

# Diarrhea in nursery pigs associated with multiple concurrent pathogens

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## Summary

This report describes postweaning diarrhea in a group of nursery pigs in which *Lawsonia intracellularis*, *Brachyspira pilosicoli*, and several strains of enterotoxigenic *Escherichia coli* were identified. Affected pigs were anorexic and gaunt, and feces were light

brown, loose to watery, and contained pieces of feed and mucus. Associated risk factors that may have played a role in occurrence of diarrhea include diet, pig movement, sanitation, environment, and rodent control. Clinical management strategies that were instituted addressed some of these risk factors.

**Keywords:** swine, nursery pigs, diarrhea, multiple pathogens

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## Resumen – Diarrea en cerdos en destete asociada a múltiples patógenos simultáneos

Este reporte describe la diarrea post-destete en un grupo de cerdos en el que se identificaron *Lawsonia intracellularis*, *Brachyspira pilosicoli*, y varias cepas de *Es-*

*cherichia coli* enterotoxigénica. Los cerdos afectados estaban anoréxicos y delgados y el excremento era café claro, de pastoso a acuoso y contenía pedazos de alimento y moco. Los factores de riesgo relacionados que pudieron haber influido en la aparición de la diarrea incluyen la dieta, el

movimiento de los cerdos, la sanidad, el medio ambiente y el control de roedores. Las estrategias clínicas que se utilizaron se dirigieron para corregir algunos de estos factores de riesgo.

## Résumé – Diarrhée dans les porcelets de la pouponnière associés avec multiples pathogènes concourants

Ce rapport décrit la diarrhée post sevrage en un groupe de porcelets dans lequel *Lawsonia intracellularis*, *Brachyspira pilosicoli*, et plusieurs strains d'*Escherichia*

*coli* enterotoxigénique ont été identifiés. Les animaux affectés étaient anorexiques et maigres, et l'excrément était marron léger, lâche à aqueux, et ont contenu des morceaux d'aliment et mucus. Les facteurs du risque associés qui ont pu jouer un rôle dans l'événement de la diarrhée incluent

l'alimentation, le déplacement des porcelets, le système sanitaire, l'environnement, et le contrôle des rongeurs. Les stratégies cliniques qui ont été instituées ont adressé quelques-uns de ceux-ci facteurs du risque.

Differential diagnoses for diarrhea in weaned pigs include salmonellosis, swine dysentery, porcine proliferative enteropathy (PPE) caused by *Lawsonia intracellularis*, rotavirus and coronavirus enteritis, postweaning colibacillosis, trichuriasis, coccidiosis,<sup>1</sup> and porcine colonic spirochetosis (PCS) caused by *Brachyspira pilosicoli*.<sup>2</sup> Postweaning diarrhea may be associated with multiple concurrent pathogens,<sup>3</sup> frequently with complex interactions among agents in individual animals.<sup>3,4</sup>

Porcine proliferative enteropathy may cause poor growth rate, diarrhea, and stunting in weaned pigs 6 to 20 weeks of age.<sup>5</sup> Porcine colonic spirochetosis occurs in weaned pigs 8 to 16 weeks of age. Affected pigs usually remain alert and active, but have depressed appetites and may become gaunt and develop rough hair coats.<sup>2</sup> Postweaning colibacillosis, caused by certain strains of enterotoxigenic *Escherichia coli* (ETEC), is mediated by enterotoxins.<sup>6</sup> Clinical signs range from sudden death of pigs, without

external evidence of diarrhea, to diarrhea varying in consistency from pasty to watery.<sup>6</sup>

Mixed infections may cause more severe clinical disease than infections with single agents, and affected animals may respond only partially to control strategies.<sup>3</sup> It has been suggested that *L intracellularis* might predispose the colonic mucosa to infection with other agents,<sup>3</sup> and that factors predisposing to increased substrate load in the large intestine, including small intestinal damage caused by viral and bacterial agents, may enhance susceptibility to colitis associated with spirochetes.<sup>4</sup> Various farm management risk factors may influence not only the development and severity of a clinical disease, but also the response to therapy.<sup>7</sup> Risk factors may be defined as variables that increase the probability of disease occurrence or the probability of an

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increase in its severity, and to which preventive programs can be directed.<sup>8</sup> This report describes diarrhea in nursery pigs involving three enteric pathogens, and outlines a treatment plan to address the risk factors involved with these diseases.

## Herd description

The affected herd was a 125-sow farrow-to-finish operation on a single site, housed in a two-story barn with the grow-finish pigs located outside in 12 shelters. Animals were moved in continuous flow in the farrowing and nursery areas. Average weaning age was 21 days, and average weaning weight was 6.5 kg.

Nursery pigs were housed in three hutches located in a farrowing room and in two mechanically ventilated rooms. The smallest pigs in each weaned group were placed in the hutches and the rest in Room One. The pigs stayed in the hutches for 1 week, then, at mean body weight 6.5 to 15 kg, were moved into Room One for 2 to 3 weeks. Finally, at mean body weight 15 to 35 kg, they were moved into Room Two for 5 to 6 weeks.

Each pig hutch had a feed trough in the front gate and a single drinker, and housed 13 pigs. In Room One, pigs were housed 18 per pen in eight pens. A rectangular feeder was located in each pen partition, and a single drinker was provided in each pen. In Room Two, pigs were housed 18 per pen in 16 pens. A round feeder was located in each pen partition, and a single swing drinker was provided in each pen.

Feed was purchased from an independent feed mill. The phase two ration was provided as a creep feed beginning when pigs were 10 days of age and was fed for 2 days at weaning. The phase three ration was introduced and fed for 7 to 10 days, then blended with the starter ration for 1 week. The starter ration was fed for 3 weeks and then replaced with the grower ration.

The phase two and phase three rations contained specialty ingredients, including spray-dried animal plasma, high-quality fish meal, whey, and milk powder. In addition, these diets contained an acidifier containing organic and inorganic acids (Tetracid 500; Jefagro Technologies, St-Hyacinthe, Quebec); an enzyme supplement containing beta glucanase, xylanase, amylase, and subtilisin (Porzyme TP-100 HP; Finnfeeds Oy, Myllykatu 20, Vaasa,

Finland); and zinc oxide (2500 g per tonne). The starter and grower rations contained mixed grains and soybean meal, and the starter ration included fish meal as well as the same acidifier and enzyme supplement included in the phase two and phase three rations.

## Case description

During the first week of January 2004, the producer noticed diarrhea and poor growth in nursery pigs on the starter and grower rations. Diarrhea was first noticed in Room One in pigs that had been weaned for approximately 14 days. A few other nursery pigs had grown poorly during the previous 6 months. For the previous 12 months, the starter ration had been medicated with lincomycin hydrochloride monohydrate (22 g per tonne) and spectinomycin sulfate tetrahydrate (22 g per tonne). In response to the outbreak of diarrhea, the medication in the starter ration was changed to 55 g per tonne of lincomycin hydrochloride for approximately 2 weeks. This was reduced to 44 g per tonne on January 26. Because of continuing poor nursery performance, and the possibility that it was associated with feed quality and exacerbated by feed delivered on January 26, the producer contacted his feed supplier the first week of February. The feed retainer samples for the starter and grower rations from the January 26 feed delivery and the corresponding on-farm feed samples were tested for moisture, protein, calcium, phosphorus, and sodium, and for vomitoxin (Agri-Food Laboratories, Guelph, Ontario).

## Clinical signs

When the herd veterinarian visited the farm on February 12, 25% to 30% of the pigs in Room Two had light brown, loose to watery diarrhea containing pieces of feed and mucus, but no blood. Diarrhea was projectile, especially when the pigs coughed. There was a moderate amount of coughing. Feed consumption was less than expected and affected pigs were gaunt. Several pigs had very severe tail-bite injuries. Total mortality was 2% to 3% in Room One and 5% in Room Two (8% overall). Historically, combined mortality and cull rate was 5% in the nursery rooms.

The performance of 40 pigs, weighing an average of 9.1 kg at an average age of 31 days, was assessed starting January 7. During the test period, one pig weighing 20 kg

died of undetermined causes. At the end of the test on February 18, the remaining pigs weighed an average of 21.5 kg. Average daily gain (ADG) was 289 g, average daily feed intake (ADFI) was 592 g, and feed conversion (FC) was 2.05 to 1.00 kg feed per kg of gain. Acceptable performance targets for pigs from 9 to 21.5 kg are ADG 543 g, ADFI 848 g, and FC 1.56 to 1.00 kg feed per kg of gain (J. Schell, Wallenstein Feed and Supply Ltd, oral communication, 2004).

## Laboratory results

Differential diagnoses included colibacillosis, salmonellosis, and spirochetosis. On February 12, two live pigs from Room Two, showing signs representative of the clinical problem, were submitted to the Animal Health Laboratory (Guelph, Ontario) for necropsy and diagnostic testing. Five rectal swabs taken from diarrheic pigs in Room Two were submitted to Gallant Custom Laboratories Inc, Cambridge, Ontario, for culture and sensitivity testing for *E coli* and *Salmonella* serovars.

The two gilts submitted for necropsy were approximately 8.5 weeks old and weighed 13.5 and 18.5 kg, respectively. In Gilt A, multifocal, round ulcerations (diameter 3 to 4 mm) and 3-mm to 10-mm linear mucosal ulcerations, covered by plaques of fibrin, were observed throughout the distal jejunum, ileum, and spiral colon. Fibrin casts filled the lumen of several segments of distal jejunum, and there was moderate and diffuse thickening of the jejunal and ileal mucosa. In Gilt B, the spiral colon and cecum were distended with abundant gray-green opaque fluid. On bacteriological culture, strains of K88-negative ETEC were isolated from these two gilts. No *Salmonella* serovars were isolated.

In silver-stained histological sections from Gilt A, argentophilic organisms, morphologically consistent with *L intracellularis*, were present in apical cytoplasm of numerous crypt enterocytes in the small intestine and colon. Final diagnosis was proliferative and necrotizing enterocolitis, consistent with *Lawsonia* enteritis infection. In Gilt B, large numbers of argentophilic organisms forming a "false brush border" at the mucosal surface were consistent in staining and morphology with *B pilosicoli*. Final diagnosis was colonic spirochetosis. In both gilts, there was chronic interstitial pneumonia consistent with viral pneumonia caused by porcine reproductive and respiratory syndrome virus (PRRSV)

or porcine circovirus type 2 (PCV2). No further testing was done to confirm the role of PRRSV or PCV2.

Rectal swabs were culture-positive for ETEC organisms. No salmonellae were isolated. Four ETEC strains were isolated, including one O149:K91:F4 (K88) strain. All isolates were sensitive to gentamicin and neomycin.

Analysis of the retainer and farm feed samples were within acceptable limits for moisture, protein, calcium, phosphorus, and sodium, and contained less than 0.89 ppm of vomitoxin. Agriculture and Agri-Food Canada guideline for vomitoxin level in pig feed is 1 µg per g (1 ppm).

## Treatment and outcome

Clinical management strategies were instituted to address the key risk factors associated with the three identified enteric pathogens, including diet, pig movement, sanitation, environment, and rodent control.<sup>2,7,8</sup> Feeding directions for the rations were reviewed, as management had been deviating from the guidelines over the previous 6 months. The phase three ration had been introduced at weaning and fed for 4 days, then replaced with the starter ration. A transition ration was added to the feeding program, to be introduced after the phase three ration, fed for 7 to 10 days, then replaced with the starter diet. The transition diet contained specialty ingredients including fish meal, whey powder, milk powder, and an acidifier (Tetracid 500), and contained zinc oxide (2500 g per tonne), oxytetracycline hydrochloride (220 g per tonne), and neomycin sulfate (220 g per tonne). The starter diet was also medicated with oxytetracycline hydrochloride and neomycin sulfate at these dosages.

Fostering to nurse sows was to be limited to the first week of life. Poor-doing nursery pigs were to be treated with their group and humanely destroyed if nonresponsive.

The disinfectant used in the farrowing and nursery areas was changed from sodium hypochlorite to Virkon S (Antec International, Sudbury, Suffolk, UK). The importance of drying time following the cleaning process was emphasized.

An agricultural engineer was to be consulted to assess the ventilation systems in Rooms One and Two. The radiant heaters in Room Two were oversized, causing rapid temperature fluctuations and high incom-

ing air speeds that chilled the smaller pigs. New heaters were to be purchased for this room.

A professional rodent control firm was to be contacted for a control program, as there had been a severe rodent infestation during the period between December 2003 and March 2004.

A second performance test was conducted between February 15 and April 15, with the modified feeding program in effect. Average daily gain was 489 grams, ADFI was 861 g, and FC was 1.76 to 1.00 kg feed per kg of gain for 39 pigs that initially weighed an average of 8.5 kg and gained to an average final weight of 36.4 kg. An achievable target for this weight range is ADG 541 g, ADFI 992 g, and FC < 1.83 to 1.00 kg feed per kg gain (J. Schell, oral communication, 2004).

In August 2004, medication was removed from the starter ration, and pigs were vaccinated with Enterisol Ileitis vaccine (Boehringer Ingelheim Vetmedica, GmbH, Ingelheim, Germany) when they were moved from Room One to Room Two. Total nursery mortality dropped to 1% and there has been no diarrhea or tail biting. Pigs are 5 kg heavier, on average, when they are moved out of Room Two than they were during the period when signs were most severe.

## Discussion

There was no response of these pigs to treatment with lincomycin in the starter ration at either 55 g per tonne or 44 g per tonne. In contrast, in a study of pigs with PPE, in-feed lincomycin administered at 44 g per tonne controlled diarrhea and clinical signs and improved performance parameters.<sup>9</sup> The lack of response in this case might be associated with the mixed infections present,<sup>3</sup> as lincomycin is not active against *E coli*,<sup>9</sup> and in a study testing 19 strains of *B pilosicoli*, only 42% of strains were susceptible to lincomycin.<sup>2</sup>

Submission of the two live pigs and five rectal swabs was an important component in achieving a diagnosis. Diagnosis of *L intracellularis* in Gilt A was achieved using histopathological examination and silver-staining techniques to identify intracellular bacteria in the proliferative lesions of affected tissue.<sup>5</sup> Silver staining of the affected tissue in Gilt B revealed a lesion unique to

*B pilosicoli*, ie, end-on attachment of the bacterial cells to the apical margin of colonic luminal epithelial cells creating a false brush-border or “hairy” appearance.<sup>2</sup> Culture of rectal swabs from diarrheic pigs is an effective method of detecting K88-positive *E coli* when clinical disease is present.<sup>10</sup> Culture of the five rectal swabs taken from diarrheic pigs in Room Two yielded a number of ETEC strains, including a strain positive for the K88 antigen. No salmonellae were isolated from the two pigs at necropsy or from the five rectal swabs, despite use of specific techniques for salmonella detection. Diagnosis of salmonellosis is confirmed by bacterial isolation and identification, and histological examination revealing the appropriate lesions.<sup>1</sup> Detection of salmonellae does not constitute diagnosis of salmonellosis.<sup>1</sup> Neither microbiological nor histological examination confirmed salmonellosis in this case. As the producer was satisfied with the improved performance of the pigs and did not wish to pursue further diagnostic testing, infection with PRRSV or PCV2 was not confirmed.

On-farm risk factors reported in association with postweaning colibacillosis, PPE, and PCS include diet, pig movement, sanitation, environment, and rodent control.<sup>2,7,8</sup> Correct feeding of the existing rations, plus addition of a transition diet, encouraged postweaning feed intake, and provided rations with highly digestible proteins and “gut-friendly” ingredients for a minimum of 14 days. Feed intake in the first week postweaning is strongly correlated to the risk of disease during the postweaning period.<sup>11</sup> Suboptimal feed intake soon after weaning causes villous atrophy, impairing digestive and absorptive functions and contributing to poor performance and increased occurrence of diarrhea.<sup>12</sup> The protection from postweaning diarrhea that has been identified with certain diets may be related to reduced availability of substrate required by bacteria in the small intestine.<sup>8</sup> Feeding high concentrations of zinc oxide (2000 to 3000 g per tonne) controls *E coli* diarrhea<sup>8,13</sup> and increases daily voluntary feed intake and weight.<sup>13</sup> Organic acids also have beneficial effects in preventing diarrhea and on growth rate.<sup>8</sup>

Recent mixing of pigs ( $\leq 2$  weeks) was found to be significantly associated with outbreaks of PPE.<sup>7</sup> There is also an association between moving and mixing pigs and onset of clinical signs of PCS 7 to 14 days

later.<sup>3</sup> Frequent mixing of pigs and continuous pig flow management increase exposure of susceptible animals to carrier animals or contaminated feces and thereby increase exposure dose of *B pilosicoli* and risk of disease.<sup>2</sup>

The importance of an effective sanitation program in controlling postweaning diarrheal disease was emphasized with the producer. Studies have shown that *L intracellularis* can survive outside the pig and infect susceptible pigs for up to 2 weeks at 5°C and 15°C.<sup>14</sup> Transmission of *B pilosicoli* is thought to be fecal-oral, and the greatest risk factor for infection is exposure of susceptible pigs to fresh feces from shedding carrier pigs.<sup>2</sup> Mice and birds are potential sources of infection.<sup>2</sup>

Environmental temperature changes such as heat stress and chilling have been identified as risk factors for clinical outbreaks of PPE.<sup>7</sup> Disruption of eating patterns caused by environment or social stress may alter intestinal motility and render the intestinal mucosa more susceptible to infection by *L intracellularis*.<sup>7</sup> Proliferative enteropathy has been reproduced in mice using pure *L intracellularis* culture extracted from pigs,<sup>15</sup> suggesting that mice might play a role in transmission of this agent.

The role that PRRSV or PCV2 played in this case was not clarified, and although K88-positive *E coli* was cultured, there was insufficient evidence to definitively confirm a diagnosis of colibacillosis. However, management changes that were instituted specifically to deal with the risk factors for postweaning diarrhea, and specific treatments for PPE and spirochetosis, greatly improved the general health of the pigs.

## Implications

- A thorough workup is necessary to ensure that all pathogens associated with postweaning diarrhea are identified.
- Effective clinical management strategy includes identification of risk factors associated with postweaning diarrhea and implementation of management changes aimed at reducing the impact of the identified pathogens on the pigs.

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