Early intervention with enrichment can prevent tail biting outbreaks in weaner pigs

Lahrmann, HP; Hansen, CF; D'Eath, RB; Busch, ME; Nielsen, JP; Forkman, B

Published in:
Livestock Science

DOI:
10.1016/j.livsci.2018.06.010

First published: 23/06/2018

Elsevier Editorial System(tm) for Livestock Science
Manuscript Draft

Manuscript Number: LIVSCI-D-18-156R1

Title: Early intervention with enrichment can prevent tail biting outbreaks in weaner pigs

Article Type: Research Paper

Keywords: pigs, tail biting, tail damage, enrichment material

Corresponding Author: Miss Helle Pelant Lahrmann, MSc

Corresponding Author's Institution: SEGES,

First Author: Helle Pelant Lahrmann, MSc

Order of Authors: Helle Pelant Lahrmann, MSc; Christian F Hansen, PhD; Rick D'Eath, PhD; Marie E Busch, Med Vet; Jens P Nielsen, DVM, PhD, Dipl. ECPHM; Björn Forkman, PhD

Abstract: Tail biting is a serious animal welfare problem in the modern pig production. A frequently studied preventive measure is enrichment materials, and increasing levels of enrichment materials, especially litter materials, reduces the risk of tail biting. However, permanent access to litter materials, can cause blockage of the slurry system and increase production cost. The aim of the present study was, therefore, to investigate if providing extra enrichment material, when observing the first tail damage could reduce the prevalence of tail biting outbreaks. The study included 1,804 weaner pigs from 7- 30 kg distributed in 60 pens with intact tails. As basic enrichment material, pens were equipped with two wooden sticks and daily provided with approximately 400 g of fine chopped straw. From outside the pen pigs were checked for tail damages three times weekly. When the first tail damage (fresh or scabbed) was recorded, the pen was assigned to one of four treatments; chopped straw (approximately 200 g/pen) on the floor (straw), haylage in a spherical cage (haylage), hanging rope with a sweet block (rope) or no extra material (control). From first treatment day and until a tail biting outbreak, tails were scored three times weekly. A tail biting outbreak occurred when four pigs in a pen had a tail damage, irrespective of wound freshness. The experiment was designed to compare the prevalence of tail biting outbreaks in each of the extra material group with the control group. A treatment was carried out in 44 of the 60 pens: 10 pens with straw, 8 pens with haylage, 7 pens with rope and 19 control pens. The risk of a tail biting outbreak was significantly lower in pens with haylage and straw compared with control pens ($P<0.05$), and there tended to be fewer tail biting outbreaks in rope-pens compared with control pens ($P=0.08$). The results should, though, be interpreted with caution due to the relatively small sample size. In control pens with no intervention, a tail biting outbreak developed in 42 % of the pens within two to five days after the first tail damage was observed, whereas a tail biting outbreak did not occur in 32% of the control pens. In conclusion, a regular tail inspection and the use of extra enrichment material, when the first minor tail damage occur, could be one way to reduce the prevalence of tail biting outbreaks.

Highlights

- Providing extra enrichment as an early intervention reduced tail biting outbreaks
- Tail damage was observed among weaner pigs with intact tails in 58 of 60 pens
- Solitary tail damage did occur without escalating into tail biting outbreaks

Early intervention with enrichment can prevent tail biting outbreaks in weaner pigs

Helle Pelant Lahrmann[1*], Christian Fink Hansen[1], Rick B. D´Eath[2], Marie Erika Busch[1,4], Jens Peter Nielsen[3] and Björn Forkman[3]

[1]SEGES, Danish Pig Research Centre, Axeltorv 3, 1609 Copenhagen V, Denmark; [2]SRUC, West Mains Road, Edinburgh EH9 3JG, UK; [3]Department of Veterinary and Animal Sciences, University of Copenhagen, Grønnegårdsvej 8, 1870 Frederiksberg, Copenhagen, Denmark; [4]Present address; Chr. Hansen Ltd., Bøge Allé 10-12, 2970 Hørsholm, Denmark.

*Corresponding author: Tel.: +45 3339 4933. E-mail address: hla@seges.dk (Helle Pelant Lahrmann)

Short title: Early intervention prevents tail biting outbreak

Highlights

- Providing extra enrichment as an early intervention reduced tail biting outbreaks
- Tail damage was observed among weaner pigs with intact tails in 58 of 60 pens
- Solitary tail damage did occur without escalating into tail biting outbreaks

Abstract

Tail biting is a serious animal welfare problem in the modern pig production. A frequently studied preventive measure is enrichment materials, and increasing levels of enrichment materials, especially litter materials, reduces the risk of tail biting. However, permanent access to litter materials, can cause blockage of the slurry system and increase production cost. The aim of the present study was, therefore, to investigate if providing extra enrichment material, when observing the first tail damage could reduce the prevalence of tail biting outbreaks. The study included 1,804 weaner pigs from 7- 30 kg distributed in 60 pens with intact tails. As basic enrichment material, pens were equipped with two wooden sticks and daily provided with approximately 400 g of fine chopped straw. From outside the pen pigs were checked for tail damages three times weekly. When the first tail damage (fresh or scabbed) was recorded, the pen was assigned to one of four treatments; chopped straw (approximately 200 g/pen) on the floor (straw), haylage in a spherical cage (haylage), hanging rope with a sweet block (rope) or no extra material (control). From first treatment day and until a tail biting outbreak, tails were scored three times weekly. A tail biting outbreak occurred when four pigs in a pen had a tail damage, irrespective of wound freshness. The experiment was designed to compare the prevalence of tail biting outbreaks in each of the extra material group with the control group. A treatment was carried out in 44 of the 60 pens: 10 pens with straw, 8 pens with haylage, 7 pens with rope and 19 control pens. The risk of a tail biting outbreak was significantly lower in pens with haylage and straw compared with control pens ($P<0.05$), and there tended to be fewer tail biting outbreaks in rope-pens compared with control pens ($P=0.08$). The results should, though, be interpreted with caution due to the relatively small sample size. In control pens with no intervention, a tail biting outbreak developed in 42 % of the pens within two to five days after the first tail damage was observed, whereas a tail biting outbreak did not occur in 32% of the control pens. In conclusion, a regular tail inspection and the use of extra enrichment material, when the first minor tail damage occur, could be one way to reduce the prevalence of tail biting outbreaks.

Keywords: pigs, tail biting, tail damage, enrichment material

1. Introduction

Tail biting is a major animal welfare and economic problem, which remains prevalent in modern pig production (D'Eath et al., 2016). To prevent or reduce the level of tail biting, a series of different actions have been implemented. One of the most common preventive measures is tail docking which decreases the risk of tail biting (Lahrmann et al., 2017; Larsen et al., 2017). Tail docking is, however, a controversial solution to the problem since there is ample evidence that the tail docking procedure itself is painful (Herskin et al., 2016), and since the long-term effect is less well documented (Di Giminiani et al., 2017). Although routine tail docking is prohibited in the EU, it is still common (D'Eath et al., 2016). The European Commission is working to decrease the number of tail docked pigs and subsequently has published guidelines to member states on how to reduce routine tail docking by improving housing systems and management routines (EC, 2016). Because of the welfare issue and increased focus on ceasing routine tail docking, it is essential to find alternative solutions to the tail biting problem.

An additional reason for reducing the use of tail docking is that it does not eliminate the underlying problems causing the tail biting behaviour (Sutherland and Tucker, 2011). Although the causation of tail biting is multifactorial and may include insufficient feeding space, poor nutrition, poor health etc. (D'Eath et al., 2014), a large proportion of studies on tail biting have investigated the effect of permanent access to loose enrichment materials in the prevention of tail biting outbreaks (e.g. straw (Zonderland et al., 2008); compost (Beattie et al., 2001); alfalfa hay and corn silage (Veit et al., 2016)). These studies have been conducted as lack of enrichment materials, which increase the risk of tail biting (Schrøder-Petersen and Simonsen, 2001; Taylor et al., 2010). Permanent access to litter materials such as compost and straw, however, has a number of disadvantages for the farmers and will increase production costs due to extra labour and material expenditures (Tuyttens, 2005). A recent survey of Swedish farmers also found that concerns about the perceived inability of the manure system to handle large amounts of straw was the main reason for not using more of it (Wallgren et al., 2016). An alternative may therefore be to give access to a material that does not block the manure system to the same extent as straw, e.g. rope or hay in a rack (D'Eath et al., 2014).

However, even these alternatives may be costly or labour intensive. Another approach could therefore be to give the more-costly, but more attractive, materials only when needed to prevent tail biting. An attractive material, was in a review dealing with pigs' motivation to explore, defined as 'edible', 'changeable', 'destructible' and 'manipulable' (Studnitz et al., 2007). While only providing extra materials in pens where the first minor tail damage is detected may be less preferable than continuous access to the material, it has the advantage of being less costly/manageable for the farmer to handle and therefore may be more likely implemented.

Until recently, tail biting outbreaks have been notoriously difficult to predict. Recent studies have, however, demonstrated that tail postures change from curly to hanging prior to a tail biting outbreak (Zonderland et al., 2009; Lahrmann et al., 2018). Lahrmann et al. (2018), found that the change in tail posture was so pronounced that it would be possible for a farmer to use in daily health monitoring.

To our knowledge, only one previous study has examined the effect of different interventions on tail damaged pigs in pens with a tail biting outbreak (removing the biting pig or giving straw - (Zonderland et al., 2008)). No previous studies have examined provision of extra enrichment material as an early intervention, just when the first minor tail damage is observed, to determine if this can reduce the tail biting behaviour and thereby prevent tail biting outbreaks. The aim of the current experiment was to investigate whether early interventions could prevent tail biting outbreaks in weaner pigs. It was hypothesized that providing straw, haylage in a spherical cage or sisal rope, when the first pig in a pen was observed with a tail damage, would reduce the occurrence of subsequent tail biting outbreaks. Further, we wanted to establish whether less than four weaners (< 14 percentage of the pigs/ pen) with a tail injury was a sign of an upcoming tail biting outbreak within the next two to five days. Finally, we scored tail posture as well as tail injury to establish the relationship between these in the early stages of tail biting outbreaks.

2. Material and methods

Before the study, the Animal Experiments Inspectorate evaluated the research protocol and decided that the study could be conducted in accordance with the guidelines of the Danish Ministry of Justice Act no. 382 (June 10,1987) and Act no. 333 (May 19, 1990), 726 (September 9, 1993) and 1016 (December 12, 2001) with respect to animal experimentation and care of animals under study.

2.1 Experimental design, animals and housing

The study was carried out at a commercial Danish farm from November 2016 to February 2017. The experimental design included four treatments differing in type of enrichment material: straw on the floor (straw), haylage in a ball of metal mesh (haylage), sisal rope with a sweet-tasting block (rope) and control treatment (no intervention). To comply with Danish legislation on permanent access to manipulable and rooting materials, each pen was equipped with two wooden sticks hanging in a chain as manipulable material and dry feed in a dispenser as rooting material.

The experiment was designed to compare the prevalence of tail biting outbreaks in control pens with each treatment where extra enrichment material was added to the pen. The number of control pens was therefore double the number of treatment pens. The treatments were initiated at pen level when at least one pig in a pen was observed with a tail wound. The sequence of the four treatments was randomized at the start of the experiment, and then followed the same order.

The subjects were 1,804 undocked DanAvl crossbred ((Landrace x Large White) x Duroc) weaner pigs (7 to 30 kg) from three farrowing batches with 590 to 617 pigs per batch. Pigs were born in a loose house farrowing system (for pen design see, Pedersen et al. (2015)). Iron injections (Uniferon, Pharmacosmos, Holbæk, Denmark), grinding of the tip of the needle teeth (Tandsliber proff, Hatting, Horsens, Denmark) and surgical castration of male piglets took place on day three or four after birth. Male piglets were given analgesic just before castration (Melovem® 5 mg/ml).

From the piglets were about 14 days old they were offered solid creep feed on the floor. Piglets had access to the straw that the sow pulled from a straw rack. Two days prior to weaning, piglets were ear tagged and their sex noted. According to the piggery's production report, the lactation period was 28.4 days. At this point the pigs were transported to a weaner facility close to the sow unit.

The weaner facility consisted of eight rooms of which three were used in the experiment. Each room had 26 or 30 pens evenly distributed on each side of an inspection aisle, and 20 or 21 pens in each unit were included in the experiment. A total of 60 pens were included in the study. Pens measured 4.85 × 2.18 m (length × width) with 7.1 m^2

solid floor towards the wall and 3.5 m^2 cast iron slatted floor towards the aisle. A 2.16 m^2 adjustable covering was placed above the lying area of the solid floor. Two adjacent pens shared a dry feed dispenser with two nipple drinkers (MaxiMat, Skiold A/S, Sæby, Denmark). In addition, a drinking bowl was placed next to the feed dispenser. Each pen was equipped with two wooden blocks hanging in a chain just above the floor, but without touching the floor. Pens were daily provided with approximately 400 g (one scoop) of fine chopped straw (Easy Strø, Dansk Dyrestimuli, Nykøbing Mors, Denmark) on the solid floor irrespective of treatment.

The ventilation system was based on negative pressure air flow from wall air inlets in one side of the building (SKOV A/S, Glyngøre, Denmark). At piglets' arrival, the room temperature was 24°C which was gradually lowered to 19°C on day 42. Thermostatically controlled floor heating pipes in the lying area led to a floor temperature on arrival of 30°C, which was turned off 14 days later.

Upon arrival at the weaner facility, pigs within batch were sorted by size with 29.6 (SD 0.56) pigs per pen with an average gender distribution within pen of 51% castrated males and 49% gilts (minimum-maximum: 31%-69% castrated males). Three different home-mixed compound diets (ad libitum access) were provided from 7 to 30 kg. The diets were formulated to fulfill the nutritional requirements of pigs of this age and genotype. Phase one diet allocated from 6-10 kg (19.4 % crude protein) consisted of 55.0 % wheat, 22.0 % Danstart 225 Vilomix (Vilomix, Mørke, Denmark), 10.0 % barley, 9.0 % fish meal and 4.0 % soy oil. Phase two diet allocated from 10-15 kg (18.2 % crude protein) consisted of 48.0 % wheat, 25.0 % barley, 14.7 % toasted soy bean, 6.8 % premix of mineral and vitamins (MIN 27600, Vilomix, Mørke, Denmark), 3.0 % fish meal and 2.5 % soy oil. Phase three diet allocated from 15-30 kg (19.0 % crude protein) consisted of 48.8 % wheat, 24.5

% toasted soy bean, 20.0 % barley, 4.5 % premix of mineral and vitamins (MIN 27603, Vilomix, Mørke, Denmark) and 2.2 % soy oil. Shifts in diets were gradually carried out over a 7 or 14 days period, depending on the age of the pigs. The onset of a diet shift depended on the average body weight of pigs in the pen.

A stock person monitored the pigs' health once a day in the morning, and, when needed according to the herd veterinarian recommendations, pigs with clinical signs of disease were treated with antibiotics. Unthrifty animals and pigs with severe tail lesions (more than half the tail missing or swelling as sign of infection) were moved to hospital pens.

2.2 Tail posture at pen level

Three times weekly (Monday, Wednesday and Friday), the number of standing pigs, tail posture and tail damage were recorded from outside the pen according to table 1 until at least one pig were observed with a tail wound. Before recording tail posture, the observer went into the pen, got every pig up, walked outside the pen and did the recordings.

Table 1 about here

2.3 Clinical examination of tails at individual tail scoring

When one pig with either a scabbed wound on a hanging tail, a tucked tail or a fresh wound irrespective of tail posture was observed, all pigs in the pen were tail scored according to the scoring system presented in Lahrmann et al. (2018) (Table 2). A wound was defined as a clear puncture of the skin with tissue damage as in Lahrmann et al (2018) with a severity of at least a 'wound' (Table 2). After tail scoring one of the four treatments, based on a random predetermined order, was allocated to the pen. From the day of the early intervention and until a tail biting outbreak, tails were scored three times weekly. A tail biting outbreak was defined as four pigs with a tail wound irrespective of tail length and wound freshness. The pen left the study if a tail biting outbreak occurred, and extra enrichment material, beyond what was used as treatments, was added to stop the tail biting behaviour.

If a pig was continuously observed chewing/biting the tail of the pen mates during formal inspection, it was removed from the pen and the pen left the study.

Table 2 about here

2.4 Treatments

When one pig (day 0) was observed with a damaged tail or a tucked tail during the three weekly tail scorings, one of four treatments was randomly allocated to the pen; straw, haylage, rope or control (no intervention).

In pens with straw treatment from day 0, approximately 200 g of chopped wheat straw (cut during harvest in the combine harvester) were provided daily during the morning hours on the solid floor (approximately 7 g per pig per day).

In the haylage treatment from day 0, ryegrass haylage was provided in a spherical cage with a diameter of 30 cm (https://heuballferkel.jimdo.com/) made of metal bars hanging in the middle of the pen above the solid floor approximately one meter from the slatted floor. The ball was placed at a height enabling pigs to pull out material from the bottom, and it was gradually lifted as pigs grew. The spherical cage was refilled once daily with approximately 650 g of haylage, and no material was left in the cage the following day.

In the rope treatment, sisal rope (diameter; 20 mm) with a sweet block hung in the same location as the spherical cage. The 650g sweet-tasting block with apple flavor (Likit™, www.likit.co.uk/treats-toys/horse-licks/) was placed on the rope at pig head level. According to the manufacturer, the Likit™ block was composed of glucose syrup, dextrose, ground safflower seed and blue-green algae extract. Rope was pulled through the block leaving 30 cm of rope lying on the floor. To keep the block in place, two round wooden discs were placed beneath and above the block and a knot was tied on the rope on each side of the wooden discs. A coil of rope hung above the pen, and every second day, if no rope was lying on the floor, new rope was pulled from the coil leaving 30 cm on the floor. If pigs consumed the Likit block, a new block was placed on the rope once. If the block was consumed again, no new block was added, but rope was still renewed as described.

In control pens, no new or additional material was provided on the day, when at least one pig in a pen was observed with a tail wound (day 0).

Of the 60 pens included in the study, an early intervention was performed in 44 pens. In these 44 pens, one of four treatments were provided: Straw on floor (10 pens), haylage in a spherical cage (8 pens), rope with a sweet block (7 pens) or no extra material (control, 19 pens). Pens with a tail biting outbreak on the intervention day were not evenly distributed between treatments, giving the inequality in number of pens provided with straw, haylage or rope. The extra material was provided until the pen left the study, either due to a tail biting outbreak (four pigs with a tail wound) or because pigs were moved to the finisher location at approximately 30 kg live weight after 6.5 weeks.

2.5 Statistical analysis

Statistical analyses were performed in SAS Enterprise Guide 7.1 (SAS Institute Inc., Cary, NC, USA) using Generalised Linear Mixed Model procedure (GLIMMIX) with a significance level of P<0.05 and pen as the experimental unit.

In the statistical model analysing for differences in prevalence of tail biting outbreaks (binomial distribution) the control group was compared to each treatment (straw, haylage or rope). Treatment and age at intervention were included as fixed effects and batch as random term.

At pen level, the correlation between percentage of hanging tails and tail damaged pigs recorded on the same day at the first five recordings after the intervention day (day 0) was analysed using GLIMMIX. To ensure homogeneity of variance, the variable number of tail damaged tails was square root transformed. Recording day after intervention and age at intervention were included as systematic effects, whereas pen was included as a random effect. Data presenting the correlation between hanging tails and tail damage had the best fit to a curve based on quadratic equation. The correlation between numbers of tail damaged pigs in pens with 0, 10, 20, 30 and 40 percentage hanging tails was estimated and is presented in Figure 1. Results are presented as back-transformed least square means including 95% confidence limits.

3. Results

In total 44 out of the 60 pens entering the study was included in the analysis. In two pens, no tail injured pigs were observed through the study period. The distribution of tail scores on the day of the early intervention is listed in Table 3. In 14 pens, there was a tail biting outbreak (four or more pigs with a tail damage) on the intervention day, and an early intervention could therefore not be conducted in these pens. In the 44 pens with an early intervention, 1.7 pigs per pen (SD 0.74, range 1-3 pigs) had a tail damage on the day of the intervention. The first tail damaged pig in a pen was observed on average 13 days (SD 10.2, range 2 - 42 days) after weaning. During the experimental period from 7 - 30 kg, no pigs had to be removed to a hospital pen due to tail biting. In pens with a tail biting outbreak, the biting behaviour was ceased either by giving extra enrichment material or by removing the biting pig. A biter was removed from one control pen ten days after the first pig was observed with tail damage. No pigs, neither victims nor biters, had to be removed due to tail damage in pens with an early intervention.

Table 3 about here

3.1 Early intervention and tail biting outbreaks

A tail biting outbreak developed in one pen with haylage, in two rope pens and two straw pens (five pens in total), Table 4. The risk of a tail biting outbreak was significantly lower in pens with haylage and straw compared with control pens ($P<0.05$). There tended to be fewer tail biting outbreaks in rope pens compared with control pens ($P=0.08$).

Table 4 about here

In total, a tail biting outbreak developed in 18 pens (Table 5), and in 62% of the control pens with outbreaks, the outbreak developed within two to five days after the first pig/pigs with tail wounds were recorded.

Table 5 about here

3.2 Tail posture and tail damage

At pen level, the number of pigs with tail damage was positively correlated with the number of pigs with a hanging tails ($F_{1,195}$= 7.97; P<0.01) (Figure 1). Significantly more pigs had a damaged tail in pens with 20, 30 and 40% hanging tails compared with pens with 0% and 10% hanging tails.

Figure 1 about here

4. Discussion

To our knowledge, this is the first study to investigate the effect of allocating extra enrichment material after the first tail damage is observed to try to prevent a tail biting outbreak. Providing the enrichment material as an early intervention, just when the biting has started, ensures high novelty of the material, which increases attractiveness (Studnitz et al., 2007). Using manipulable materials as an early intervention measure instead of as a permanent preventive measure might increase the materials effect on tail biting due to increased attractiveness. This may further imply that less material or other kinds of materials can prevent tail biting outbreaks when used as an early intervention measure but not when used as a permanent preventive measure. However, the results should be interpreted with some caution because it was a minor study.

In previous studies, permanent access to various amount of straw has demonstrated to reduce the risk of a tail biting outbreak (20 g/weaner pig on the floor and 5 g/weaner pig in a straw rack (Zonderland et al., 2008), 150 g/finisher pig (Larsen et al., 2017) and deep straw (5 cm) (Van de Weerd et al., 2006). In a review by D'Eath et al. (2014), different amounts of straw were ranked according to its relative preventive effect. Based on comparison of relatively few studies, this ranking suggests that small or larger amounts of straw seemed to prevent tail biting to almost the same extent. However, this ranking may be influenced by different definitions of tail biting across studies. In the present study a small amount of chopped straw, allocated daily just when the biting started, reduced the prevalence of tail biting outbreaks. A reason for this positive effect could be that the current environment and the possibility to explore influenced the development in tail biting behaviour to a greater extent, than earlier experiences with enrichment materials, as discussed by Van de Weerd et al. (2005) Additionally, and based on a minor study, Zonderland et al. (2008) reported that a small amount of straw provided twice daily stopped the biting in outbreak pens to the same extent as removing the biter.

Giving haylage in an elevated spherical cage probably increased the time the material was present in the pen compared to giving it on the floor. The material disappeared less rapidly through the slat openings, and probably this allocation method also increased the time pigs spent interacting with the material (pulling it out of the cage and exploring/chewing the material on the floor) (D'Eath et al., 2014). Earlier findings reported that straw in a rack reduced damaged tails to a greater extent than unchangeable materials (Van de Weerd et al., 2006; Zonderland et al., 2008), but straw in a rack was ranked lower across studies compared to straw on the floor (D'Eath et al., 2014). However, the accessibility of material (rack design) and the material presented in the rack probably influences the preventive effect on tail biting.

Sisal rope with a sweet-tasting lick block hanging in the middle of the pen did not reduce the risk of a tail biting outbreak compared to control pens. However, the result should be interpreted with caution as it was a minor study. In a review, ranking the attractiveness of enrichment materials, rope was ranked lower than straw (Studnitz et al., 2007). This could explain rope's non-significant effect on tail biting. Our casual observations suggested that the time pigs spent interacting with the material (not recorded) was spent on exploring the rope, rather than licking the sweet taste block, even though pigs do have a preference for sweet taste (Day et al., 1996). The preventive effect of the rope might have been improved if the rope itself had had a sweet taste, thereby combining sweet taste with a destructible material.

A common slurry system is the vacuum based system where the slurry is sucked out through pipes. In these systems, larger amount of litter material can block up the system as discussed by D'Eath et al. (2014). In the current study, intervention treatments were maintained until pigs were moved to the finisher facility. Causal observations indicate that, in pens with haylage, the slat openings near the solid floor were blocked, and the farmer had difficulties getting the material sucked through the slurry pipes. From a practical point of view it would, therefore, be relevant in future studies to investigate for how long the material should be present to put a stop to the tail biting behaviour. However, removing the material might redirect pigs' behaviour and trigger the tail biting behaviour to start again (Munsterhjelm et al., 2009).

Research indicates that upcoming tail biting outbreaks can be predicted based on changes in tail posture from curly to hanging (Zonderland et al., 2009; Lahrmann et al., 2018). Our results support these findings. We found that an increase in hanging tails was correlated with increasing number of damaged tails. However, the correlation was only evident when 20% or more of the tails were hanging at pen level. No difference in number of tail damaged pigs was observed in pens with pigs with 10% and 0% hanging tails. This is in agreement with Lahrmann et al. (2018), reporting approximately 15% hanging tails in pens not close to a tail biting outbreak. Overall, this indicate that other elements aside from tail biting also affect tail posture as discussed by Larsen et al. (2016).

Of the 60 pens entering the study, 14 pens had to be excluded (23%). In these pens, on the day when the first pig was observed with a tail damage, at least four pigs had a tail wound (tail biting outbreak definition). No severe outbreaks developed between the three weekly recording days, but we did miss the beginning of the tail biting behaviour in some pens. To detect tail damages, as an indicator of tail biting behaviour, just when it has started, tails should be checked at least once a day.

In control pens with no intervention, the development in tail damage was recorded until a tail biting outbreak. In 42% of the control pens (8 pens), a tail biting outbreak occurred within two to five days after the first pig was observed with a tail damage. In contrast, a tail biting outbreak did not develop during the study period in 32% of the control pens (6 pens). In comparison, the transition from one tail damaged pig to a tail biting outbreak was between half a week and 12 weeks in a finisher study (Statham et al., 2009), while in a weaner study the transition from bite marks to a tail wound was in average 7.5 days (SD 5.4 days) with a large variation between pigs (Zonderland et al., 2008). The transition time from one tail damage to a tail biting outbreak probably depends on the definition of a tail biting outbreak. In the present study, the definition of a tail biting outbreak was four tail damaged pigs (14 % of the pigs/pen) irrespective of the freshness of the wound. In Zonderland et al. (2008), at least two pigs (20% of the pigs/pen) should have tail damage with one being a fresh wound. In Statham et al. (2009), they distinguished between underlying outbreaks (signs of tail biting observed during formal inspection) and severe outbreaks (blood in pen and severe damage on at least two pigs, 6.7% of the pigs/pen). However, the variation in transition time from one tail damaged pig to a tail biting outbreak indicates that a solitary tail damage does not always develop into a tail biting outbreak. This is supported by a study, reporting that in 43% of the pens with tail damaged pigs, one pig was observed with a tail wound without further escalation of the tail biting behaviour into a tail biting outbreak (Zonderland et al., 2008).

Time spent getting every pig up and observe damaged tails from outside the pen was not monitored. However, it is estimated that it took one to two minutes per pen including writing down tail posture and tail injury as reported in Lahrmann et al. (2018). If tails were to be checked in this way during the daily health monitoring, it would, in addition to the time spent providing extra material, take roughly 30 to 60 seconds per pen.

5. Conclusion

An early intervention with provision of a small amount of straw on the floor or haylage in a spherical metal mesh cage reduced the risk of tail biting outbreak compared to control pens with no intervention. In comparison, the use of rope with a sweet block as an early intervention did not reduce tail biting outbreaks significantly compared to pens with no intervention. The results should, however, be interpreted with some caution due to the relatively small sample size.

In control pens with no intervention, a tail biting outbreak developed in 42% of the pens within two to five days after the first tail damage was observed. In 32% of the control pens a tail biting outbreak never occurred. This indicates that tail biting behaviour did not, in every case, escalate from one tail damaged pig into a tail biting outbreak.

Even though this was a small study, the results suggest that tail biting outbreaks can in many cases be prevented by giving the pigs access to extra enrichment material, when the first minor tail damage is noticed. Therefore, a thorough regular inspection of tails and the use of early interventions could be one way to reduce the prevalence of tail biting outbreaks and by it the need for tail docking.

Funding

This work was supported by The Danish Pig Levy Foundation and Innovation Fund Denmark. The work of SRUC was supported by the Rural and Environment Science and Analytical Services Division of the Scottish Government.

Acknowledgements

The authors would like to acknowledge pig producer Niels Aage Arve and staff for making his herd available to the study. Further, we would like to thank Hans Peter Thomsen, SEGES for technical assistance and Mai Britt Friis Nielsen, SEGES for statistical help.

References

Beattie, V.E., Sneddon, I.A., Walker, N., Weatherup, R.N., 2001. Environmental enrichment of intensive pig housing using spent mushroom compost. Animal Science 72, 35-42.

D'Eath, R.B., Arnott, G., Turner, S.P., Jensen, T., Lahrmann, H.P., Busch, M.E., Niemi, J.K., Lawrence, A.B., Sandoe, P., 2014. Injurious tail biting in pigs: how can it be controlled in existing systems without tail docking? Animal 8, 1479-1497.

D'Eath, R.B., Niemi, J.K., Ahmadi Vosough, B., Rutherford, K.M.D., Ison, S.H., Turner, S.P., Anker, H.T., Jensen, T., Busch, M.E., Jensen, K.K., Lawrence, A.B., Sandøe, P., 2016. Why are most EU pigs tail docked? Economic and ethical analysis of four pig housing and management scenarios in the light of EU legislation and animal welfare outcomes. Animal 10, 687-699.

Day, J.E.L., Kyriazakis, I., Lawrence, A.B., 1996. An investigation into the causation of chewing behaviour in growing pigs: the role of exploration and feeding motivation. Applied Animal Behaviour Science 48, 47-59.

Di Giminiani, P., Edwards, S.A., Malcolm, E.M., Leach, M.C., Herskin, M.S., Sandercock, D.A., 2017. Characterization of short- and long-term mechanical sensitisation following surgical tail amputation in pigs. Scientific Reports 7, 4827.

EC, 2016. Commission staff working document on best practices with a view to the prevention of routine tail-docking and the provision of enrichment materials to pigs. European Commission, https://ec.europa.eu/food/sites/food/files/animals/docs/aw_practice_farm_pigs_stfwrkdoc_en.pdf.

Herskin, M.S., Di Giminiani, P., Thodberg, K., 2016. Effects of administration of a local anaesthetic and/or an NSAID and of docking length on the behaviour of piglets during 5 h after tail docking. Research in Veterinary Science 108, 60-67.

Lahrmann, H.P., Busch, M.E., D'Eath, R.B., Forkman, B., Hansen, C.F., 2017. More tail lesions among undocked than tail docked pigs in a conventional herd. Animal 11, 1825-1831.

Lahrmann, H.P., Hansen, C.F., D'Eath, R., Busch, M.E., Forkman, B., 2018. Tail posture predicts tail biting outbreaks at pen level in weaner pigs. Applied Animal Behaviour Science 200, 29-35.

Larsen, M.L.V., Andersen, H.M.-L., Pedersen, L.J., 2016. Can tail damage outbreaks in the pig be predicted by behavioural change? The Veterinary Journal 209, 50-56.

Larsen, M.L.V., Andersen, H.M.-L., Pedersen, L.J., 2017. Which is the most preventive measure against tail damage in finisher pigs: Tail docking, straw provision or lowered stocking density? Animal 2, 1-8.

Munsterhjelm, C., Peltoniemi, O.A.T., Heinonen, M., Hälli, O., Karhapää, M., Valros, A., 2009. Experience of moderate bedding affects behaviour of growing pigs. Applied Animal Behaviour Science 118, 42-53.

Schrøder-Petersen, D.L., Simonsen, H.B., 2001. Tail Biting in Pigs. The Veterinary Journal 162, 196-210.

Statham, P., Green, L., Bichard, M., Mendl, M., 2009. Predicting tail-biting from behaviour of pigs prior to outbreaks. Applied Animal Behaviour Science 121, 157-164.

Studnitz, M., Jensen, M.B., Pedersen, L.J., 2007. Why do pigs root and in what will they root? A review on the exploratory behaviour of pigs in relation to environmental enrichment. Applied Animal Behaviour Science 107, 183-197.

Sutherland, M.A., Tucker, C.B., 2011. The long and short of it: A review of tail docking in farm animals. Applied Animal Behaviour Science 135, 179-191.

Taylor, N.R., Main, D.C.J., Mendl, M., Edwards, S.A., 2010. Tail-biting: A new perspective. The Veterinary Journal 186, 137-147.

Tuyttens, F.A.M., 2005. The importance of straw for pig and cattle welfare: A review. Applied Animal Behaviour Science 92, 261-282.

Van de Weerd, H.A., Docking, C.M., Day, J.E.L., Breuer, K., Edwards, S.A., 2006. Effects of species-relevant environmental enrichment on the behaviour and productivity of finishing pigs. Applied Animal Behaviour Science 99, 230-247.

Van de Weerd, H.A., Docking, C.M., Day, J.E.L., Edwards, S.A., 2005. The development of harmful social behaviour in pigs with intact tails and different enrichment backgrounds in two housing systems. Animal Science 80, 289-298.

Veit, C., Traulsen, I., Hasler, M., Tölle, K.-H., Burfeind, O., Beilage, E.g., Krieter, J., 2016. Influence of raw material on the occurrence of tail-biting in undocked pigs. Livestock Science 191, 125-131.

Wallgren, T., Westin, R., Gunnarsson, S., 2016. A survey of straw use and tail biting in Swedish pig farms rearing undocked pigs. Acta Veterinaria Scandinavica 58, 84.

Zonderland, J.J., van Riel, J.W., Bracke, M.B.M., Kemp, B., den Hartog, L.A., Spoolder, H.A.M., 2009. Tail posture predicts tail damage among weaned piglets. Applied Animal Behaviour Science 121, 165-170.

Zonderland, J.J., Wolthuis-Fillerup, M., Reenen, C.G.V., Bracke, M.B.M., Kemp, B., den Hartog, L.A., Spoolder, H.A.M., 2008. Prevention and treatment of tail biting in weaned piglets. Applied Animal Behaviour Science 110, 269-281.

Table 1 Tail posture and tail damage

Tail posture/ tail damage	Description
Tail posture	
Curly	Tail is up and curly
Hanging	Tail is down and hanging relaxed alongside the rear end of the pig
Tucked	Tail is down and pressed against the rear end of the pig
Hanging tails – tail condition[1]	
Intact tail	Hanging tail with no visible change in colour as a sign of a tail wound
Scabbed wound on tail end	The tail end is black and covered with a scabbed wound
Bleeding tails	
Bleeding wound	Tails with a fresh wound irrespective of tail posture

[1] Tail condition was only scored on hanging tails. Scoring the tail condition (wound or not) on tucked tails from outside the pen was not possible.

Table 2 Tail injury scoring system used in the present study and in Lahrmann et al. (2018)

Tail scoring	Description
Damage severity	
No	No visible tail lesions. Earlier lesion is healed
Minor scratches	Minor superficial scratches
Wound	Visible wound and tissue damage
Wound – tail end will fall of	The outer part of the tail has almost been bitten off. During healing tail tip will fall off
Wound freshness	
Intact scab	The wound is covered with a hard-dry scab
Not intact scab	The wound is covered with a scab, but cracks in the scab and dried blood/ fresh tissue are visible
Fresh wound – weeping	Skin is broken, no scab, no blood – only weeping
Fresh wound – bleeding	Fresh lesion and fresh blood are visible
Tail length	
Intact	Full length tail
Outer part is missing	The outer part of the tail is missing
More than half is missing	More than half of the tail is missing
< 1 cm left of the tail	Less than 1 cm of the tail is left
Swelling	
No	No swelling
Yes	Swollen red tail indicating an infection

Table 3 Tail damage frequency and distribution (%), broken down by damage to intact tails, and damage when part of the tail is missing on day 0 (day of early intervention) in 58 pens.

Tail score	Early intervention day	
	No.	%
No tail injury	1,534	89.4
Intact length and...		
Scratches, intact scab	10	0.6
Scratches, scab not intact	1	0.06
Scratches, fresh/ bleeding	5	0.3
Wound, intact scab	109	6.4
Wound, scab not intact	12	0.7
Fresh wound, not bleeding	5	0.3
Fresh wound, bleeding	38	2.2
Outer part of tail is missing and…		
Wound, intact scab	0	0
Wound, scab not intact	1	0.06
Fresh wound, not bleeding	1	0.06
Fresh wound, bleeding	0	0
Intact, outer part of tail will fall off	0	0
Total*	1,716	100

* Some pigs were moved to hospital pens or euthanized between weaning and day 0

Table 4 The number of pens with an early intervention, the number of pens with a tail biting outbreak and the average number of tail damaged pigs per pen on the intervention day (day 0) and on the day of the tail biting outbreak (SE).

	Intervention				**P-value**		
	Control	Straw	Haylage	Rope	C x S	C x H	C x R
Number of pens, n	19	10	8	7	-	-	-
Tail damaged pigs, day 0	1.7 (0.73)	1.5 (0.71)	1.4 (0.52)	2.1 (0.9)	0.22	0.45	0.46
Pens with tail biting outbreak, n	13	2	1	2	-	-	-
Pens with tail biting outbreak, % of pens[1]	73 (18.3)	15 (14.6)	8.9 (10.9)	28 (23.8)	<0.05	<0.05	0.08
Tail damaged pigs per pen on the day of the outbreak, n	7.4 (6.0)	15.5 (14.9)	4.0	4.5 (0.7)	-	-	-

[1] The P-value in the overall F-test of differences between interventions was 0.03 (F=3.48). Data is presented as LS-means.

Table 5. Tail biting outbreaks at pen level within group. Listed according to days after intervention.

	Tail biting outbreak, day after intervention					
Intervention	2-3	4-5	6-7	8-10	>10	Total
Straw		1			1	2
Haylage	1					1
Rope		2				2
Control	6	2	1	1	3	13

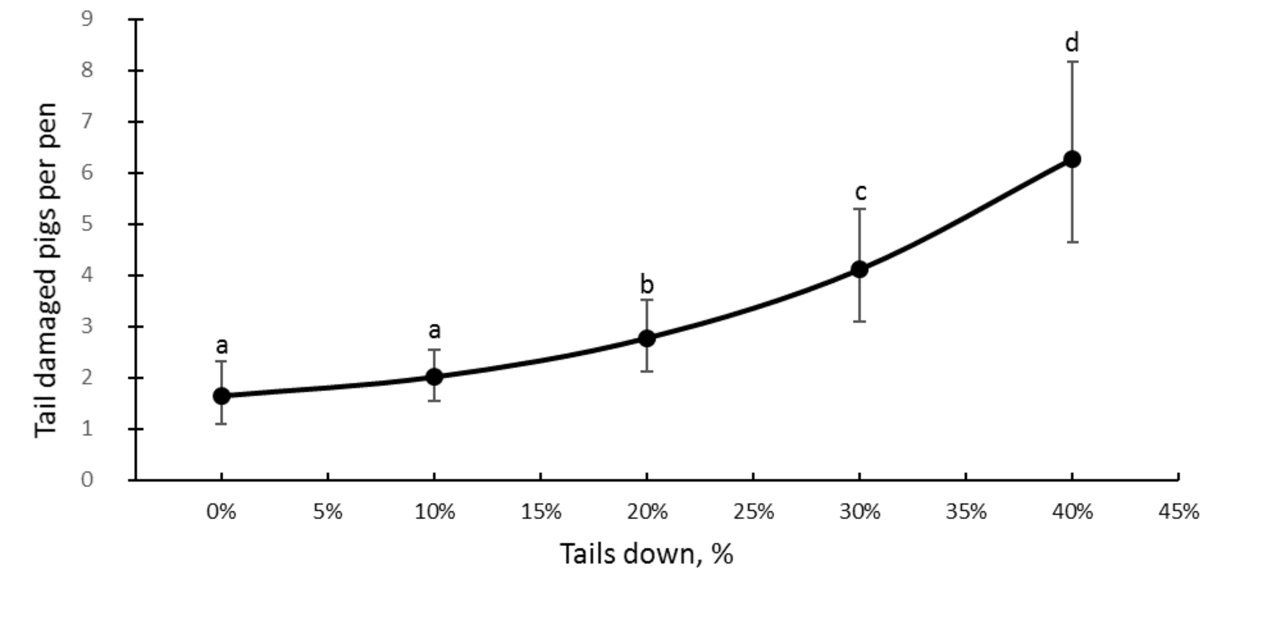

Figure 1 Plot of the percentage of tails down (back-transformed least square means) against the average number of tail damaged pigs per pen within the first ten days after intervention (n=255). Different superscripts indicate significant difference of P<0.001.

***Conflict of Interest Statement**

AUTHOR DECLARATION TEMPLATE

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

We further confirm that any aspect of the work covered in this manuscript that has involved either experimental animals or human patients has been conducted with the ethical approval of all relevant bodies and that such approvals are acknowledged within the manuscript.

We understand that the Corresponding Author is the sole contact for the Editorial process (including Editorial Manager and direct communications with the office). She is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs. We confirm that we have provided a current, correct email address which is accessible by the Corresponding Author and which has been configured to accept email from: hla@seges.dk

Signed by all authors as follows:

7/2 2018

Date, signature

7.2.2018

Date, signature

Date, signature

7/2-18

Date, signature

7/2-2018

Date, signature

7/2-18

Date, signature

Figure

Click here to download Figure: Figure_1_tail_posture_tail_damage_paper_24012018.xlsx