RESEARCH REPORT

ANIMAL WELFARE

Title: Is tail docking necessary and if so, how long should the tail be? – **NPB #06-183**

Investigators: John J. McGlone and Mhairi Sutherland

Institution: Texas Tech University / Pork Industry Institute

Date Submitted: September 30, 2009

Industry Summary:
Tail docking of piglets is a routine procedure on farms to control tail biting behavior, however docking can cause an acute stress response. The objectives of this research were to 1) determine if tail docking prevents tail biting behavior in pigs, 2) determine if different methods of tail docking influence the prevalence of tail biting and reduce the stress caused by tail docking, 3) evaluate different methods of analgesia on the pain response in pigs to tail docking. In experiment 1, tail biting lesion scores were similar among docked and non-docked at 3 and 5 weeks of age, however at 7 weeks of age lesion scores were greater among non-docked compared with tail docked pigs. Body weights were lower among non-docked compared docked pigs and C-Reactive protein (CRP) levels (an indirect measure of inflammation) was elevated among non-docked compared with tail docked pigs at 7 weeks of age. In experiment 2, piglets were tail docked at a length of 2 cm (Short) or 5 cm (Long). Tail biting lesion scores were greater among Long compared with Short pigs. In experiment 3, pigs were tail docked using conventional cutting (CUT), cautery (CAUT), conventional cutting while the pig was anesthetized with carbon dioxide gas (CO2), conventional cutting with local anesthetic administered immediately prior to cutting (LA), conventional cutting with short acting topical anesthetic administered immediately after cutting (SHORT), conventional cutting with long acting topical anesthetic administered immediately after cutting (LONG), or sham docked (CON). Cortisol concentrations were reduced in pig's tail docked using cutting when a short acting topical anesthetic was applied to the wound. None of the other methods of analgesia were effective at reducing the cortisol response to tail docking in pigs, including using carbon dioxide as a form of general anesthesia. Pig's tail docked without analgesia performed a higher percentage of lying-alone behavior compared with all other treatments. Body weight change and wound healing was not affected by tail docking treatment. Poor welfare of tail bitten pigs was indicated by severity of lesion, level of CRP, and reduced pig body weights. Until root causes of tail biting are understood and preventative measures adopted, the long term benefits of tail docking outweigh the acute stress caused by this procedure. More research is needed to find effective analgesic treatments that could reduce the distress caused by tail docking to the pigs and which are practical on-farm.

Scientific Abstract
Tail docking of piglets is a routine procedure on farms to control tail biting behavior, however docking can cause an acute stress response. The objectives of this research were to 1) determine if tail docking prevents tail biting behavior in pigs, 2) determine if different methods of tail docking influence the prevalence of tail biting and reduce the stress caused by tail docking, 3) evaluate different methods of analgesia on the pain response in pigs to tail docking. In experiment 1, piglets were either tail docked using hot cautery iron (CAUT), blunt trauma cutters (BT), or their tails were left intact (CON). Blood samples were taken from pigs at 3 and 7 weeks of age to measure C-reactive protein (CRP). Tail biting lesions were scored at 3, 5, and 7 weeks of age. Behavior was recorded for 72 hours when tail biting was observed in 7 week old pigs. Tail biting lesion scores were similar among treatments at 3 and 5 weeks of age, however at 7 weeks of age lesion scores were greater among CON compared with CAUT and BT pigs. Body weights were lower among CON compared with CAUT or BT pigs and CRP was elevated among CON compared with CAUT and BT pigs at 7 weeks of age. In experiment 2, piglets were tail docked at a length of 2 cm (Short) or 5 cm (Long). Tail biting lesions were scored every 2 weeks until the end of finishing. Tail biting lesion scores were greater among Long compared with Short pigs. In experiment 3, pigs were tail docked using conventional cutting (CUT), cautery (CAUT), conventional cutting while the pig was anesthetized with carbon dioxide gas (CO2), conventional cutting with local anesthetic administered immediately prior to cutting (LA), conventional cutting with short acting topical anesthetic administered immediately after cutting (SHORT), conventional cutting with long acting topical anesthetic administered immediately after cutting (LONG), or sham docked (CON). Sequential blood samples were collected to measure cortisol concentrations and leukocyte measures. Behavior was also measured using 1-scan samples. Cortisol concentrations were reduced in pig's tail docked using cutting when a short acting topical anesthetic was applied to the wound. None of the other methods of analgesia were effective at reducing the cortisol response to tail docking in pigs, including using carbon dioxide as a form of general anesthesia. Pig's tail docked without analgesia performed a higher percentage of lying-alone behavior compared with all other treatments. Body weight change and wound healing was not affected by tail docking treatment. Poor welfare of tail bitten pigs was indicated by severity of lesion, level of CRP, and reduced pig body weights. Until root causes of tail biting are understood and preventative measures adopted, the long term benefits of tail docking outweigh the acute stress caused by this procedure. More research is needed to find effective analgesic treatments that could reduce the distress caused by tail docking to the pigs and which are practical on-farm.

IIntroduction:
Tail biting in pigs is a behavioral problem that is of economic concern for producers and a welfare problem. Tail biting not only affects the welfare of the pigs being bitten directly, but the procedure of tail docking as a means to prevent tail biting in pigs is also an animal welfare issue as it can cause acute pain. Animal welfare issues play an active role in purchasing and marketing decisions in the USA by major retailers. Many "standard agricultural practices" among pork producers cause inevitable temporary distress (FASS, 1999). For example, one to three day-old pig's tails are docked to prevent an undesirable tail-biting behavior among pen mates. This tail biting behavior can lead to open wounds, thus compromising the animal's immune system and ultimately resulting in slower growth and performance thus having economic consequences (Smith et al., 1998; Bracke et al. 2004). By docking the tails and causing "short-term" pain, the long term animal welfare is preserved. However, it is important to first establish if tail docking practices do actually prevent or reduce the incidence of tail biting in pigs.

It is unknown how tail biting arises among pigs. It may begin by an individual pig that begins to play or manipulate the tail of a pen mate through sucking and biting behaviors. Tail biting has been attributed to physical, environmental, nutritional and feeding management, group size, over crowding, gender, genetic makeup, length of tail, and lack of substrates (Fraser, 1987a; Fraser, 1987b, Jankevicius and Widowski 2003, 2004, Guy et al. 2002, Bilkei 2006). Exactly what causes tail biting episodes remains elusive and controlled experimental studies on tail biting have been variable in their successes (Frasure 1987b; Bracke et al. 2004, Jankevicius and Widowski 2003, 2004; Moinard et al. 2003). Tail docking is routinely used on farms in the US as a solution to this problem. However, there is limited scientific data to confirm if tail docking in fact reduces the prevalence of tail biting behavior in pigs.

The objective of this study is to first establish if tail docking practices do actually prevent or reduce the incidence of tail biting in pigs. If it is established that tail docking is an important management practice to prevent tail biting behavior in pigs, the next step will be to establish the optimum tail length for the health of the pigs and to prevent tail biting. Lastly, it is important to evaluate the effect of different methods of analgesia on the pain response in pigs to tail docking to determine ways to reduce the distress caused by this procedure.

Objectives

1) To determine if tail docking prevents tail biting behavior in pigs.

2) To determine if different methods of tail docking influence the prevalence of tail biting and reduce the stress caused by tail docking.

3) To evaluate different methods of analgesia on the pain response in pigs to tail docking.

Materials and Methods

Pigs used in this study were PIC USA genetics using the Camborough-22 sow line. All animals were fed a diet to meet or exceed NRC (1998) nutrient requirements. Water was provided ad libitum. All animal procedures were approved by the Texas Tech University Animal Care and Use Committee.

<u>Experiment 1:</u>

Eight weight-matched, healthy piglets per litter (n = 10 litters), were allocated to one of two treatment groups; docked (n = 40) and non-docked (CON, n = 40). Within each litter, two gilts and two barrows were allocated to the CON treatment groups. Of the four pigs (two gilts and two barrows) allocated to the tail docking treatment, one gilt and one barrow were allocated to one of two docking treatments: blunt trauma cutting (BT, n = 20) or hot iron cautery (CAUT, n = 20). Thus, the same number of gilts and barrows were allocated to each treatment.

Within the first 3 d after farrowing, piglets were routinely castrated, ear notched (for pig ID), and given an iron injection (100 mg). Piglets were then allowed 3 d to recover from this processing experience. At 6 d of age (± 2 d) piglets were tail docked or left intact, depending on which treatment group the pig was assigned. Piglets were removed from the sow individually and taken to an adjoining room separated by a closed door, so as not to disturb the remaining sows and piglets in the farrowing room. Piglets were held by one handler with the tail facing outward. The second handler marked a length of 2 cm on the pigs' tail starting at the base on the pigs' tail and then either sham cut each pig's tail or cut the tail using BT or CAUT. Sham cutting involved placing two fingers, one on either side of the tail, and making a cutting motion on the tail. Tail docking was performed using one of two methods: 1) conventional BT cutting with disinfected stainless steel cutting pliers; or 2) cutting with a commercial cutting cautery iron (Meador TNSC, Meador swine health developers, Gretna, Nebraska). Once all the piglets from one litter were tail docked or sham handled they were returned to their home pen as a group. The tail docking treatment order was randomized over time. Pigs were weighed at tail docking, weaning, and at the end of the study.

At 21 ± 5 d of age all pigs were moved into conventional nursery pens measuring 1.5 X 2.1 m with woven wire floors. Each pen contained one feeder with six head spaces and one nipple waterer. Ten pigs were housed in each pen. Pigs from the same treatment were penned together so that tail length did not confound tail biting behavior. Treatment pens were randomly allocated throughout the nursery building. Body weights were recorded at weaning and at the end of the experiment (7 wk of age).

Blood sample collection

At 3 (weaning) and 7 wk (once the study was ended) of age, a sub-set of pigs (5 pigs per pen) were held in a supine position and blood was obtained by anterior vena cava puncture (catching and blood sampling took ~1 min). Blood (5 mL) was collected into vacutainers containing sodium heparin. Whole blood was analyzed to determine white cell counts and differential leukocyte counts using a cell counter (Cell-Dyn® 3700, Abbott laboratories, Abbott Park, IL) and the neutrophil to lymphocyte (N:L) ratio was calculated by dividing the percent of neutrophils by the percent of lymphocytes. Ten mL of blood was collected without an anticoagulant and samples were centrifuged and serum collected for analysis of C-reactive protein (CRP). C-reactive protein was analyzed using a commercially available enzyme immunoassay kit (Tridelta development Ltd, Cc. Kildare, Ireland).

Tail biting behavior

Once tail biting lesions above a score of two (for the 'injury' and 'blood' categories) were observed, overhead cameras (Panasonic wv-BP70 and Panasonic wv-CP412) and time-lapse VCRs (Panasonic, TL 500) on 72-h mode (0.8 frames/s) were set to record behavior in each nursery pen were tail biting lesions had been observed. Tail biting lesions were observed in all four CON pens, so behavior was recorded in all these pens. All pigs in the pen were individually marked with a heavy duty marking pen (Super mark pen, Fearing International Ltd, Northampton, UK) using a series of lines to differentiate among individual pigs for easy identification during the live observations. Tapes were watched continuously and behaviors were scored with The Observer 5.0 (Noldus, Leesburg, PA) over the entire 72 hour period for the incidence of tail biting behavior, the number of the pig doing the tail biting (perpetrators), the number of the pig being bitten (victims), and the location of these pigs in the pen at the time the tail biting was recorded.

Wound healing scoring

All tail docked piglets were examined daily to assess wound healing from the day after tail docking until pigs were weaned and moved into the nursery. The purpose of assessing wound healing was to determine if one method of tail docking was better than the other in relation to wound healing. Wounds were scored from 1 to 6 with 1 being completely healed (no scab) and 6 still showing signs of fresh blood (Table 1).

Tail biting lesion scoring

Tail biting lesion scores were recorded approximately every two weeks from weaning until the end of the study. Tail biting lesions were scored using a modified scoring technique established by Zonderland *et al* (2003; Table 2). Briefly, tail biting lesions were scored using three categories based on tail length, the appearance of injuries, and the appearance of blood. The severity of the lesion was scored from 1 to 4 (injuries and blood) or 1 to 5 (tail length). The sum of all tail lesions were calculated for each individual pig. At 7 wk of age, tail biting broke out amongst all pens of CON pigs and the study was terminated for humane reasons and to allow the affected pigs to be treated.

<u>Experiment 2:</u>

Eight piglets from 10 sows were allocated to one of two treatment groups; docked short (Short; n = 40) and docked long (Long; n = 40). Within each litter, two gilts and two barrows were allocated to each of the two treatment groups. The same number of gilts and barrows were allocated to each treatment.

Within the first 3 d after farrowing piglets were routinely castrated, ear notched (for pig ID), and given an iron injection (100 mg). Piglets were tail docked at 6 d of age (± 2 d) depending on which treatment group the pig was allocated to (as described in experiment 1). Pigs' tails were cut using blunt trauma at a length of 2 cm (Short) or 5 cm (Long) from the base on the tail.

At 21 ± 5 d of age all pigs were moved into conventional nursery pens measuring 1.5 X 2.1 m with woven wire floors. Each pen contained one feeder with six head spaces and one nipple waterer.

Ten pigs were housed in each pen. Pigs from the same treatment were penned together so that tail length did not confound tail biting behavior. Treatment pens were randomly allocated throughout the nursery building.

At 9 wk of age all pigs were moved into conventional finishing pens measuring 2.1 X 3.7 m with fully slated floors. Each pen contained one feeder with four head spaces and one nipple waterer. Ten pigs were housed in each pen. Pigs from the same treatment were penned together so that tail length did not confound tail biting behavior. Treatment pens were randomly allocated throughout the finishing building.

Tail biting lesion scoring

Tail biting lesion scores were recorded approximately every two weeks from weaning until the end of the study. Briefly, tail biting lesions were scored as described in experiment 1, except the tail length score was scored relative to the baseline tail length.

Experimental 3:

This study comprised of seven treatment groups: 1) Sham tail docking (CON; n = 10); 2) Tail docking using conventional cutting with side-cutting pliers (CUT; n = 10); 3) Tail docking using commercial cutting cautery iron (CAUT; n = 10); 4) Tail docking plus local anesthetic administered immediately prior to tail docking (LA; n = 10); 5) Tail docking plus short acting topical anesthetic (SHORT; n = 10); 6) Tail docking plus long acting topical anesthetic (LONG; n = 10), and 7) Tail docking conducted while the pig were anesthetized with carbon dioxide using conventional cutting with side-cutting pliers (CO2; n = 10). At approximately 3 days of age, piglets were allocated to one of the seven treatment groups. Piglets in the CON treatment group were restrained and their tails sham cut by placing two fingers, one on either side of the tail, and making a cutting motion on the tail. Piglets in the CUT group were restrained and their tails cut using stainless steel cutting pliers. Piglets in the CAUT group were restrained and their tails cut using a commercially viable cutting cautery iron (Meador TNSC, Meador swine health developers, Gretna, NE). Piglets in the LA treatment group were restrained, 0.5 mL local anesthetic (Lidocaine 2%) administered subcutaneously across the full width of the tail, then the piglet was tail docked immediately in the same manner as CUT piglets distal to the sight of injection. Lidocaine was selected for use in this study because it is a fast acting commonly available local anesthetic. Piglets in the LONG treatment group were tail docked in the same manner as the CUT piglets and then a topical anesthetic (Tri-Solfen, Animal Ethics, VIC, Australia) applied to the wound. Tri-Solfen consists of a mixture of fast acting (lignocaine hydrochloride) and long acting (bupivacaine hydrochloride) anesthetic to quickly numb the wound, beginning within 1-3 minutes and lasting for several hours, a vasoconstrictor (adrenaline tartrate) which acts on the cut blood vessels to stop the bleeding, and an antiseptic agent (cetrimide). Piglets in the SHORT treatment group were tail docked in the same manner as the CUT piglets and then a topical anesthetic (Cetacaine®, Cetylite Industries, Inc., Pennsauken, NJ) sprayed onto the wound. Cetacaine® consists of Benzaine a fast acting local anesthetic that lasts approximately 30 to 60 minutes and is readably available in the USA. Finally, piglets in the CO2 treatment were anesthetized by placing a mask over the piglets snort and administering 100% CO_2 gas for 30 sec. After 30 sec, the mask was removed and piglets were tail docked immediately in the same manner as CUT piglets.

Experiment 3a

Prior to (baseline), and 30, 60, and 120 minutes after tail docking, piglets were held in a supine position and 2.5 mL blood obtained by veni-puncture. Blood was collected into vacutainers containing sodium heparin. Whole blood was analyzed to determine white cell counts and differential leukocyte counts (Cell-Dyn® 3700, Abbott laboratories, Abbott Park, IL) and the neutrophil to lymphocyte (N:L) ratio was calculated by dividing the percent of neutrophils by the percent of lymphocytes. Blood samples were centrifuged and plasma collected for analysis of cortisol using an enzyme immunoassay kit (Assay designs, Ann Arbor, MI).

Experiment 3b

Experiment 3a was repeated as described above, except that piglets were not blood sampled, to assess the behavioral response of piglets to the different tail docking methods. Sixty minutes prior to tail docking, experimental piglets were individually marked with a heavy duty marking pen (Super mark pen, Fearing International Ltd, Northampton, UK) using a series of lines in the cross sectional plan to differentiate among individual pigs for easy identification during the live observations. After 60 min of recording piglet 'normal' behavior, all piglets from one sow were removed and taken to an adjoining room separated by a closed door, so as not to disturb the remaining sows and piglets in the farrowing room. Piglets were tail docked depending on which treatment group they were allocated to. After tail docking, all piglets were returned to their home pen at the same time and the behavior of each individual pig was recorded using 1 min scan-samples (live observations) for 120 min. The observer sat directly behind the sow to prevent disturbing her as much as possible, but still giving the observer a complete view of all piglets in the farrowing crate. Behaviors and postures measured included lying-alone, lying-touching the sow or other piglets, nursing/massaging, standing, sitting, walking and pain-like behaviors and postures (e.g. hunching, scooting, and tail jamming) (Table 6).

All piglets (from experiment 1 and 2) were weighed prior to tail docking and 24 hours after tail docking. Wound healing was assessed on all piglets after tail docking until pigs are weaned and moved into the nursery using procedures developed and published earlier (Sutherland et al., 2008).

Statistical Analysis

All data were tested for constant variance and departures from normal distribution. Data lacking normality were transformed logarithmically using $\log_{10}$. Data were subjected to analysis of variance using the mixed model procedure of SAS version 9.1 (SAS Inst., Inc., Cary, NC). Behavioral data were also analyzed using analysis of variance using the mixed model procedure of SAS. Correlations among behavior and performance and physiological measures were determined using the correlations procedure of SAS version 9.1 (SAS Inst., Inc., Cary, NC).

Results:

<u>Experiment 1</u>

Wound healing was assessed in pigs tail docked using CAUT or BT daily until the pigs were moved into the nursery (≅ 15 d after tail docking). Pigs tail docked using CAUT had a higher ($P < 0.005$) wound healing score compared with BT pigs overall (CAUT: 2.5 ± 0.04; BT: 2.3 ± 0.04). There was no interaction ($P > 0.05$) between tail docking treatment and day after tail docking.

Tail biting lesions scores (tail length, injury, blood, and sum of lesions) were greater ($P < 0.001$) in CON compared with CAUT and BT pigs seven weeks post tail docking (Figure 1). At 2 and 4 weeks post tail docking there was no difference ($P > 0.05$) in lesion scores (tail length, injury, blood, or sum of lesions) among treatment groups (Figure 1). There was no gender effect ($P > 0.05$) on any of the lesion score categories.

C-reactive protein was measured at 3 (weaning) and 7 (end of study) wk of age (Figure 2). At 3 wk of age, there was no difference ($P > 0.05$) in CRP concentrations among treatments. At 7 wk of age, CRP concentrations were elevated ($P < 0.05$) in CON compared with CAUT and BT pigs, but CRP concentrations did not differ ($P > 0.05$) between CAUT and BT pigs. There was no gender effect ($P > 0.05$) on CRP concentrations.

Leukocyte counts, differentials, and the neutrophil to lymphocyte ratio did not differ ($P > 0.05$) among treatments at 3 or 7 wks of age (Table 3). There was no gender effect ($P > 0.05$) on leukocyte values.

The sum of lesion scores (Tail length + injury + blood) was negatively correlated with the body weights of pigs at the end of the study (r = -0.36; $P < 0.05$), the average daily gain of pigs from weaning until the finish of the study (r = -0.41; $P < 0.05$), and positively correlated with CRP concentrations (r = 0.51; $P < 0.001$).

The majority of tail biting behavior occurred while pigs were lying in the pen or standing at the feeder (Table 4). The duration (r = 0.44; $P < 0.005$) and number of occurrences (r = 0.38; $P < 0.05$)

of perpetrating tail biting behavior was positively correlated with the sum of lesions. The duration of perpetrating tail biting behavior was negatively correlated with the end weight (r = -0.41; $P < 0.05$) of pigs and the average daily gain (r = -0.42; $P < 0.05$) of pigs from weaning until finishing. The duration of being 'victimized' was positively correlated (r = 0.35; $P < 0.05$) with tail length, but not injury, blood, or sum of lesion scores. The occurrence of being 'victimized' was positively correlated (r = 0.60; $P < 0.005$) with CRP concentrations at weaning. No other correlation ($P > 0.05$) coefficients were identified.

Pig weight and average daily gain did not differ ($P > 0.05$) among CAUT, BT, or CON treatments at weaning, but at 7 wk of age CAUT and BT pigs had higher ($P < 0.05$) body weights than CON pigs (Table 5). Body weight was greater among barrows ($P < 0.01$) than gilts at 7 wk of age (barrow: 19.9 ± 0.36 kg and gilt: 18.6 ± 0.32 kg). Average daily gain was greater among barrows ($P < 0.01$) than gilts from weaning until 7 wk of age (barrow: 0.47 ± 0.010 kg/d and gilt: 0.43 ± 0.009 kg/d).

Experiment 2

The tail biting lesion score category 'tail length' was greater ($P < 0.005$) among Long compared with Short pigs at 18 and 20 wk of age (Figure 3). The tail biting lesion score category 'blood' was greater ($P < 0.06$) in Long compared with Short pigs at 11, 14, 16, and 18 wk of age (Figure 4). The tail biting lesion score category 'injury' was greater ($P < 0.001$) in Long compared with Short pigs over the entire trail period (Short: 1.1 ± 0.03 and Long: 1.3 ± 0.03). There was no gender effect ($P > 0.05$) on any of the lesion score categories (length, blood, injury, or sum) over the entire trail period.

Experiment 3

Change in body weight did not differ ($P > 0.05$) among treatment groups 24 hours after tail docking treatment was performed (Fig. 5).

Leukocyte counts, differentials, and the neutrophil to lymphocyte ratio did not differ ($P > 0.05$) among treatments (Table 7). There was no gender effect ($P > 0.05$) on leukocyte values.

Cortisol concentrations did not differ ($P > 0.05$) between CUT and CAUT pigs and were greater ($P < 0.05$) in CUT and CAUT compared with CON pigs 30 min after tail docking (Fig. 6). Cortisol concentrations did not differ ($P > 0.05$) between CUT and CO2 pigs and were greater ($P < 0.001$) in CO2 compared with CON pigs 30 min after tail docking (Fig. 7). Cortisol concentrations did not differ ($P > 0.05$) between LA, LONG, and CUT pigs and were greater ($P < 0.05$) in LA and LONG compared with CON pigs 30 min after tail docking (Fig. 8). At 30 min, SHORT pigs had lower ($P < 0.05$) cortisol concentrations than CUT pigs and cortisol concentrations did not differ ($P > 0.05$) CON and SHORT pigs at 30 min (Fig. 8).

Wound healing was assessed over time in pigs tail docked until the pigs were moved into the nursery (≅ 21d after tail docking). There was no difference in wound healing ($P > 0.05$) regardless of treatment (CUT: 2.9 ± 0.06; CAUT: 2.8 ± 0.09; CO2: 2.9 ± 0.06; LA: 3.0 ± 0.07; SHORT: 2.9 ± 0.07; LONG: 2.9 ± 0.09).

The percentage of time pigs spent lying alone after tail docking tended to be greater ($P = 0.06$) in CUT pigs compared with all other tail docking treatments and CON pigs (Table 8). The percentage of time pigs spent performing pain-like behaviors after tail docking was greater ($P < 0.03$) in LA and LONG pigs compared with CAUT and CET pigs (Table 8). There was no interaction (P > 0.05) between tail docking treatment and time after tail docking.

Discussion:

The effect of tail docking method and tail biting behavior on the physiology and behavior of pigs was examined in the present study. In previous research, tail docking using a cautery iron was shown to reduce the cortisol response to tail docking on 6 d old pigs (Sutherland *et al* 2008). It has been suggested that cautery may delay wound healing which could possibly lead to chronic infections (Graham *et al* 1997). In experiment 1, tail docking wounds of pig's tail docked using CAUT took slightly longer to heal than BT pigs, but not in experiment 3. However, there was no difference in the acute phase response, as measured by C-reactive protein (CRP) or the total white blood cell count between pigs tail docked using CAUT or BT at weaning. Furthermore, there was no difference in the acute phase response or the total white blood cell count among non-docked and docked pigs, suggesting that at weaning there was no residual inflammatory response in pigs due to tail docking methods. Tail docking using cautery was shown to reduce the acute stress response to tail docking and had no long term detrimental effects on the health or discomfort experienced by the pig (Sutherland et al., 2008), therefore cautery may be a practical alternative to reduce the stress caused by this procedure. Neuroma formation has been shown to be present in the tail stump of docked pigs (Simonsen *et al* 1991) and tail docked heifers showed increased sensitivity to heat and cold (Eicher *et al* 2006), therefore tail docking may cause long term pain. It would be interesting to determine if pigs docked using cautery experienced more chronic distress due to regeneration of nociceptors compared with pigs docked using the BT method.

In the present study, different analgesic treatments were evaluated in relation to reducing the pain caused by tail docking in pigs as measured by behavior and physiological measures of distress. Analgesic treatments included applying a long or short acting topical anesthetic to tail after the tail had been cut using pliers, administering local anesthetic just prior to tail docking, and using carbon dioxide gas to anesthetize pigs prior to tail docking. Tail docking without the use of analgesia increased the performance of lying-alone behavior, which may be indicative pain. Cortisol concentrations were reduced in pigs given a short acting topical anesthetic after tail docking, but not in pigs anesthetized with carbon dioxide gas. Applying a topical anesthetic to the tail wound immediately after tail docking may be an effective and easy way to reduce the pain caused by tail docking. Carbon dioxide reduces the initial response to tail docking, but does not reduce the long term stress response to this procedure. More research is needed to study the effectiveness of different analgesics that could be used to reduce the pain caused by tail docking in pigs.

Individual pigs that spent more time performing tail biting behavior during the 72 hour recording period had lower weights at the end of the study and lower average daily gain from weaning until the end of the study. Beattie *et al* (2005) found that pigs that spent 1.5 % of their time performing tail biting behavior were lighter at weaning and tended to be lighter at 7 wk of age than pigs that spent less that 1.5 % of the time performing tail biting behavior. A nutrition or mineral deficiency in the diet could account for the association between reduced average daily gain and the increased performance of tail biting behavior in pigs (Fraser *et al* 1987b). However, in the present study pigs were fed a diet to meet or exceed NRC nutrient requirements (1998), suggesting that another reason may underlay the performance of tail biting in pigs in this study. In the present study, 30 % of tail biting behavior occurred while pigs were standing at the feeder. Competition for feeder space may lead to smaller lower ranking pigs performing tail biting behavior while other more dominate pigs are feeding (Rasmussen *et al* 1962; Geers *et al* 1985). Reduced access to feed could lead to reduced feed intake and average daily gain in these lower ranking pigs. Reduced weight gain in pigs performing tail biting behavior makes tail biting not just a welfare issue, but also an economic one for producers.

The acute phase response occurs in animals in response to infection, inflammation, or trauma. Part of the acute phase response is the release of acute phase proteins, such as haptoglobin and CRP, into the circulation. Eckersall *et al* (1996) demonstrated that CRP and haptoglobin are good markers for the identification of inflammatory lesions in pigs. In the present study, CRP concentrations were positively correlated with the severity of tail biting lesions. Heinonen *et al* (2006) showed that CRP, serum amyloid-A (SAA), and haptoglobin were elevated in pigs with tail bit lesions and acute phase protein concentrations were positively correlated with the severity of the tail bit lesion. The acute phase response is mediated by a combination of cytokines, including interleukin-1, interleukin-6, and tumor necrosis factor-α. The cytokines associated with the acute phase response are also responsible for somnolence, anorexia, and reduced growth. Therefore, reduced growth in pigs with severe tail bit lesions may be the result of sickness behavior induced by the activation of the acute phase response rather than a nutrition deficiency or competition for feeder space.

Tail docking is the most commonly used preventive measure for tail biting behavior. It has been suggested that tail docking may prevent tail biting behavior due to increased sensitivity in the tip of the tail caused by nerve regeneration and the formation of neuromas after tail docking (Simonsen *et al* 1991). The increased sensitivity in the tip of the tail may cause the pig to react more vigorously to pen mates chewing on their tails and therefore motivate the pig to move preventing further tail biting and potential injury. If this is the case then it should be sufficient to remove only part of the tail to reduce tail biting behavior in pigs. In the present study, tail biting lesions were greater in pigs tail docked at a longer length compared with conventionally short tails. Hunter *et al* (1999) found that pigs tail docked at a longer length or left intact tails were more than 3 times as likely to be bitten compared with conventionally docked pigs. Tail biting lesions observed in pigs with longer docked tails occurred in the later stages of finishing compared with the tail biting outbreak that occurred amongst pigs with intact tails in the nursery. In other studies, tail biting was also more commonly observed in older pigs (Haske-Corelues *et al* 1979; Sambraus 1985). Furthermore, the tail biting lesions observed in pigs with longer docked tails were considerably less severe than the tail lesions observed in pigs with intact tails. However it would still not be recommendable to leave pigs with longer docked tails due to the increased risk of tail biting compared with conventionally docked pigs. Furthermore, tail docking pigs at a longer length still results in acute pain and therefore does not benefit the welfare of the pig in the short run. We recommend docking pig tails at the shorter length in that it reduces the risk of tail biting and tail wounds.

Conclusion and animal welfare implications

Tail docking causes acute pain in pigs. The cortisol response to tail docking can be reduced by using cautery or short acting topical anesthetic compared with convention blunt trauma cutting. Analgesic treatments did not delay wound healing or increase the incidence of infections in pigs, suggesting that cautery or topical anesthetic may be a viable alternative compared to conventional tail docking. The incidence of tail biting behavior was greater in pigs with intact or long tails compared with pigs with tails docked shorter. Tail biting reduced the welfare of pigs as measured by an increase in the acute phase response and reduced performance along with the behavioral problem of tail biting. Tail biting has a major negative impact on the welfare of pigs and therefore it is important to find management practices that can reduce the incidence of this behavior. Until root causes of tail biting are understood and preventative measures adopted, the long term benefits of tail docking (short) outweigh the acute stress caused by this procedure.

Literature cited

Eicher SD, Cheng HW, Sorrells AD and Schutz MM 2006. Behavioral and physiological indicators of sensitivity or chronic pain following tail docking. Journal of Dairy Science 89, 3047-3051.

Federation of Animal Science Societies 1999. Guide for the care and use of agricultural animals in agriculture and teaching, first revised edition. FASS, Savoy, IL, USA.

Fraser D 1987. Mineral deficient diets and the pig's attraction to blood: implications to tail biting. Canadian Journal of Animal Science 67, 909-918.

Fraser D and Rushen J 1987. Attraction to blood as a factor in tail biting by pigs. Applied Animal Behaviour Science 17, 61-68.

Geers R, Berckmans D, Goedseels V, Maes F, Soontjens J and Mertens J 1985 Relationships between physical characteristics of the pig house, the engineering and control systems of the environment, and production parameters of growing pigs. Annales de Zootechnies 34: 11-22

Graham M J, Kent JE and Molony V 1997. Effects of four analgesic treatments on the behavioural and cortisol response of 3-week-old lambs to tail docking. The Veterinary Journal 153, 87-97.

Guy JH, Rowlinson P, Chadwick JP and Ellis M 2002. Behaviour of two genotypes of growing–finishing pig in three different housing systems. Applied Animal Behaviour Science 75, 193-206.

Haske-Cornelius H, Von Bogner H and Pescheke W 1979 Untersuchungen zum verhalten von mastschweinen in verschiedene stallsystemen unterbesonderer berucksichtigung des schwanz-undohrenbeissens. Bayerisches landwirtschaftliches jahebuch 56: 162-200

Heinonen MH, Orro T, Kokkonen T, Munsterhjelm C, Valros and Peltoniemi OAT 2006 The effect of tail biting on acute phase protein concentrations in finishing pigs. In: Proceedings of the 19th IPVS Congress, Copenhagen, Denmark, vol 2, pp 609

Hunter EJ, Jones TA, Guise HJ, Penny RHC and Hoste S 2001 The relationship between tail biting in pigs, docking procedure and other management practices. The Veterinary Journal 161: 72-79

Jankevicius ML and Widowski TM 2003. Does balancing for color affect pigs' preference for different flavored tail-models? Applied Animal Behaviour Science 84, 159-165.

Jankevicius ML and Widowski TM 2004. The effect of ACTH on pigs' attraction to salt or blood-flavored tail-models. Applied Animal Behaviour Science 87, 55-68.

Kent JE, Molony V and Graham MJ 1998. Comparison of methods for the reduction of acute pain produced by rubber ring castration or tail docking of week-old lambs. The Veterinary Journal 155, 39-51.

Rasmussen OG, Banks EM, Berry TH and Becker DE 1962 Social dominance in gilts. Journal of Animal Science 21: 520-522

Sambraus HH 1985 Mouth-based anomalous syndromes. World Animal Science, A5, Ethology of Farm Animals. A comprehensive study of the behavioral features of common farm animals, pp 391-422

Simonsen HB, Klinken L and Bindseil E 1991. Histopathology of intact and docked pigtails. British Veterinary Journal 147, 407-412.

Sutherland MA, Bryer PJ, Krebs N and McGlone JJ 2008 Tail docking in pigs: acute physiological and behavioral responses. Animal 2: 292-29

Zonderland JJ, Fillerup M, van Reenen CG, Hopster H and Spoolder HAM 2003 Prevention and treatment of tail biting in weaned piglets. PV report Pigs 18, RIAH, Lelystad, The Netherlands

Table 1. Description of wound healing score

Score	**1**	**2**	**3**	**4**	**5**
Description	 Completely healed tail docking wound	 A slight scab still present at the tip of the tail	 Fully formed scab over the wound (thick and bumpy in appearance)	 Fully formed scab over the wound (thin in appearance)	 Wound is still open and there is signs of fresh blood

Table 2. Description of tail biting lesion score

Tail length	Injuries	Blood
1. Complete tail 	1. None 	1. None 
2. ¾ tail to almost complete 	2. “Bite” spots. Multiple little spots on the tail 	2. Black in color (dried scab) 
3. Half to ¾ tail 	3. A small wound/s (smaller than a dime) 	3. A scab, which has cracked and revealing fresh blood 
4. Quarter to ½ a tail	4. A severe wound (larger than a quarter)	4. Fresh blood / raw wound

		
5. Less than ¼ tail 		

Table 3. Leukocyte values of pigs tail docked using cautery (CAUT), blunt trauma cutting (BT), and sham docking (CON) at 3 and 7 weeks of age.

Variable	Age (wk)	Treatment						P-value
		CON	SE	CAUT	SE	BT	SE	
N		10		10		20		
WBC ($10^3/\mu L$)	3	11.9	2.34	9.8	2.49	11.6	3.19	0.649
	7	18.0	1.85	19.6	2.70	17.3	2.42	
Neutrophils ($10^3/\mu L$)	3	2.0	0.79	0.8	0.83	1.3	1.08	0.930
	7	6.4	0.88	6.0	1.28	5.9	1.14	
Lymphocytes ($10^3/\mu L$)	3	9.5	1.79	8.5	1.89	10.1	2.45	0.487
	7	10.7	1.66	13.2	2.42	9.7	2.17	
Neutrophils (%)	3	10.3	4.18	6.8	4.77	18.5	5.75	0.436
	7	36.3	4.30	33.4	6.28	33.4	5.62	
Lymphocytes (%)	3	86.4	3.96	88.6	4.49	79.9	5.45	0.769
	7	58.0	4.66	63.6	6.82	58.9	6.09	
N:L	3	0.14	0.076	0.09	0.086	0.29	0.105	0.720
	7	0.76	0.121	0.63	0.176	0.73	0.158	

WBC = Total white blood cell count; N:L = Neutrophil to lymphocyte ratio

Table 4. The percentage of time tail biting behavior was performed by 7 week old pigs over a 72 hour period at different locations in the pen.

Behavior	The occurrence of behavior, %
Lying at the feeder	2.0
Lying in pen	47.9
Standing at drinker	11.8
Standing at feeder	30.5
Standing in pen	7.9

Table 5. Weights and average daily gain of pigs tail docked using cautery (CAUT), blunt trauma cutting (BT) and sham docking (CON)

Variable	Period	CAUT	SE	BT	SE	CON	SE	P-value
		Treatment						
n		20		20		40		
BW, kg	Initial	2.7	0.10	2.9	0.10	2.8	0.07	0.551
	Weaning	6.2	0.29	6.8	0.30	6.7	0.22	0.256
	End*	19.5[a]	0.60	20.5[a]	0.62	17.8[b]	0.46	0.002
ADG, kg/d	Weaning +	0.13	0.009	0.15	0.009	0.15	0.006	0.251
	End#	0.42	0.018	0.43	0.018	0.40	0.013	0.498

*End of the study (pigs were approximately 60 days old)
+Average daily gain calculated between initial weight and weaning weight
#Average daily gain calculated between weaning and the end of the study
[a,b]Least square means accompanied by different subscripts are different at P < 0.05.

Table 6. Experiemnt3: Description of behaviors

Behavior	Description
Walking[1]	Relatively low speed locomotion in which propulsive force derives from the action of legs
Sitting[1]	Resting on the caudal part of the body
Standing[1]	Assuming or maintaining an upright position on extended legs
Lying-alone	Maintaining a recumbent position and not in contact with other piglets or the sow
Lying-touching	Maintaining a recumbent position while contacting another piglet/s or the sow
Nursing/Massaging[1]	This category includes both nursing and massaging behaviors. Massaging is the rhythmic and sustained mechanical manipulation of the mammary of the sow by the piglets prior to and after nursing. Nursing is the act of releasing milk to suckling young
Pain-like behaviors	These include ‘scooting’ behavior (caudal part of the body being dragged across the ground), ‘hunching’ (hunching of the back at an abnormal posture), and ‘Jamming’ behavior (the tail is jammed between the rump and hind legs in a protective posture).
Total active	All behaviors combined, with the exception of the lying behavior
Total inactive	Lying-alone and lying-touching behaviors combined

[1]Hurnik, 1995

Table 7. Leukocyte values of pigs tail docked using conventional cutting (CUT), cautery (CAUT), conventional cutting while the pig was anesthetized with carbon dioxide gas (CO2), conventional cutting with local anesthetic administered immediately prior to cutting (LA), conventional cutting with short acting topical anesthetic administered immediately after cutting (SHORT), conventional cutting with long acting topical anesthetic administered immediately after cutting (LONG), or sham docked (CON).

	Treatment								
Variable	CON	CUT	CAUT	LA	CO2	SHORT	LONG	*Pooled SE*	*P-value*
N	10	10	10	10	10	10	10		
WBC ($10^3/\mu L$)	8.0	9.4	8.2	8.6	8.9	10.7	8.8	0.80	0.398
Neutrophils ($10^3/\mu L$)	5.4	6.3	5.5	5.8	5.8	7.5	6.4	0.71	0.739
Lymphocytes ($10^3/\mu L$)	1.8	2.2	1.8	2.0	1.9	2.0	1.7	0.17	0.21
Neutrophils (%)	68.3	68.0	68.8	69.9	67.8	70.5	71.8	1.81	0.672
Lymphocytes (%)	23.2	24.2	22.4	21.7	22.6	21.7	20.4	1.47	0.653
N:L	3.1	3.1	3.1	3.5	3.2	3.8	4.1	0.38	0.576

WBC = Total white blood cell count; N:L = Neutrophil to lymphocyte ratio

Table 6. The percentage of time pigs spent performing different behaviors after being tail docked using conventional cutting (CUT), cautery (CAUT), conventional cutting while the pig was anesthetized with carbon dioxide gas (CO2), conventional cutting with local anesthetic administered immediately prior to cutting (LA), conventional cutting with short acting topical anesthetic administered immediately after cutting (SHORT), conventional cutting with long acting topical anesthetic administered immediately after cutting (LONG), or sham docked (CON). Least square means accompanied by subscripts are different at *P* < 0.06.

	Treatments								
Behaviors, %	CON	CUT	CAUT	CO2	LA	SHORT	LONG	*Pooled SE*	*P-values*
N	10	10	10	10	10	10	10		
Lying alone	3.7^{b}	9.6^{a}	5.5^{b}	4.2^{b}	4.8^{b}	5.1^{b}	5.3^{b}	1.35	0.060
Lying touch	63.0	60.1	65.1	61.7	61.1	64.5	62.3	2.88	0.885
Nursing	21.7	18.8	19.3	23.3	19.6	19.3	20.1	2.46	0.859
Standing	4.1	4.7	4.4	4.5	5.5	3.9	4.5	0.91	0.931
Sitting	1.2	1.3	1.1	0.8	1.4	1.7	0.8	0.33	0.401
Walking	5.3	4.8	4.4	5.4	6.8	5.4	6.3	0.96	0.621
Pain-like behaviors	0.4bc	0.3bc	0.1c	0.3bc	0.8ab	0.1c	1.0a	0.22	0.027
Active	33.3	30.4	29.4	34.5	34.3	30.4	32.8	2.64	0.729
Inactive	66.7	69.7	70.6	65.9	65.9	69.6	67.5	2.64	0.775

Figure 1. The sum of all lesion score categories (length, injury, and blood) for pigs tail docked using cautery (CAUT; n = 20), blunt trauma cutting (BT; n = 20), or sham docked controls (CON; n = 40) at 3, 5, and 7 weeks of age. At each time, least square means accompanied by different subscripts are different at $P < 0.05$.

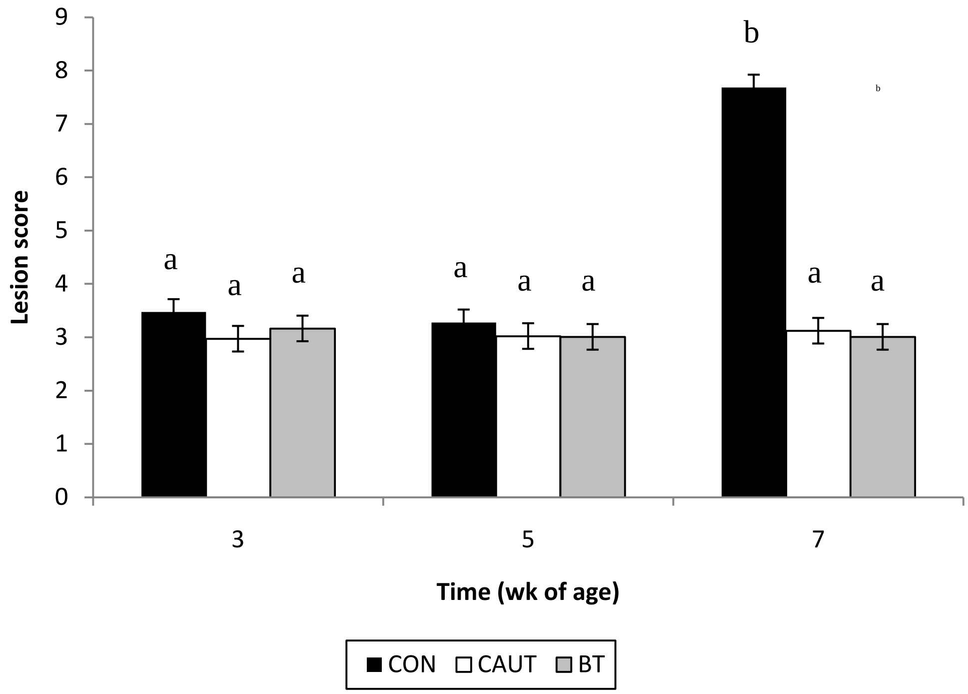

Figure 2. C-reactive protein concentrations of pigs tail docked using cautery (CAUT; n = 20), blunt trauma cutting (BT; n = 20), or sham docked controls (CON; n = 40) at 3 and 7 weeks of age. At each time, least square means accompanied by subscripts are different at $P < 0.05$.

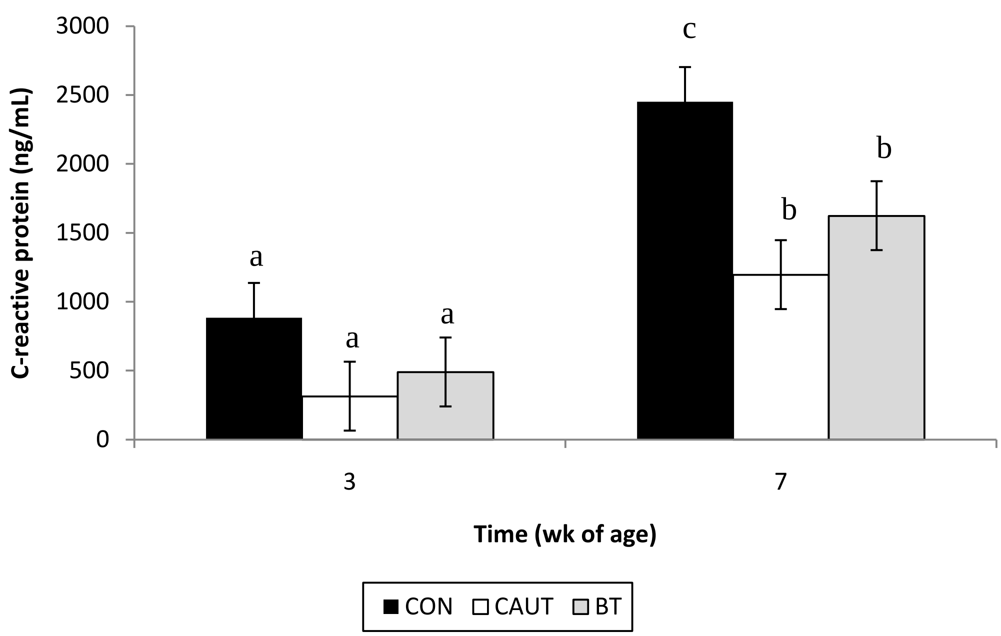

Figure 3. The tail lesion score category 'tail length' for pigs tail docked at 2 cm (Short; n = 40) or 5 cm (Long; n = 40) over time. At each time, least square means accompanied by * are different at $P < 0.05$.

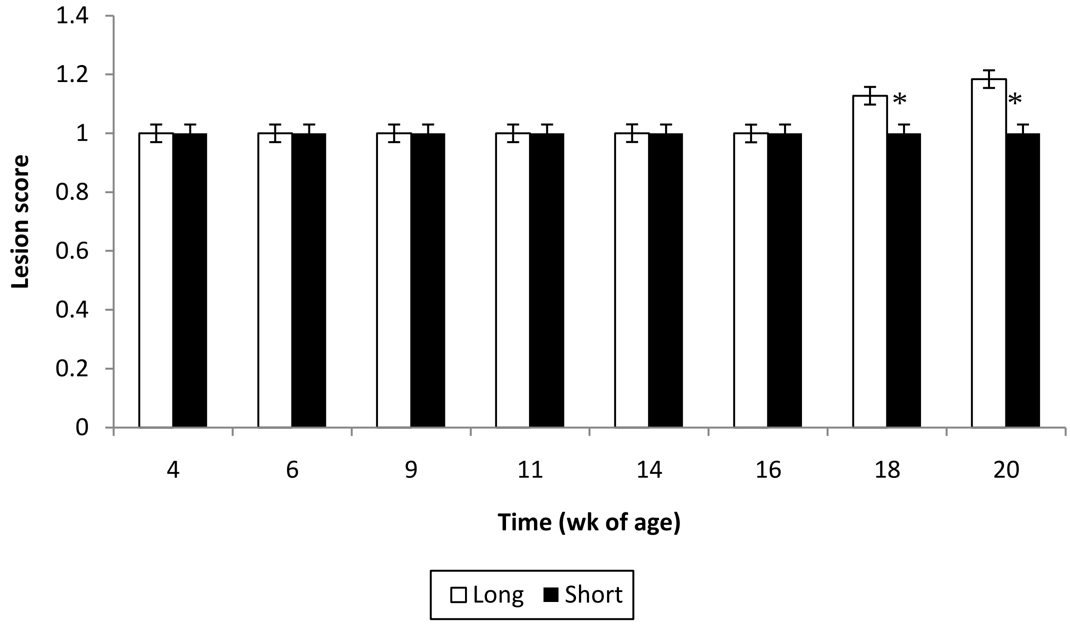

Figure 4. The tail lesion score category 'blood' for pigs tail docked at 2 cm (Short; n = 40) or 5 cm (Long; n = 40) over time. At each time, least square means accompanied by * are different at $P < 0.06$.

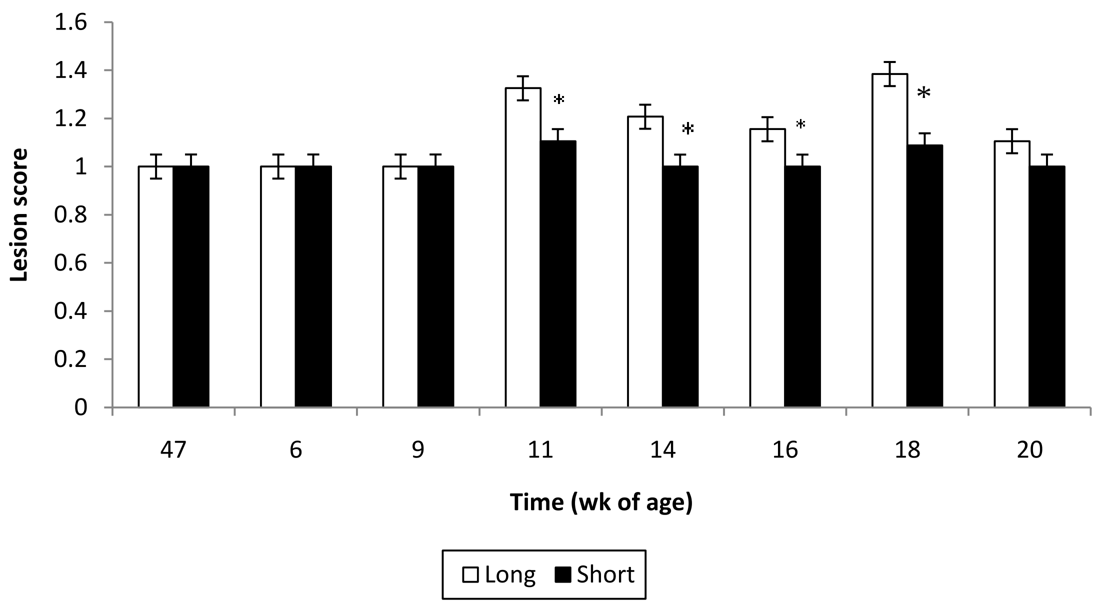

Figure 5. Change in body weight (Kg) in pigs 24 hours after tail docked using conventional cutting (CUT; n = 17), cautery (CAUT; n = 17), conventional cutting while the pig is anesthetized with carbon dioxide (CO2; n = 17), conventional cutting with local anesthetic administered immediately prior to cutting (LA; n = 17), conventional cutting with short acting topical anesthetic administered immediately after cutting (SHORT; n = 17), conventional cutting with long acting topical anesthetic administered immediately after cutting (LONG; n = 17), or sham docked controls (CON; n = 16). Least square means accompanied by subscripts are different at *P* < 0.05.

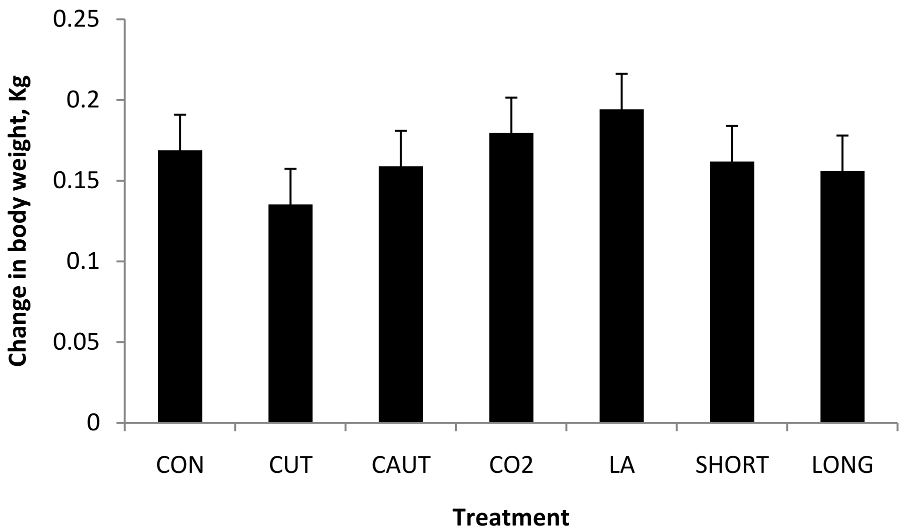

Figure 6. Cortisol concentration of pigs tail docked using conventional cutting (CUT; n = 10), cautery (CAUT; n = 10), or sham docked (CON; n = 10). At each time point, least square means accompanied by a different subscript differs (*p* < 0.05).

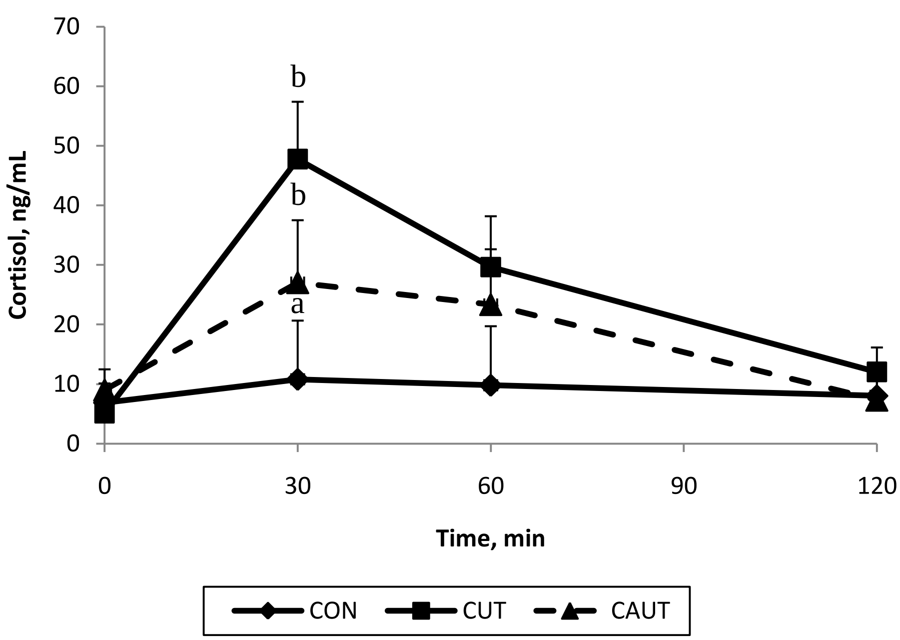

Figure7. Cortisol concentration of pigs tail docked using conventional cutting (CUT; n = 10), conventional cutting while the pig is anesthetized with carbon dioxide (CO2; n = 10), or sham docked (CON; n = 10). At each time point, least square means accompanied by a different subscript differs (*p* < 0.05).

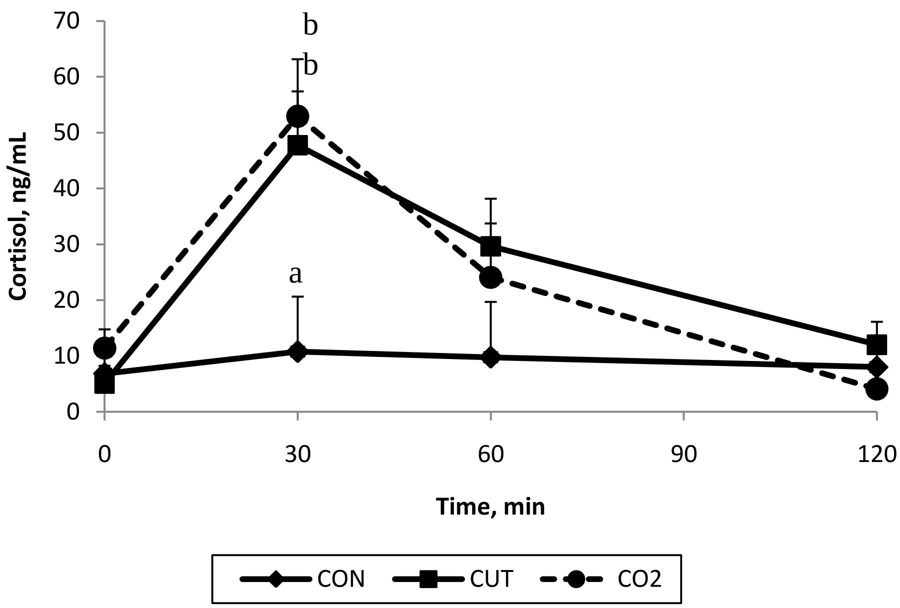

Figure 8. Cortisol concentration of pigs tail docked using conventional cutting (CUT; n = 10), conventional cutting with local anesthetic administered immediately prior to cutting (LA; n = 10), conventional cutting with short acting topical anesthetic administered immediately after cutting (SHORT; n = 10), conventional cutting with long acting topical anesthetic administered immediately after cutting (LONG; n = 10), or sham docked controls (CON; n = 16). At each time point, least square means accompanied by a different subscript differs ($p < 0.05$).