or clinical PE. Therefore, malabsorptive diarrhea appears to be the main process involved in physiopathology of PE diarrhea.

References


Acknowledgement

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An alternative protocol for cultivation of Lawsonia intracellularis

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Introduction

Lawsonia intracellularis is an obligate intracellular bacterium and causative agent of porcine proliferative enteropathy (PPE). The isolation and growth of L. intracellularis in vitro require dividing eukaryotic cells in strict environmental conditions. The standard protocol for growth of this bacterium in monolayers has been described using a specific incubator (Tri-gas) with 83.2% nitrogen, 8.8% carbon dioxide and 8% oxygen and a temperature of 37oC (2). This requirement has limited the maintenance of this microorganism in vitro to only a few research institutes. The aim of this study was to describe an alternative protocol for cultivation of L. intracellularis in cell monolayers providing necessary growth conditions without Tri-gas incubators.

Materials and Methods

The L. intracellularis isolate PHE/MN1-00 previously isolated from a pig with the hemorrhagic form of PPE was used for evaluating growth under two different environmental conditions. The strain was grown in murine fibroblast-like McCoy cells, maintained in a cell culture system and stored at -72°C until use, as described previously (1). The frozen bacteria were thawed and grown in cell culture for three continuous passages in specific conditions, which are described below in order to allow the bacteria to recover from the frozen stage. The infection was monitored during every passage using immunoperoxidase staining with polyclonal antibody specific for L. intracellularis (1). After three passages, two 16-well tissue culture plates with one-day-old McCoy cells were infected with bacterial suspensions containing approximately 3.4 x 10^7 L. intracellularis organisms/ml. The method for quantification was performed by direct count as previously described (1). One plate was placed in an anaerobic jar and the air was evacuated by vacuum pump to 500 mm Hg and replaced with pure hydrogen. The plate was then incubated at 37oC in a Tri-gas incubator for five days (2). The other plate was placed in a plastic bag (Original Space Bag®) and hermetically closed. The air inside the bag was then removed by vacuum pump to 100 mm Hg. Afterward, the bag was inflated through a cuff connected to a gas cylinder containing 10% hydrogen, 10% carbon dioxide, and 80% nitrogen. Finally, the bag was incubated in a conventional 37oC incubator for five days. Every 24 hours, the gas inside the bag was replaced. Carbon dioxide and oxygen percentages was monitored in both protocols using CO2 and O2 indicators (FYRITE® Gas Analyzer) at the initiation of incubation and every 24 hours during the five days of incubation.

Results

After five days, the McCoy cell monolayers in both plates were heavily infected by L. intracellularis demonstrating the success of the alternative incubation protocol. The infection rate was quantified by direct counting of the number of heavily infected cells after immunoperoxidase staining (1,3). Four wells were counted for each incubation protocol. The average rate of infection of the monolayer was 78.9% (+1.3) in the Tri-gas incubator and 76.7% (+2.6%) in the bag incubation. The CO2 level measured between 11-12% in the Tri-gas incubator and 7.0-7.5% in the bag. The O2 level was 9.0% in the Tri-gas incubator in all measurements and ranged from 5.0 to 5.5% in the bag.

Discussion

Incubation in the bag provided environmental conditions for L. intracellularis to infect and multiply in the cells, similar to the published protocol (2). Based on these preliminary results, we believe this approach can be used for static cultivation of bacteria without requiring a Tri-gas incubator. This fact creates a option for in vitro studies and gives an opportunity to engage more research institutes in this area. Other isolates of L. intracellularis have been cultivated with this approach with the results being analyzed. In addition, studies using various conditions for growth and incubation in the bags are being conducted.

References


Effect of diarrhea on average daily weight gain in grower-finisher pigs

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Introduction
Diarrhea is an economically important disease, in grower-finishers. Pigs with diarrhea may have impaired growth and feed conversion. The objective of this study was to estimate the effect of diarrhea on the average daily weight gain in grower-finisher pigs in 5 herds with diarrhea.

Materials and Methods
A prospective cohort study was carried out in five grower-finisher herds with a history of diarrhea and seroconversion to Lawsonia intracellularis and PCV2 virus in the pigs. The herds were selected by convenience. In each herd 60 pigs from four pens were individually ear tagged. The pigs were weighed at the beginning of the study and at the end of the six-week observation period. A total of 298 pigs, all approximately 12 weeks old, were included in the study during the first week in the grower-finisher barn. No routine flock medication against diarrhea was used in the observation period. Faecal samples from each pig were collected in week 1, 3, 5 and 7 during the observation period and scored visually. A faecal score was assessed on 0-3 scale (normal=3, loose=2, fluid=1, fluid+discoloration=0). Diarrhea was defined as faecal score ≤ 1.

The proportion of pigs with diarrhea in the observation period ranged from 3-28 % in the five herds. A total of 9.7 % of the pigs had diarrhea on one or more occasions during the six-week observation period. The proportion of pigs having diarrhea on one occasion was 7.4 % while 23 % had diarrhea on two or more occasions. The variation in prevalence during the observation period is shown in Figure 1. A total of 26 pigs had missing observations. The statistical analysis including 272 pigs showed a significant interaction between start weight and diarrhea on one or more occasions. (P<0.05). This means that the effect of diarrhea increases as the start weight increases. There was an additional effect of diarrhea more than once (p<0.0001). The start weight (P<0.0001), and squared start weight (P<0.0001) had significant effects on the average daily gain. The results are shown in Figure 2.

The graph in Figure 2 indicates that the average effect of having diarrhea (fecal score ≤ 1) on one or more occasions was a 118 g/day reduction of growth rate in the observation period for a pig with a start weight of 35 kg. Pigs in the same weight category with a fecal score ≤ 1 on two or more occasions had an average growth rate reduction of 477 g/day in the observation period.

Discussion
It should be kept in mind that this study was based on a small number of herds and that most of the pigs with diarrhea originated from one herd only (fig 1).
Antimicrobial susceptibility of Belgian Brachyspira hyodysenteriae isolates

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Introduction

Swine dysentery, a muco-hemorrhagic colitis caused by Brachyspira hyodysenteriae, is responsible for substantial economic losses in affected herds. The prevalence of B. hyodysenteriae in Belgium has increased in the last ten years. Until 2004, isolates were characterized as susceptible to pleuromutilins. Since the appearance of pleuromutilin-resistant strains elimination attempts at farm level have become compromised. Susceptibility testing prior to the start of treatment protocols is now inevitable. The present study summarizes the antimicrobial susceptibility of B. hyodysenteriae isolates during 2008 and 2009.

Materials and methods

Sixty and 58 isolates of B. hyodysenteriae were collected for susceptibility testing in 2008 and 2009 respectively. Isolates were recovered from 49 and 52 different farms in 2008 and 2009. The strains were isolated on modified Trypticase Soy Agar (TSJ-BJ) with 5% sheep blood from feces or colon contents submitted for diagnostic purposes. Susceptibility was determined using the agar dilution technique against valnemulin, tiamulin, tylvalosin, lincomycin and doxycycline as described earlier. The tested concentrations (μg/ml) ranged in two-fold dilutions from 0.015 to 2 for valnemulin, 0.03 to 16 for tiamulin, 0.25 to 32 for tylvalosin, 2 to 128 for lincomycin and 0.062 to 16 for doxycycline.

Results

Table 1 outlines the results of 101 isolates from different farms. Similar results were obtained in 2008 and 2009. A high proportion of isolates with decreased susceptibility was observed for pleuromutilins: 40-45% had MIC for valnemulin ≥ 2 μg/ml; 45 – 50% had MIC ≥ 1 for tiamulin. Results for both molecules were similar: a high MIC for tiamulin coincided with a high MIC for valnemulin. Forty isolates (40%) had decreased susceptibility for both pleuromutilins. Only three isolates had a lower MIC for tiamulin compared to valnemulin, once with more than a two-fold dilution.

For tylvalosin, MIC50 was 32 μg/ml. Two-third of the isolates was categorized as susceptible for this molecule (≤ 32 μg/ml). In the case of lincomycin, 15 to 18% of the isolates were considered susceptible. Twenty-eight isolates showed decreased susceptibility for both tylvalosin and lincomycin. Seventeen isolates, resistant to both pleuromutilins, had an MIC for tylvalosin of ≤32 μg/ml. All four antimicrobials were considered ineffective in 21 isolates. Considering doxycycline, 61% had an MIC of ≥ 4 μg/ml and were considered susceptible.

For the 17 farms from which two or more isolates were tested, susceptibility patterns of the isolates were within one dilution for all antimicrobials.

Discussion

The present data show the widespread distribution of decreased susceptibility to pleuromutilins in Belgian B. hyodysenteriae isolates. The decrease in susceptibility to both valnemulin and tiamulin reflects the problems on farm when treating animals infected with these strains (P. Vyt, personal observations). On those farms a complete susceptibility panel to all antibiotics may reveal other treatment options. Although limited sensitivity data was available for tylvalosin, recent B. hyodysenteriae isolates from Spain had lower MIC values than in Belgium. Doxycycline, based on a limited number of isolates, could be used in affected farms. These data demonstrate that in nearly half the cases with pleuromutilin resistance tylvalosin could be an alternative treatment.

Literature

Comparison of three commercial vaccines for the control of Salmonella spp in pigs

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Introduction

Salmonellosis is one of the most common infections in swine production, leading to important economic loss due to mortality, morbidity and the cost of non-specific treatment. Attenuated vaccines have been the main immunological basis for the control of these infectious diseases. In general, live attenuated vaccines induce a superior immunological response than the inactivated ones. Vaccination significantly reduces clinical signs, and the colonization and excretion of Salmonella sp. The available bacterin vaccines stimulate a strong humoral response providing protection against the septicemic phase\textsuperscript{1,2}. The aim of this study was to investigate the effect of three different products on the shedding of Salmonella spp in feces, and on standard production parameters.

Materials and Methods

The study was carried out on a farm in Mexico operating a continuous production system. From weekly batches, pigs were randomly selected, individually identified and assigned to one of four treatment groups, each of 20 piglets: three vaccinated with different commercial vaccines, and an unvaccinated control group. Group 1: unvaccinated controls; Group 2: a modified vaccine\textsuperscript{a} from S. cholerae suis strain SC-54, for intranasal use in a single dose at one day old; Group 3: modified vaccine\textsuperscript{b} against S. cholerae suis, for oral administration in a single dose at three weeks of age; Group 4: a bacterin vaccine against S. cholerae suis and S. typhimurium, for parenteral administration in two doses at 3 and 5 weeks of age.

Rectal swabs were taken 5, 10 and 21 days post-vaccination for bacteriological analysis. Serum samples were collected at 70, 109 and 154 days of age for the detection of S. cholerae suis antibodies by ELISA (HerdCheck\textsuperscript{\texttrademark}, Idexx, EE.UU). Pigs were weighed at birth, 21, 70, and 105 days old and when sold. Average daily weight gain (ADG) and feed efficiency were calculated for a series of growing periods. Data were evaluated by variance analysis with a Tuckey test using SPSS 15.0 statistics software.

Results

Graph 1 shows S. cholerae suis fecal shedding after vaccination.

Chart 1 shows the production parameters (ADG by period, and feed efficiency), morbidity (signs of digestive disturbance) and mortality. 
\textsuperscript{a}Boheringer-Ingelheim Vetmedica,\textsuperscript{b}Intervet-Schering-Plough \textsuperscript{c}Novartis Animal Health Inc.

Discussion

Shedding in Group 3 was less than in the control group throughout the cycle. Although all products led to reduced shedding, the single dose vaccine on the first day of age (Group 2) applied to an immature intestine in the presence of high MDA seemed to compromise the health of the piglets, evident from low weight gains during the sucking and growing phases, with severe morbidity and mortality.

The vaccine given at weaning (Group 3) produced the best performance with respect to ADG, morbidity, mortality and Salmonella sp shedding.

The use of a safe vaccine against Salmonella spp is a useful tool in the control of the disease. It helps reduce excretion and, together with biosecurity measures and good management, is the key to reducing damage and economic loss due to disease caused by Salmonella spp.

References

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**Vaccination to control Salmonella and improve weight gain in pigs**

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**Introduction**

Immunization appears to be one of the most promising approaches for control of Salmonella on swine farms (1). Salmonella Choleraesuis vaccines are commercially available (2-3), however S. Choleraesuis does not appear to be a common pathogen in Ontario swine herds any longer (4). On the other hand Salmonella Typhimurium var. Copenhagen has become the most frequent serovar recovered on Ontario swine farms (4). The objectives of the present study were i) to determine if an autogenous S. Typhimurium vaccine or a commercial live S. Choleraesuis vaccine can reduce the prevalence of Salmonella shedding in pigs, ii) to determine if Salmonella shedding is associated with weight gain in pigs.

**Materials and methods**

The trial was conducted on one farrow-to-finish pig operation with the history of salmonellosis. Nine cohorts of weaned pigs, with approximately 350 pigs in each group, were randomly assigned S. Typhimurium bacterin, S. Choleraesuis vaccine, or as the control group. A Salmonella Typhimurium var Copenhagen strain was used to prepare the autogenous vaccine. In each cohort, one pen was randomly selected in the nursery stage and 30 pigs were ear-tagged and weighed. The tagged pigs were weighed again when marketing. Pooled fecal samples were collected bi-weekly from manure found on the pen floor and cultured for Salmonella. A Generalized Linear Latent and Mixed Models was used to compare the presence of Salmonella in the pooled fecal samples collected from the pens in three groups. A mixed linear regression method was applied to compare the average daily gain in the vaccinated and the control pigs.

**Results**

The prevalence of Salmonella shedding in each group is shown in Figure 1. The odds of Salmonella shedding during finisher stage in S. Choleraesuis vaccinated pigs [OR=5.2 (1.8, 15.5)] and S. Typhimurium vaccinated pigs [OR=3.3 (1.1, 9.9)] was higher than in the control group. The S. Choleraesuis vaccinated pigs were more likely to shed Salmonella compared to pigs which were vaccinated with S. Typhimurium bacterin. The control pigs which had the lowest average of Salmonella shedding showed the best growth performance compared to the vaccinated groups (Table 1). In addition, the pigs from pens with a higher Salmonella recovery rate were deemed to have a lower average daily gain.

**Table 1: The impact of Salmonella vaccination on average daily gain in pigs**

<table>
<thead>
<tr>
<th>Vaccine</th>
<th>Coefficient</th>
<th>95% CI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. Choleraesuis</td>
<td>-26.6</td>
<td>-53.0, 0.27</td>
<td>0.048</td>
</tr>
<tr>
<td>S. Typhimurium</td>
<td>-90.8</td>
<td>-122.5, -59.0</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Control</td>
<td>Reference</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight at weaning (Kg)</td>
<td>4.7</td>
<td>0.7, 8.7</td>
<td>0.022</td>
</tr>
</tbody>
</table>

**Discussion**

The prevalence of Salmonella shedding was initially lower in the control group. Younger pigs are more likely to shed Salmonella than finisher pigs (5) and therefore our estimate of vaccine effectiveness may be biased because the decrease in shedding might be due to age. It is possible that vaccination was performed after pigs had been exposed and that efficacy might have been improved had the pigs been vaccinated sooner. At least one study suggests that it might be prudent to establish a vaccination strategy for pregnant sows to control Salmonella in their piglets (6). Another significant finding of this study is that pigs that appeared clinically healthy but were found to be shedding Salmonella grew slower than pigs not shedding Salmonella. This suggests that there is an economic cost to subclinical Salmonella infection and provides an economic incentive for producers to implement Salmonella control measures.

**References**

Clinical findings in outbreaks of acute diarrhea with indication of antibiotic treatment

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Introduction

Gastrointestinal disease in weaners is the most common cause of antibiotic consumption in Danish pig production. Most antibiotics are used as recurring therapeutic batch medication of acute outbreaks of diarrhea. Clinical signs, pathology and microbiology of this type of outbreak have been poorly described. The objective of the current study was to estimate within batch prevalence of clinical signs in outbreaks of acute treatment requiring diarrhea in pigs between 10 and 70 days post weaning. Results of the pathological and microbiological investigations are reported elsewhere in these proceedings.

Materials and Methods

A cross sectional study was conducted. Herds were selected by multistage sampling. All herds serviced by six specialized swine veterinarians from the same vet practice at Zealand and fulfilling the inclusion criteria were selected. The criteria were recurring therapeutic use of in-feed or in-water medication for diarrhea at room level in pigs between 10 and 70 days post weaning. Only herds with modern intensive production systems were selected. One outbreak of acute diarrhea was investigated in each herd. Farmers and herd veterinarians notified the authors at initiation of an outbreak of acute diarrhea in a nursery room, where treatment by in-feed or in-water medication at the room level was necessary in their opinion. All herds were visited the day following notification and the farmer was not allowed to medicate any pigs before the pigs were examined. If the pigs had received antibiotic batch medication within the last 7 days of the examination day, the outbreak was excluded from the study. A sample of 80 pigs in each herd was selected for clinical examination by systematic random sampling among all pigs in the nursery room where the outbreak of acute diarrhea occurred. The selected pigs were subjected to a clinical examination by the same observer. The observer’s diagnostic sensitivity and specificity for detection of diarrhea was estimated by fecal dry matter (DM%) determination for a subset of the examined pigs (n = 773). DM% ≤ 18.8 was considered as diarrhea (1).

Results

A total of 20 herds were examined during outbreaks of acute treatment requiring diarrhea in 2009. On average the pigs were 32 days post weaning (range: 12 to 63 days). Mean within batch prevalence of diarrhea (loose + watery) was 37% (range: 25% - 67%), Table 1. For detection of diarrhea the observer had a diagnostic sensitivity = 0.88 and specificity = 0.91.

Discussion

The prevalence of diarrhea was higher than expected. The observer’s diagnostic sensitivity and specificity gave an overestimated prevalence (true prevalence = 35%, analysis not shown). The 24 hours between notification and examination may have contributed to the higher than expected prevalence. The within batch prevalence of other clinical signs than diarrhea was low. This may be due to the study of the early part of the outbreaks. The different within batch prevalence of clinical signs between herds may be due to different treatment thresholds for the individual farmers. It may also be the result of different etiology showing different clinical behavior. Further analyses are planned to explore these aspects. The small sample of herds investigated in the current study only represents modern intensive production systems. However, the results do imply that more pigs have diarrhea at initiation of antibiotic batch medication than is commonly believed.

References


Table 1. Within batch prevalence of clinical signs in 20 herds with outbreaks of acute treatment requiring diarrhea 10 to 70 days post weaning (n = 1585 pigs)

<table>
<thead>
<tr>
<th>Clinical sign</th>
<th>mean</th>
<th>min</th>
<th>max</th>
<th>p-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diarrhea - Loose consistency</td>
<td>24%</td>
<td>16%</td>
<td>34%</td>
<td>1.0</td>
</tr>
<tr>
<td>Long hair coat</td>
<td>14%</td>
<td>5%</td>
<td>39%</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Diarrhea - Watery consistency</td>
<td>13%</td>
<td>1%</td>
<td>33%</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Mildly emaciated</td>
<td>10%</td>
<td>0%</td>
<td>35%</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Perineal fecal stain</td>
<td>9%</td>
<td>0%</td>
<td>29%</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Lumbar cavity</td>
<td>8%</td>
<td>1%</td>
<td>31%</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Pot-bellied</td>
<td>2%</td>
<td>0%</td>
<td>9%</td>
<td>0.02</td>
</tr>
<tr>
<td>Fecal blood, mucus or necrotic material</td>
<td>1.4%</td>
<td>0%</td>
<td>9%</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Pale</td>
<td>0.3%</td>
<td>0%</td>
<td>3%</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Chi-sq or Fishers exact test for test of different prevalence between herds. P-value adjusted by Bonferroni-correction for multiple comparisons.

Enteric Diseases - Grow/Finish

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Intestinal pathology of acute diarrhea in weaners: A case control study in 20 Danish herds

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Introduction
The most common cause of antibiotic consumption in Danish pig production is gastrointestinal disorders in weaners. The largest part of the consumption is used as recurring therapeutic batch medication of acute outbreaks of diarrhea. It is generally believed that proliferative enteropathy associated with Lawsonia intracellularis is the major cause of these outbreaks of diarrhea. The objective of the current study was to describe the gross pathology in outbreaks of acute treatment requiring diarrhea in pigs between 10 and 70 days post weaning. Results of clinical and microbiological investigations of these outbreaks are reported elsewhere in these proceedings.

Materials and Methods
A case control study was conducted. Herds were selected by multistage sampling. All herds serviced by six specialized swine veterinarians from the same vet practice at Zealand and fulfilling the inclusion criteria were selected. The criteria were recurring therapeutic use of in-feed or in-water medication for diarrhea at room level in pigs between 10 and 70 days post weaning. Only herds representing modern intensive production systems were selected. One outbreak of acute diarrhea was investigated in each herd. All herds were visited the day following notification from the farmer/veterinarian of an acute treatment requiring outbreak of diarrhea and the farmer was not allowed to medicate before the pigs were examined. If the pigs had received antibiotic batch medication with-in the last 7 days of the examination day, the outbreak was excluded from the study.

A sample of 80 pigs in each herd was selected by systematic random sampling among all pigs in the nursery room where the outbreak occurred. The selected pigs were subjected to a clinical examination and fecal samples were collected. Among the examined pigs a simple random sample of 8 pigs with diarrhea and 8 pigs without diarrhea was selected. The 16 pigs were killed and transported to DTU-VET for necropsy the following day. Fecal dry matter (DM%) was determined. DM% ≤ 18.8 was considered as diarrhea (1) and was used (if necessary) to reclassify the pigs as diarrheic (cases) or non-diarrheic (controls) in the statistical analysis.

Results
Twenty-four non-diarrheic and 12 diarrheic pigs (determined at clinical examination) were reclassified according to the DM% determination. Seven pigs were excluded from analysis. Results of the gross pathological examinations are displayed in Table 1.

Discussion
Small intestinal lymph node hyperplasia, large intestinal mucosa hyperemia and proliferative enteropathy-like changes were found at low but significantly higher levels in pigs with diarrhea than those without. The low prevalence of proliferative enteropathy-like changes implies that the importance of Lawsonia intracellularis in relation to diarrhea could be much lower than previously believed. Interestingly, obvious signs of infectious enteritis were rare and most of the other intestinal changes were equally prevalent in pigs with or without diarrhea.

Further conclusion awaits results of histological and microbiological examinations.

References

Table 1. Prevalence of gross intestinal changes* in 20 herds with outbreaks of acute treatment requiring diarrhea 10 to 70 days post weaning (n = 313 pigs)

<table>
<thead>
<tr>
<th></th>
<th>Pigs with diarrhea (DM%≤18.8) (n=166)</th>
<th>Pigs without diarrhea (DM%&gt;18.8) (n=147)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small intestine:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hyperemia</td>
<td>35%</td>
<td>32%</td>
</tr>
<tr>
<td>Flaccid</td>
<td>23%</td>
<td>24%</td>
</tr>
<tr>
<td>Lymph node hyperplasia</td>
<td>11%#</td>
<td>3%#</td>
</tr>
<tr>
<td>Blood tingled contents</td>
<td>6%</td>
<td>5%</td>
</tr>
<tr>
<td>Congestion of blood vessels</td>
<td>5%</td>
<td>4%</td>
</tr>
<tr>
<td>Thickened intestinal wall</td>
<td>5%</td>
<td>0.7%</td>
</tr>
<tr>
<td>Large intestine:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hyperplasia of colon associated lymphatic tissue</td>
<td>26%</td>
<td>25%</td>
</tr>
<tr>
<td>Mesenteric edema</td>
<td>10%</td>
<td>16%</td>
</tr>
<tr>
<td>Lymph node hyperplasia</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>Mucosa hyperemia</td>
<td>5%#</td>
<td>0%#</td>
</tr>
<tr>
<td>Mucosa erosions, ulcerations and/ or necrosis</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>Proliferative enteropathy-like:</td>
<td>8%#</td>
<td>0.7%#</td>
</tr>
<tr>
<td>No intestinal changes:</td>
<td>32%</td>
<td>37%</td>
</tr>
</tbody>
</table>

Only the most prevalent changes are displayed. # P-value < 0.05 in Chi-sq or Fishers exact test for unconditional test of different prevalence between pigs with and without diarrhea.