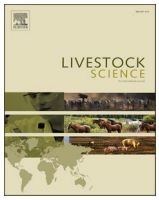
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Short Communication



Impact of gastric ulceration on weight gain in finisher pigs

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HIGHLIGHTS

- Erosion of the non-glandular region of the pig stomach is a common non-infectious condition, caused by a combination of feed processing and intake factors. We examined the effects of a naturally occurring outbreak of erosion/ulceration in a modern pig farm system. Pigs were monitored from 3.5 to 22.5 weeks of age, including a 2-day period of reduced feed intake at 10 weeks of age, due to unintentional inclusion of an unpalatable high salt additive. Pelleted diets supplied to the farm consisted of standard wheat, plant protein and feed additive ingredients, averaging 610 μm particle size. At 22.5 weeks of age, all remaining study pigs (n = 901) were processed and the non-glandular stomach region visually scored for erosion/ulceration. The ulcer score for each study animal was correlated to its average daily weight gain, based on the age at weaning (days), age at processing (days), and carcass weight (kg). This correlation indicated a significant reduction in growth rate among growing pigs with stage 3 stomach erosion/ulceration. The economic impact as calculated from the weights at slaughter, average daily feed intakes and 5-year averages of feed cost and carcass value indicated a significant reduction in likely market income derived from growing and finishing pigs with stage 3 stomach lesions. No such reduction was evident in study pigs with stage 1 lesions. The study confirms the likely economic impact of severe gastric ulceration in modern farm pigs.

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ABSTRACT

Erosion of the non-glandular region of the pig stomach is a common non-infectious condition, caused by a combination of feed processing and intake factors. We examined the effects of a naturally occurring outbreak of erosion/ulceration in a modern pig farm system. Pigs were monitored from 3.5 to 22.5 weeks of age, including a 2-day period of reduced feed intake at 10 weeks of age, due to unintentional inclusion of an unpalatable high salt additive. Pelleted diets supplied to the farm consisted of standard wheat, plant protein and feed additive ingredients, averaging 610 μm particle size. At 22.5 weeks of age, all remaining study pigs (n = 901) were processed for processing, and the non-glandular stomach region visually scored for erosion/ulceration. The ulcer score for each study animal was correlated to its average daily weight gain, based on the age at weaning (days), age at processing (days), and carcass weight (kg). This correlation indicated a significant reduction in growth rate among growing pigs with severe stomach erosion/ulceration. The economic impact as calculated from the weights at processing, average daily feed intakes and 5-year averages of feed cost and carcass value indicated a significant reduction in likely market income derived from growing and finishing pigs with deeper stomach lesions.

1. Introduction

Erosion and ulceration of the non-glandular region of the pig stomach is a common non-infectious condition, usually affecting growing and finishing pigs. Its aetiology is considered a combination of factors in the composition and processing of the diet, along with a period of cessation of feed intake (Ayles et al., 1996, Lawrence et al., 1998). Pelleted feeds containing processed cereal components with a mean particle size of less than 600 μm are considered ulcerogenic but are often preferred in modern pig management for reasons of improved feed handling and efficiency. Corn or wheat cereal components processed through a hammer mill and pelleting apparatus are considered even more ulcerogenic, due to a higher content of these fine particles (Wondra et al., 1995, Mößeler et al., 2012). Temporary feed intake cessation (e.g., 24 to 48 h) can occur for numerous reasons, such as illness, feed delivery disruption or feed aversion due to unpalatable ingredients. This period

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Table 1
Ingredient and chemical composition of the stage diet from 10.5 to 22.5 weeks of age.

Ingredient composition (%)[*]	Finishing stage diet
Wheat	45.4
Corn	23
Mung beans	8
Canola (rapeseed) meal	8.7
Soybean meal	8
Meat and bone meal	5.5
Vegetable oil	1.8
Chalk limestone	0.5
Chemical composition [**]	
Metabolizable energy (MJ/kg)	13.6
Dry matter (%)	88.9
Crude protein (%)	16.4
Crude fat (%)	3.6
Crude fibre (%)	6.1
Sodium (g)	0.18
Calcium (g)	0.84
Total phosphorous (g)	0.66
Lysine (g)	1.0

[*] The diet also contained standard premix vitamin and amino acids. The diet initially offered to study pigs at 10 to 10.5 weeks of age was of the same ingredient composition, but with the unintentional addition of high salt whey by-product (2 %).

[**] Analysis of the diet offered from 10.0 to 10.5 weeks of age showed the same chemical composition, except for the presence of 9.6 g sodium.

(s) of feed cessation and the greater surface area of the feed-colloidal sol within a constant intake of fine particulate feed both tend to generate a much greater output of stomach acid fluid, rising to affect and erode the non-glandular portion of the pig stomach over an extended period.

While many studies of porcine gastric ulceration have been conducted in experimentally housed pigs, the actual impact of this common condition on pig performance has been alternatively suggested to be minimal or contrastingly to be of significant impact on growth rates and economic performance, in modern farm pig production. Any negative impact of non-glandular stomach erosion may be temporary and may tend to be off-set by the improved feed efficiency of at-risk particulate diets. It can be difficult to reproduce the condition in a controlled, ethical experimental environment over a long period, including any coordinated monitoring of individual stomach lesions and live pig parameters. We therefore aimed to examine the growth rate and economic effects of a naturally occurring outbreak of erosion/ulceration in a modern pig farm system.

2. Materials and methods

2.1. Animals and diet

The research was carried out at a commercial grow-finish farm in southern temperate Australia, consisting of 10 identical purpose-built, curtain-sided sheds. Incoming pigs were supplied once weekly from a Large White/Landrace breeding farm (2,500 sows). Each weekly batch of pigs (800 to 1,000) were sex-sorted and housed into compartmentalised sheds from 3.5 to 22.5 weeks of age, from weaning to market, with stage-appropriate feed and water systems. The farm had a history of stomach erosions recorded sporadically in pigs at previous abattoir inspections. The farm was of high-health status and pigs remained healthy throughout the study.

Stage-specific diets were provided twice weekly by a local commercial feed mill, which formulated 400 metric tonnes (MT) of pig feed per week. Diets supplied to the farm consisted of standard wheat, maize, plant protein and feed additive ingredients, see Table 1 for composition of the typical finisher diet from 10 to 22.5 weeks of age. Feed preparation consisted of standard milling, mixing and pelleting conditioning procedures. Cereal and plant protein components were passed through a hammer mill with a screen size of 6.35 mm. Every 2 weeks, 100 g portions of freshly mixed mash feed were placed into a test sieve shaker and remnant material weighed for estimation of mean particle size by standard methods (Anon., 2008). Pelleted feed was delivered to the pigs via dedicated graduated silos, in-line augers, and pen hoppers. Daily feed intake was estimated from silo auger monitors. Commercial mycotoxin adsorptive products (clay-silicate) were added to every diet at dosages recommended by the manufacturers.

Unintentional error led to the inclusion of an excessive quantity of high salt whey by-product feed additive into the entire stage-specific diet (80 MT) newly supplied to 2 silos for adjacent sheds containing pigs of 9.5 and 10.5 weeks of age (shed 6: 510 male pigs; shed 10: 399 male pigs). All these pigs were therefore offered an unpalatable high-salt diet for 48 h, which was accompanied by widespread refusal to eat (estimated feed intake 0.1 kg/pig/day). This diet was then fully replaced by the standard formulated diet (see Table 1), and the observed feed intake of study pigs quickly resumed to normal levels (1.3 kg/pig/day at 11 weeks of age).

2.2. Monitoring

All pigs were weighed and tagged at shed entry (3.5 weeks of age, average 6.5 kg). Mortality and culling levels were within reference ranges for the study period of 3.5 to 22.5 weeks of age (2 %). Following the grow-finish period, all remaining study pigs (n = 901) were transported 180 km to a local abattoir at 22.5 weeks of age, where they were immediately inspected then processed, without feed withdrawal. During processing, individual carcasses were tagged to match to individual pig viscera. After the viscera were removed for inspection, the remaining carcass (including the head) was weighed and processed. Each stomach was opened, emptied and gently washed, and the non-glandular region visually examined for erosion/ulceration under an established stomach scoring system, wherein 0 is normal shiny white squamous epithelium, 1 is parakeratosis and thickened epithelium, 2 is erosions with sloughing of the epithelium and 3 is developed ulceration (Cook, 1996, Kopinski and McKenzie, 2007, Swaby and Gregory, 2012). The individual observer who assigned all scores was trained and independently audited to pictorial reference charts (Cook, 1996, Kopinski and McKenzie, 2007) twice daily. Portions of non-glandular stomach from pigs representative of each score (n = 3 per score) were collected randomly and fixed for routine histopathology examination.

The ulcer score for each study animal was correlated to its average daily weight gain, based on its age at weaning (days), age at processing (days), and carcass weight (kg). An economic impact of the ulcer scores was calculated from the assumed live weights at processing (carcass weight x 1.28), an assumed average daily feed intake from weaning to processing of 4 % of the average body weight of each group after weaning (at 6.5 kg bodyweight), the 5-year average feed cost per tonne (USD), and the 5-year average market carcass value per kg (USD). These calculations therefore estimate the cost of ulceration in terms of i/ reduced carcass weight or ii/ extra feed days to achieve a desired liveweight, assuming that other variable and fixed costs (finance, labour, facilities) are comparable.

3. Results

Table 1 indicates the ingredient and chemical composition of the diets offered to the study pigs; the mean particle size was 610 μm (±10) over the study period.

The study pigs appeared normal throughout, with no specific clinical signs noted prior to or during the 2-day reduced feed intake period, the resumed grow-finish period (11 to 22.5 weeks of age) or at pre-processing inspection at the abattoir. The carcass characteristics were within breed and farm reference ranges for lean meat percentage (range 57 to 63 %) and backfat thickness (P2 range 10.8 to 12.5 mm). Besides

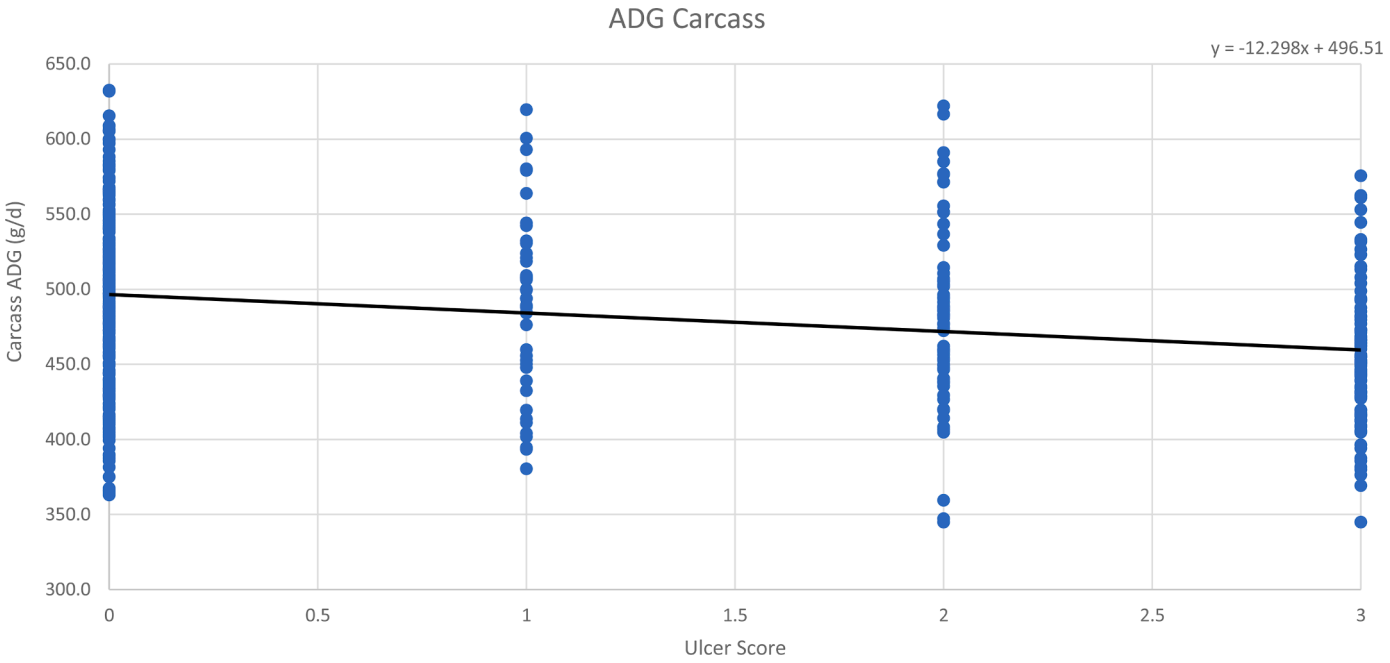


Fig. 1. Correlation of the average daily weight gain (ADG) of each individual pig carcass ($n = 901$) from weaning (3.5 weeks of age) to processing (22.5 weeks of age) to its individual erosion/ulcer score (1, 2, 3) or normal = 0, recorded at each post-mortem inspection.
Proportions (%) of scores recorded:
Score 0: 55.8; score 1: 9.2; score 2: 14.7; score 3: 20.3.
The linear line of best fit presents an equation of $y = 12.298x + 496.5$

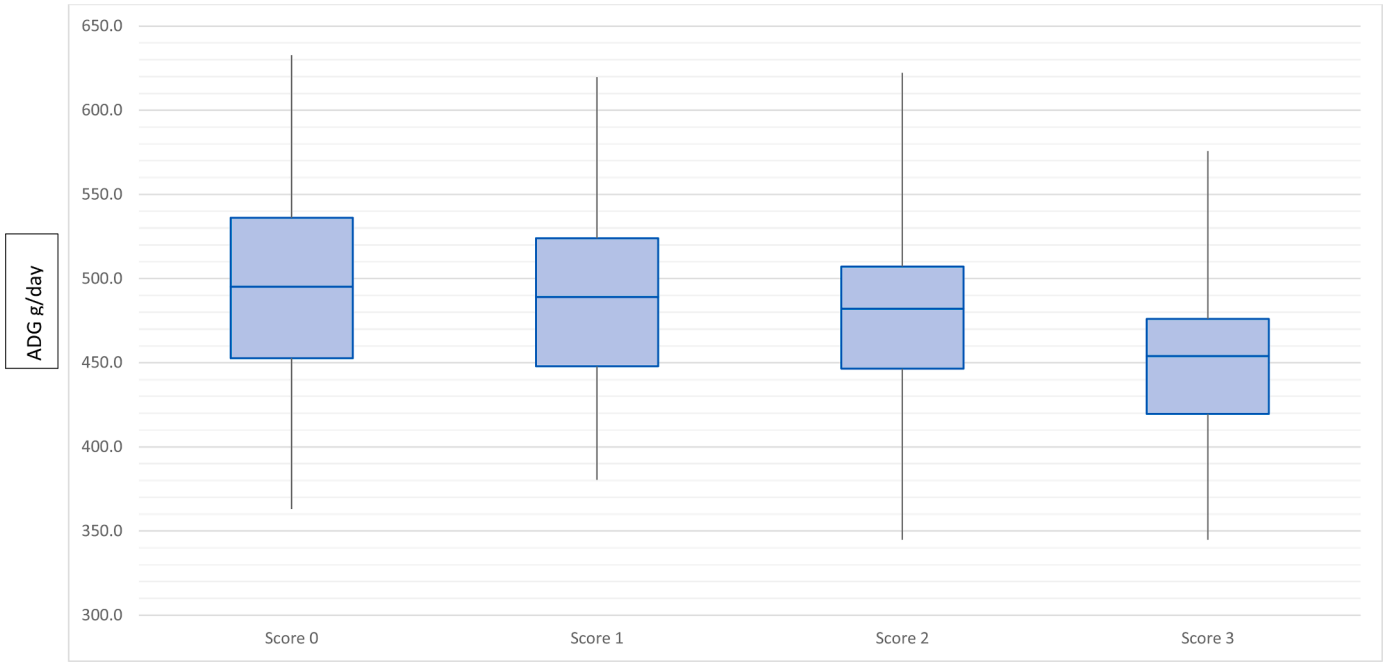


Fig. 2. Correlation of individual erosion/ulcer score (1, 2, 3) or normal = 0, recorded at each post-mortem inspection, with the average daily weight gain (ADG) from weaning (3.5 weeks of age) to processing (22.5 weeks of age), illustrating the mean, the 25th percentile and the 75th percentile. The whiskers are shown as 1 standard deviation from the mean.
Proportions (%) of scores recorded:
Score 0: 55.8; score 1: 9.2; score 2: 14.7; score 3: 20.3.

the stomach lesions, no other lesions were noted among the viscera of study pigs at post-mortem inspection. The gross and histological features of the various presentations of hyperkeratosis, erosion and ulcerations noted in pig stomachs at processing were consistent with previous textbook reference descriptions (Cook, 1996, Kopinski and McKenzie, 2007) of the varying degrees of gastric hyperkeratosis, erosion and ulceration. The histological features of stage 3 ulcers typically included deep degeneration of the entire epithelium and submucosa, with a necrotic zone at the base of the ulcer with minimal granulation tissue, overlying the residual lamina propria.

Table 2
The average age, carcass weight and assumed live weight at processing was 157.5 days, 76.27 kg and 97.78 kg respectively. The average daily feed intake from weaning to processing was estimated at 2.09 kg feed /day. The 5-year average feed cost per MT was USD 362.3, the 5-year average market pig price was USD 2.45 per kg.

Ulcer score	Average daily weight gain (g/day)	Average carcass weight (kg)	Estimated gross income (USD)	Income compared to pigs with ulcer score 0	*p* value of comparison to ulcer score 0
A. Financial comparison (per pig) if all pigs processed at 157.5 days of age.					
0	495.1	77.98	191.2	-	-
1	489.0	77.01	188.9	- $ 2.30	0.49
2	482.2	75.94	186.2	- $ 5.00	0.084
3	454.0	71.50	175.3	- $ 15.90	0.00001
B. Financial comparison (per pig) if all pigs were to be processed at 76.27 kg carcass weight.					
Ulcer score	Average daily weight gain (g/day)	Days taken to reach average carcass weight	Estimated total feed cost (USD) from wean to processing	Feed cost compared to pigs with ulcer score 0	*p* value of comparison to ulcer score 0
0	495.1	154	116.2	-	-
1	489.0	156	117.7	+ $ 1.50	0.49
2	482.2	158.2	119.4	+ $ 3.20	0.084
3	454.0	168	126.8	+ $ 10.60	0.00001

The correlation of individual ulcer score noted at processing to the daily weight gain of the study pigs is presented in Figs. 1 and 2. These results indicate a significant decrease in growth rate among some finishing pigs, particularly noted with score 3 stomach ulcers. The stage 1 pigs showed no significant difference in growth rates to normal pigs.

The suggested economic impacts on feed costs and carcass value of these ulcer and growth data is presented in Table 2. The average live bodyweight at processing (97.78 kg) was typical of the national average. The data indicate a significant economic impact of pigs suffering ulcer score 3 through the finishing period, in calculations based on either the actual carcass weight at processing (Table 2A) or on feed intake and what extra feed days would be required for processing at a particular desired bodyweight (Table 2B).

4. Discussion

Erosion and ulceration of the non-glandular region of the porcine stomach remains a common occurrence globally, partly due to the widespread usage of ulcerogenic dietary formulations of pelleted corn or wheat diets, composed of a fine particle size (Mößeler et al., 2012, Swaby and Gregory, 2012). While the second factor in this ulcerogenesis, namely feed cessation, can occur at various times in the life of a weaned pig, studies on natural outbreaks in modern farm conditions are limited. Some previous studies have examined the impact of feed withdrawal periods that are often incorporated just prior to routine slaughterhouse processing (Eisemann et al., 2002), but the growth rate and economic impact of an ulcerogenic feed cessation period may be greater when it occurs during the growing or finishing stages (Lawrence et al., 1998).

In this study, a homogenous group of otherwise healthy growing pigs were subjected to a feed cessation period, then fed a typical diet likely to invoke moderate on-going erosion/ulceration for an extended period of 12 weeks. The proportion of pigs in this study with the highest stage 3 erosion/ulceration score (20%) was therefore somewhat higher than that noted in a survey of the stomach amongst a general pig population at a processing facility, with various diets and presumably mostly without feed cessation periods (6.4 %, Swaby and Gregory, 2012). We also suggest that the 12-week period of ulcerogenic dietary factors is correlated to the resulting growth rate reduction in study pigs with non-healing deeper lesions. While the occurrence of a feed cessation period is a known causative factor in gastric ulceration (Lawrence et al., 1998), its exact contributory level in this field study in pigs maintained on ulcerogenic diets is not certain. The timing of the suggested feed cessation event (10 weeks-old) compares to that seen in many other herds, such as pre-processing feed interruption events (Eisemann et al., 2002).

Along with some previous studies, we confirmed that the significant performance impact of these lesions is only likely to occur in growing and finishing pigs with stage 3 ulcers - deeper non-healing lesions (Ayles et al., 1997, Elbers et al., 1995). Some other previous studies of stomach ulceration in pigs have contrastingly indicated little or no impact on their growth rate and likely economic impact (Pocock et al., 1969, Guise et al., 1997). The reasons for this limited impact could include that the stomach lesions are not present on an absorptive surface and that the causative factor of ulceration, that is intake of finely ground corn/wheat-based feeds, may also act to improve feed digestion and conversion. The suggested negative impact of non-glandular stomach erosion/ulceration on average daily weight gain and economic performance in this study and others, is therefore presumably due to more severe stage 3 lesions with leakage of serum proteins into the stomach, increased stomach fluidity with reduced stomach activity and a reduced feed intake, with accompanying abdominal pain, compared to the insignificant impact in pigs with the hyperkeratosis stage (stage 1). It is possible that carcass weight accumulation (compared to total bodyweight) would be adversely impacted by more severe stomach lesions.

We suggest that the identification of feed cessation in a group of growing and finishing pigs may enable the manager to confidently predict ongoing erosion/ulceration in the stomachs of pigs on pelleted corn/wheat diets. However, despite the likely economic impact in this situation, we note that a useful preventive or ameliorative product or management technique has yet to be widely promulgated.

5. Conclusions

Under the conditions of this study, the evaluation of individual stomach lesions noted at processing indicated a significant reduction in growth rate and economic performance among growing pigs with stage 3 stomach erosion/ulceration.

Author statement

A second revision is supplied, following the excellent further brief comments of the 3 reviewers.
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Declaration of Competing interest

None

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