Early indicators of tail biting outbreaks in pigs

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Wedin et al Early Indicators of Tail biting – Highlights

- Tail biting in pigs is unpredictable so early indicators could help farmers
- Behaviour of tail biting vs no tail biting groups observed for 1 week pre-outbreak
- Outbreak groups had fewer curly tails and more tucked tails
- Activity pre-outbreak was no different in outbreak groups
- Day and time of day had little or no effect on these findings

Early Indicators of Tail Biting Outbreaks in Pigs

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Abstract

Tail biting outbreaks in pig farming cause suffering through pain and stress, and producers lose revenue due to carcass condemnation. Reliable behavioural indications of when an outbreak is imminent would provide farmers with tools for mitigating the outbreak in advance. This study investigated changes in body and tail posture in the 7 days pre-outbreak.

Pigs in 15 groups with a mean (± s.d.) group size of 27.5 (± 2.6; 427 in total) were raised from birth under intensive commercial conditions and with tails intact. Twice daily inspections were made, and a tail biting outbreak was identified (and treated) if 3 or more pigs had fresh tail injuries, or any pig was seen with a freshly bleeding tail or vigorously biting a tail. Video footage was recorded continuously to allow pre-outbreak behaviour recording of body posture (lying laterally, lying ventrally, sitting, standing) and tail posture (curled or uncurled (high, low, tucked)). Pigs were not individually marked, thus observations were made at pen level by group scan sampling 12 times per day on day -1, -3, -5 and -7 pre-outbreak. Each outbreak group was paired with a non-outbreak group of the same age and kept at the facility at the same time which served as a control. A total of 12 pairs were used. Outbreak pigs had fewer curled tails ($P = 0.013$) and more uncurled ($P = 0.008$) and tucked tails ($P < 0.001$) than control pigs overall, but particularly on day -1. Outbreak groups had more tucked tails compared to control on day -7 ($P = 0.001$). Tail posture did not vary over days, or with time of day. Body posture was not different between outbreak and control groups, and although it was affected by time of day, there was no interaction between outbreak vs. control condition and day, or time of day. Synchrony of behaviour between pigs (more pigs in the pen showing the same body posture) was not reduced in outbreak groups. In conclusion, this study supports other recent findings showing that an increase in tucked tails, and reduced curled tails is an advance indicator of a tail biting outbreak giving at least 7 days warning, and it does not matter what time of day tails are observed. Pig farmers could take note of tail posture changes to identify high risk pens. Considerable variability between pens, and in the timing and magnitude of change means that technology to automate tail posture detection will be of benefit.

Keywords

Tail biting, Tail damage, Tail posture, Activity, Indicators, Intact tails

1. Introduction

Tail biting can be defined as a pig chewing or biting another pig's tail . The problem first came to the attention of the scientific community in the late 1960's, and was believed to be a result of intensification, and the earliest studies identified that it had more than one cause (Van Putten 1969; Ewbank 1973). More recent reviews and studies confirm that there are multifactorial risk factors, although inability of the pig to perform explorative and foraging behaviour is a key element (Schrøder-Petersen & Simonsen, 2001, EFSA, 2007, Taylor et al 2010, D'Eath et al 2014, Valros & Heinonen 2015; Scollo et al., 2017). The recipient of tail biting can suffer from pain, stress and morbidity (Kritas & Morrison, 2007; Schrøder-Petersen & Simonsen, 2001), which in turn can result in reduced growth rate (Wallgren & Lindahl, 1996), condemnation of the carcass at slaughter (Kritas & Morrison, 2007; Marques et al., 2012), and if left untreated, death (Fritchen & Hogg, 1983). Thus, there are direct impacts on both the welfare of the pig and the revenue of the producer.

Prevalence of tail biting varies between farms and countries (Taylor et al., 2010), but an estimated 3 % of tail docked pigs, and around 6-10 % of non-docked pigs, bear lesions from tail biting at time of slaughter (EFSA, 2007), although these figures are likely to be under-estimates of the true on-farm prevalence (Lahrmann et al., 2017).

Not all pigs within a pen receive damaging tail biting (Zonderland et al., 2011a), but tail biting is an indication that welfare is low in the pen as a whole, as it is an expression of poor welfare (Fritchen & Hogg, 1983). Enrichments, such as provision of rooting material (Beattie et al., 2001) and/or manipulative objects such as logs (Petersen et al., 1995) or (some) toys (Bracke et al., 2006) can reduce the tail biting outbreak, as can the removal of the biter and potentially also the victim pig(s) (Zonderland et al., 2008). However, these methods are costly, and as producers lack predictability of when an outbreak is approaching (EFSA, 2007), action is usually taken only once the outbreak is underway. As pigs are omnivores, the presence of blood during an outbreak encourages further biting from both the primary biter and other pen-mates which can escalate the problem (Fraser, 1987) and make it more difficult to stop (Schrøder-Petersen & Simonsen, 2001).

To prevent an outbreak, tail docking, which reduces, but does not fully inhibit the occurrence of tail biting, is performed to a large extent within the EU (Sutherland et al., 2009; Nannoni et al., 2014, Valros & Heinonen 2015). This procedure constitutes a mutilation, and should according to legislation only be used as a last resort, after both space requirement and enrichment has been addressed (European Commission, 2008). Nonetheless, the vast majority of EU pigs are tail docked, as producers see no other viable method to mitigate the problem (EFSA, 2007). A method to alert the producer to an imminent outbreak would allow for preventive treatment and potentially stop the outbreak from occurring.

Two recent papers have reviewed the evidence that tail biting could be predicted before an outbreak using change in behaviour (D'Eath et al., 2014, Larsen et al., 2016). There is evidence that increased activity (Statham et al., 2009; Zonderland et al., 2011b; But see Lahrmann et al., 2018a) and lowered tail posture (Statham et al., 2009; Zonderland et al., 2009; Paoli et al., 2016; Lahrmann et al., 2018a; Larsen, 2018) could be used as predictors of tail biting outbreaks. It has also been suggested that changes in the timing or nature of activity rather than in the total amount of activity might be characteristic of tail biting. For example, Statham (2008) found some evidence for increased activity at night before tail biting outbreaks, while Larsen (2018) found that activity in the afternoon was higher pre-outbreak in biting groups compared to non-biting control groups. Zonderland et al (2011b) found that 'restlessness' indicated by the frequency of posture changes increased before tail biting, and diverse environmental stressors such as draughts, disturbance and changed feed have been associated with increased tail biting risk, perhaps because they result in restlessness and irritability (Taylor et al., 2010). Another potential characteristic of behavioural disturbance and restlessness is a loss of synchrony of behaviour. In a normal pen, pigs often eat, engage in social and exploratory activities and then rest more or less as a group.

To investigate potential behavioural 'early warning signs' of tail biting, the present study examined five hypotheses in the week preceding a tail biting outbreak by comparing outbreak and paired contemporary non-outbreak (control) pens: H1) Outbreak pigs show lowered tail posture H2) Activity increases in outbreak groups H3) Low tail posture and/or activity increase over time as an outbreak draws closer in outbreak groups H4) Activity and/or tail posture vary with the time of day differently in outbreak groups H5) Synchrony of behaviour between pigs is reduced in outbreak groups.

2. Materials and Methods

This study was part of a larger project working to discover early indications of impending outbreaks of tail biting in pigs, with the aim to create a technological solution capable of automatically alerting farmers to risk pens on farm (D'Eath et al., 2018).

2.1 Ethical Approval

This study was conducted under Home Office licence and has been reviewed and approved by SRUC's Ethics Committee (ED-AE-27-2016). Steps taken to reduce suffering to pigs are described in detail in D'Eath et al. (2018), but in brief, housing pigs with intact tails under commercial stocking density, fully slatted floors and reduced enrichment was done to increase the risk of tail biting for this study (in order to have some tail biting to study). This was considered a regulated procedure under the Animals and Scientific Procedures Act 1986 by the UK Home Office. Pigs were checked and tails inspected at least twice a day. Sick or injured pigs were immediately given appropriate veterinary treatment in pen or were removed to hospital pens to aid recovery, or were humanely euthanized. As soon as a tail biting outbreak was observed (see criteria under behavioural observations below), the biter (if known) was removed, injured pigs were either treated in pen or removed to hospital pens for treatment if necessary, and enrichment was added to the pen (shredded paper, additional toys and chews – wooden blocks, plastic balls).

2.2 Animals and Husbandry

The study was conducted at SRUC's pig research unit near Edinburgh, Scotland, between November of 2016 and July of 2017. Pigs of both genders (Large White × Landrace × Hampshire) were born and raised at the research facility with tails left intact. Every two weeks, three groups of approximately 30 pigs each (mean ± s.d. = 27.5 ± 2.6) were weaned, resulting in 15 groups divided into five batches (427 pigs in total). Weaning occurred at 4-5 weeks of age and the piglets were ear-tagged for ID, sorted by size (small, medium and large) and reared under intensive commercial conditions in a flat-deck pen with fully slatted floor (2.5 m × 2.5

m). Each group was moved without mixing to a grower pen (3.4 m × 3.7 m) and a finisher pen (3.6 m × 3.8 m) at approximately 9 and 12-13 weeks of age, respectively. Room temperature was maintained at 30 °C for the first few days after weaning before being gradually reduced to 24 °C prior to the pigs being moved to the grower pens. TinyTags recorded temperature and humidity (TinyTag Ultra 2, Gemini Data Loggers, UK). Artificial lighting was operated on a 8h light:16h dark schedule (0700 – 1600h), but the grower rooms had natural ventilation which let in daylight. Throughout the experiment the pigs were inspected at least twice daily and had *ad libitum* access to water and feed. Feed was provided in a communal trough with a commercial grower diet (For Farmers HiGro). Basic enrichment in the form of one flavoured porcichew (East Riding Farm Services ltd., East Yorkshire, UK) per pen was provided. If a tail biting outbreak occurred, protocols were immediately followed to safeguard pig welfare and stop the outbreak (see ethical approval above).

2.3 Inspecting pigs to identify tail biting outbreaks

Twice daily inspections of all pigs were made by experienced stockworkers or technical staff. An outbreak, deemed day 0, was declared when at least 3 pigs had a fresh tail wound (defined as a non-bleeding but weeping or bloodied fresh wound), or at least one pig had a fresh wound dripping with blood, or if obvious tail biting behaviour which was causing tail damage was seen. In addition, each pig's tail was scored manually by trained staff three times per week according to a set protocol incorporating tail damage, wound freshness, tail length and swelling. The results of this are reported elsewhere (D'Eath et al 2018).

2.4 Behavioural Observations

Each pen was equipped with two 2D video cameras ("Gamut Professional" Sony Effio Bullet CCTV Camera (Gamut, Open 24 seven Ltd., Bristol, UK)) mounted in the ceiling; one capturing the entire pen and one capturing the feeding area as the exposed tails during feeding made this area a high-risk zone. Cameras were positioned directly above the pen (approximately

2.2 m) as an angled camera would increase the risk of pigs obscuring each other's tails and thereby reduce the amount of recorded tails per scan. The two cameras recorded continuously 24 hours per day and data were stored on a CCTV system (GeoVision software, GeoVisionUK, Hert, UK).

When an outbreak was declared, the outbreak group was paired with a corresponding control group from the same batch that had not had a tail biting outbreak, meaning that the control group was of the same age and had been in the facility for the same length of time. Day 0 was set for outbreak and control groups as being the day the outbreak was first identified according to the criteria above. One control group experienced an outbreak 11 days later, and one outbreak group had a second outbreak 21 days later, with both outbreaks being used in the present study. Furthermore, one control group was used as a control 35 days after having experienced an outbreak. Control groups were, when needed, used as control for both of the other groups in their batch. Therefore, the total number of outbreak – control pairs was 12.

By using video footage from the week preceding the outbreak, the behaviours for both the outbreak and control group were recorded for body postures and tail postures according to an ethogram (Table1). Observation was done by a single observer who was blinded to treatment. Pigs had ID eartags, but were not marked to make them individually identifiable on video. The assessed days were day -1, -3, -5 and -7 pre-outbreak. Observation was done through a freeze frame group scan the first second of every hour during lights on (7:00, 8:00, 9:00, 10:00, 11:00, 12:00, 13:00, 14:00 and 15:00) and once every fourth hour during lights off (3:00, 19:00 and 23:00). All visible pigs and pig tails were recorded. The video footage could be played to ease recognition if posture was not directly recognisable but only the posture displayed at the freeze frame time point was recorded. For each pen the observer used the camera that provided the highest amounts of reliable data, meaning that, depending on the quality of the camera angles, either one or both cameras in a pen were used for the behavioural scoring.

2.5 Statistical Analysis

As recording was done on pen level, pen was the statistical unit, with n = 1074 scan samples completed. Four days from each of Outbreak and Control, 12 pairs of groups, 12 scan samples a day = 1152. Seventy-eight scans were not completed due to missing video recordings or where scans were discarded due to staff being in the pen with the pigs. Occasions with less than five tails visible (n = 470) were deleted before analysis of tail posture, to avoid a small number of visible pigs leading to more extreme proportion rates, resulting in 604 registered recordings of tail posture. Mean number of pigs visible in a pen was 24.25, with a range of 10 to 31, and mean number of tails visible was 11.64, with a range of 5 to 27, after recordings with fewer than 5 tails had been removed from the dataset. The 12 recordings per day were divided into the categories Morning (7:00, 8:00 and 9:00), Late morning (10:00, 11:00 and 12:00), Afternoon (13:00, 14:00 and 15:00) and Night (3:00 am, 19:00 pm and 23:00 pm).

Data were plotted and inspected before analysis to identify trends. As part of this, data from the group which was experiencing a second outbreak, and control groups which had had an earlier outbreak, or would go on to have an outbreak (see 2.4 Behavioural Observations) were examined, and found to be typical. Statistical analyses were performed using Genstat 11. GLMM (Generalised Linear Mixed Model) of frequency of body postures were modelled as a binomial out of the pigs visible at that scan, while frequency of tail postures were modelled as a binomial of pigs with visible tails. Logit transformations were applied as part of the modelling. Models included the following random effects: group pair ID, outbreak or control group within pair and day. Fixed effects included treatment (outbreak or control) , days (-7,-5,-3,-1), time of day (morning, late morning, afternoon, night) and all interactions of these. Inclusion of treatment in the models allowed H1 and H2 concerning differences in tail posture and activity between outbreak and control groups to be addressed. The inclusion of day, and day*outbreak vs. control treatment interactions in models enabled H3, concerning changes over time (and treatment-dependent changes over time) in tail posture and activity to be addressed. The inclusion of time of day and time of day*treatment interactions enabled H4 concerning time of day effects on tail posture and behaviour to be addressed.

To investigate H5, than synchrony of behaviour varies between outbreak and control pens, we calculated 'MaxPosture' the maximum number of pigs at each scan sample which were all showing the same body posture (sit, stand, lying ventrally or lying laterally), and used this in GLMM analysis using the models described above (using binomial modelling with the total visible pigs as the denominator). In a situation of perfect synchrony, all pigs would be showing the exact same posture as each other in a scan, so the value of MaxPosture, expressed as a proportion of all visible pigs would be 1, while a value as low as 0.25 would indicate the most behavioural asynchrony- an equal number of pigs in each of the four different body postures.

Means for the proportion of body and tail postures reported in graphs and tables were derived from the raw data (mean ± standard error mean; M ± SEM), while F- and p-values were calculated through modelling. Differences between each treatment and each day, as well as the interactions of treatment*day, were examined through the use of LSD tests on predicted means generated by modelling. Results are reported for $p < 0.05$.

3. Results

3.1 Tail Posture

There was a significant effect of treatment on tail posture, with outbreak groups displaying fewer tails curled than control groups ($F_{1, 10.9} = 8.92$, $p = 0.013$; Figure 1a). Post hoc tests (LSD) indicated that outbreak pigs showed a lower occurrence of curled tails than control pigs on day -1 ($p < 0.05$). There was no effect of day or time of day on the number of curled tails, and no interactions.

The proportion of uncurled tails displayed was affected by treatment, with outbreak pigs showing more uncurled tails than control pigs ($F_{1, 10.9} = 10.26$, $p = 0.008$; Figure 1b). Post hoc tests (LSD) showed that there was a significant difference between treatments on day -1 ($p < 0.05$). There was no effect of day or time of day on the number of uncurled tails, and no interactions.

Tail tucking was significantly affected by treatment ($F_{1, 10.4} = 18.34$, $p = 0.001$; Figure 1c) and day ($F_{3, 52.5} = 4.98$, $p = 0.004$), with outbreak pigs showing a higher proportion of tucking than control pigs, and more tucked tails were seen on day -1 than on day -7 ($p < 0.05$). Post hoc testing revealed that outbreak pigs exhibited more tucked tails than control pigs on days -7 and -1 ($p < 0.05$, Figure 1c). There was no effect of time of day on the number of tucked tails, and no interactions. There was no effect of treatment or day on the proportion of high loose or low loose tails, although there was a significant time of day effect on high loose tails which were observed more at night and less in the morning ($F_{3,531.3} = 3.73$, $p<0.011$).

3.2 Body Posture

There were no differences in body posture between control and outbreak groups (Figure 2), and there were no interactions between control vs. outbreak and any other explanatory variable. Sitting and lying laterally increased over the 4 observed days (Sitting, $F_{3,54.8} = 7.38$, $p < 0.001$; Lying laterally, $F_{3,69.6} = 3.02$, $p = 0.035$), while lying ventrally reduced ($F_{3,61.3} = 2.97$, $p = 0.039$). Time of day also affected all body postures (Lying lateral $F_{3,968.4} = 171.63$, $p < 0.001$; lying ventral $F_{3,965.8} = 6.79$, $p <0.001$; sitting $F_{3,976.6} = 33.34$, $p < 0.001$, standing $F_{3,965} = 103.87$, $p < 0.001$). Lateral lying was highest at night and lowest in the afternoon, while sitting and standing were lowest at night and highest in the morning. There were also significant day*time of day interactions for standing and lying ventrally.

Synchrony of behaviour (MaxPosture) did not differ between outbreak and control groups, and there were no interactions between outbreak vs. control treatment and day, or time of day. There was a significant main effect of the time of day, with the lowest values of MaxPosture occurring at night ($F_{3,966.8} = 11.13$, $p < 0.001$; Back-transformed predicted means, Morning, 0.5796; Late Morning, 0.6083; Afternoon, 0.5860; Night, 0.5397). This was unexpected, but appears to be because pigs are either lying laterally or ventrally at night (which count as different postures), while standing (one posture) is more frequent during the day.

4. Discussion

4.1 Tail Posture

In support of H1, outbreak groups did show altered tail posture, with fewer curled tails and more uncurled and tucked tails than control groups. This was significant over the entire study period, but was most evident on the day before an outbreak. This is in line with a number of other similar reported findings. Zonderland et al. (2009) and Larsen (2018) found that tail tucking in an individual pig meant a greater likelihood of tail damage in that pig 2-3 days later. At the pen level, Lahrmann et al. (2018a) found that outbreak pens had more hanging/tucked tails than control pens in the last 3 days pre-outbreak, while Statham et al. (2009) found that pens that would later go on to exhibit a tail biting outbreak (later than 11 weeks of age) showed more tail tucking at 7 and 11 weeks of age than non-outbreak pens. Finally, in a related study from this programme of work and in a population consisting of some of the same outbreak groups as those used here, an automated algorithm was used to measure tail posture from 3D camera data and found that the proportion of low or tucked tails detected were greater in outbreak than in control groups, increased over time pre-outbreak and were positively correlated with tail injury (D'Eath et al., 2018).

Tucked tails increased closer in time to outbreaks, but surprisingly there was no interaction between control vs. outbreak and day, suggesting that change over days was not affected by control vs. outbreak condition. We had expected (H3) a control vs. outbreak*day interaction to show that control groups remained the same while changes over time took place in the outbreak groups as the outbreak grew nearer. The graphs in figures 1-3 visually suggest that the lack of an effect that we found might be because there are already differences in the tail metrics between control and outbreak groups on day -7, and that any further divergences are small. For tucked tail (figure 3) this impression can be supported by the post-hoc statistics which show that a significant difference in the proportion of tucked tails between outbreak and control groups is present already on day -7. Video analysis going further back pre-outbreak than day -7 would be needed to identify the point at which tail tucking begins to diverge between control and outbreak groups, and might reveal the expected interaction over a longer period of time. These findings are similar to those of Larsen (2018) who found no increase in lowered tails over the last 3 days pre-outbreak, and suggested that a longer period of study was necessary to find out when the difference begins. The study of D'Eath et al. (2018) did go further back, and using a machine-vision algorithm to detect low tails, found a greater proportion of low tails during week -1 than in week -2 pre-outbreak.

The present findings also showed that the changes in tail posture were not affected by the time of day (H4). This either means that the cause of tail posture change (presumably pre-injurious tail-directed behaviours from pen-mates) remain constantly present, or have a sufficiently long lasting effect. If lowered tail posture was a brief and transient response to tail-directed behaviour, then we might have expected to see greater differences in tail posture in outbreak pigs during the most active periods of the day, and a decline when pigs were relatively inactive.

In the present study, fewer curled tails (and more uncurled tails) in the outbreak groups than in the control groups were also seen during the week pre-outbreak. Previous reports have found that the proportion of curled tails in a pen is reduced during an outbreak (McGlone et al., 1990; Statham et al., 2009) and that tail tucking is higher during the days leading up to the outbreak (defined as blood seen from outside of the pen; Statham et al., 2009). It would be feasible that this behaviour begins pre-outbreak, as victim pigs are exposed to an increased amount of tail directed behaviours the days leading up to an outbreak, such as tail bites (Statham et al., 2009; Zonderland et al., 2011a) and non-damaging 'tail in mouth' behaviour (Fraser, 1987; Schrøder-Petersen & Simonsen, 2001). This tail directed manipulation might lead to pigs not curling their tails if they are trying to protect them from being bitten by other pigs (McGlone et al., 1990). The findings in the present study therefore indicate that tail posture, in the form of curled, uncurled and tucked, show potential for being used as predictors of tail biting outbreaks.

However, tail biting outbreaks are complex, and each outbreak is slightly different from other outbreaks (Statham et al., 2009; Ursinus et al., 2014). It would therefore be beneficial to repeat a study like ours under different husbandry conditions and with pigs of different breeds, to see if the results produced in the present study are applicable to pigs housed under other conditions. Tail biting is more likely to occur under intensive housing conditions (Beattie et al., 1996) and it would therefore be interesting to see if the tail postures that here were found to be significant would be applicable as tail biting indicators in more enriched environments as well. Furthermore, building on the present study, future research should also look into if the tail postures used in this study can predict outbreaks even earlier than seven days pre-outbreak.

4.2 Body Posture

In the present study, no body posture was significantly different between outbreak and control groups (H2), and there was also no interaction between outbreak vs. control and day, which would have picked up different time trends between outbreak and control, such as an increase in activity over days in outbreak but not control groups (H3). Also we did not find evidence for differences in body posture between outbreak and control groups dependent on the time of day (e.g. an increase in active behaviours such as standing during the night; H4).

Body postures were analysed as simple frequencies here, to avoid the problem of how to categorise intermediate postures into a single metric. We assume that standing, sitting, ventrally lying and laterally lying in that order represent a continuum from active to inactive. Some recent studies have shown the potential of activity as a reliable predictor of tail biting outbreaks. Statham et al. (2009) found that outbreak groups had a higher proportion of standing and a lower proportion of sitting and lying inactive as early as four days pre-outbreak, compared to control groups. However, there were no differences between treatment during observations at week 7 and 11 (all outbreaks occurred after the observations in week 11; Statham et al., 2009).

Zonderland et al. (2011b) studied behaviour in outbreak pens pre-outbreak by studying the behaviour of the biter, the victim and a control pig (performing and receiving an 'average' amount of biting within the pen) in each pen. They found that within the pen, the biter showed a tendency to sit more than the control, and that victim pigs tended to change posture more often than controls (Zonderland et al., 2011b). Overall, over the six days leading up to a tail biting outbreak, there was a decrease in ventral lying and an increase in sitting/kneeling but no effect was found on standing or lateral lying (Zonderland et al., 2011b). It is interesting that Zonderland et al. (2011b) found outbreak groups performing sitting more than controls, as Statham et al. (2009) found a decrease in this behaviour during the days leading up to an outbreak.

Ursinus et al. (2014) found that walking and fighting during week 4-7 increased the risk of tail damage at week 16-23, while inactivity at week 4-7 reduced the risk of tail biting at week 8-15. They concluded that a higher general activity level (a combination of multiple behaviours) was associated with increased level of tail damage/ tail biting later on in the pen (Ursinus et al., 2014). It has been proposed that the increased level of activity could stem from a decreased amount of resting (Statham et al., 2009) or an increased level of restlessness pre-outbreak, as indicated by the increased amounts of posture change seen in Zonderland et al. (2011b).

The above mentioned studies found a positive correlation between activity and tail biting behaviours or tail biting outbreaks, and it is therefore interesting that there were no such results in the present study. In the present study, the pen had a fully slatted floor, while in Statham et al. (2009) the flooring was solid and covered with litter (straw or wood shavings). This could in part explain the differing results, as provision of straw reduces tail biting behaviour (Beattie et al., 1996). Furthermore, the present study used 12 pairs of outbreaks and controls, while Statham et al. (2009) used six, although Statham et al. (2009) had more observations per day as they recorded the behaviours hourly for four days, compared to the present with 12 times per day for five days. The lower frequency of night-time scans in the present study could also have contributed to the differing results, as pigs show a diurnal rhythm in behaviour (Andersen et al., 2008). The behaviours Ursinus et al. (2014) found significant differences for indicated increased activity, but they were not the same behaviours that the present study looked into, and Ursinus et al. (2014) compared different time periods to each other while the present study only spanned over seven days. Regarding Zonderland et al. (2011b), they observed differences between individuals within an outbreak pen, which makes comparisons to the present study difficult as it investigated differences between control and outbreak groups. The lack of similarities with previous studies is therefore not a problem, but rather an addition to the growing scientific knowledge of how pig behaviour changes prior to a tail biting outbreak.

Furthermore, not all studies have found changes in body posture pre-outbreak. Zonderland et al. (2003) did not find any increase in activity in the days leading up to an outbreak, and a recent study by Lahrmann et al. (2018a) also failed to find any pre-outbreak difference in activity between tail biting outbreak and control groups.

The final analysis of body posture involved a metric aimed at capturing the degree of synchrony between groups, by recording the maximum number of pigs all showing the same body posture (H5). There was no evidence that synchrony differed between outbreak and control groups, and there were no interactions between outbreak vs. control and either day or time of day. So we found no evidence that outbreak groups were less synchronised in their behaviour, or that synchrony changed over days or with time of day in different ways in outbreak and control groups.

4.3 Implications

Our results suggest that an increase in tucked tails and a reduction in curled tails have potential as early warning signs of tail biting. However, the magnitude of these changes (a difference of around 15% in the rate of curled vs. uncurled; and a change from around 5% to 15-20% tucked) may mean that it is difficult for pig caretakers to detect them based on daily visual inspections.

An automated system to detect changed tail posture in advance of tail biting (as proposed by Sonoda et al., 2013; Larsen et al., 2016 and D'Eath et al., 2018) still faces a number of practical challenges. For example, the frequency of tail posture change that indicates that an outbreak is underway, differs between pens (Statham et al., 2009; D'Eath et al., 2018), which means that warning would need to be relative to that pen's normal baseline rather than an absolute threshold. The extent to which factors other than tail biting can also influence tail posture is still poorly understood (Groffen, 2012). In the future though, it is likely that an increased amount of welfare and health-related measurements will become automated (Matthews et al., 2016).

The earlier a potential outbreak pen could be predicted, the easier it would be for the animal caretaker to stop the outbreak from ever occurring (Fraser, 1987; Schrøder-Petersen & Simonsen, 2001). This could be done through providing enrichment such as straw (Beattie et al., 1996) or rooting material (Beattie et al., 2001). Lahrmann et al. (2018b) have recently shown that it is possible to successfully mitigate/prevent severe tail biting by introducing enrichment in response to early warning signs (minor tail injury). Zonderland & Zonderland-Thomassen (2016) suggested that a system to automatically detect tail biting should be combined with a mechanism to automatically provide the pigs with enrichment to stop the tail biting.

5. Conclusion

Outbreak groups showed fewer curled tails and more uncurled and tucked tails compared to control groups, and within the outbreak groups there were more tucked tails on day -1 than on day -7 pre-outbreak. This indicates that tail posture has the potential to be used as an early warning indicator of a tail biting outbreak, which could either be directly observed on-farm or by means of automatic recording (D'Eath et al., 2018). If early warning is used to guide targeted intervention such as additional enrichment (Lahrmann et al., 2018b), this could lead to a reduction in damaging tail biting outbreaks, thus improving pig welfare and production.

Conflicts of interest

None

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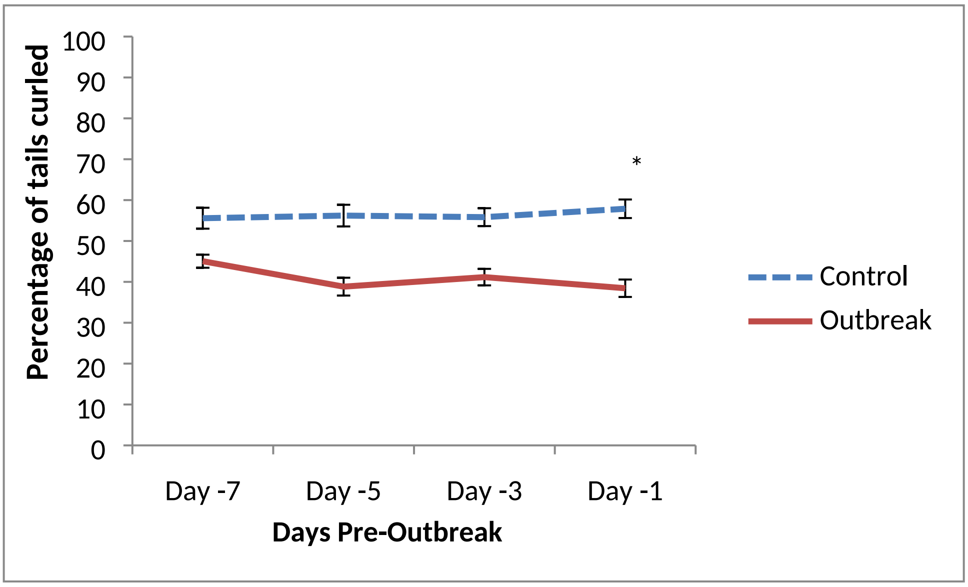
Table headings

Table 1 Ethogram of body and tail postures

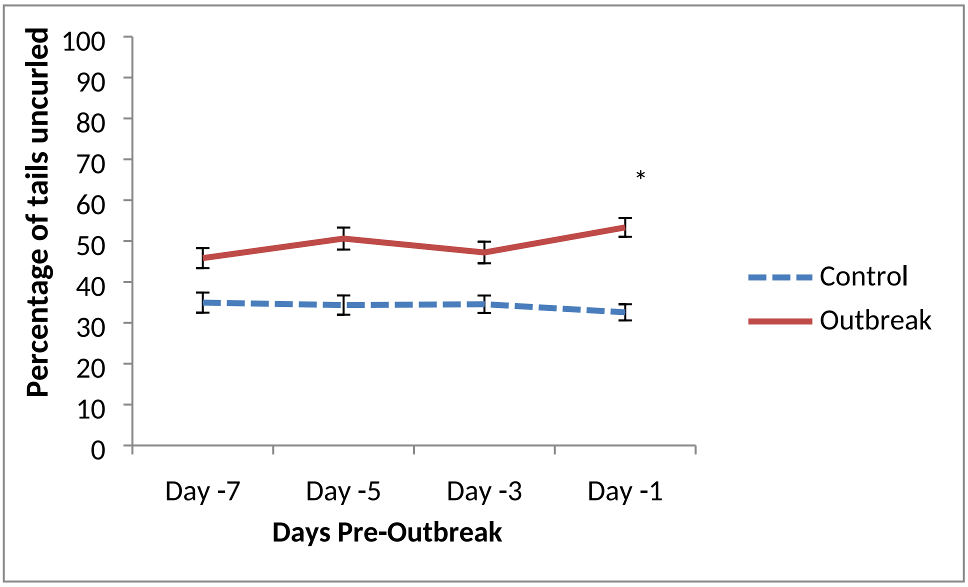
Figure Captions

Figure 1. Mean percentage of curled (a), uncurled (b) and tucked (c) tails observed during the week leading up to a tail biting outbreak. Means (± SEM) displayed are from raw data. An asterix indicates significant differences between control and outbreak groups on that day ($P < 0.05$) derived from Post-hoc LSD tests after GLMM modelling. $N = 604$.

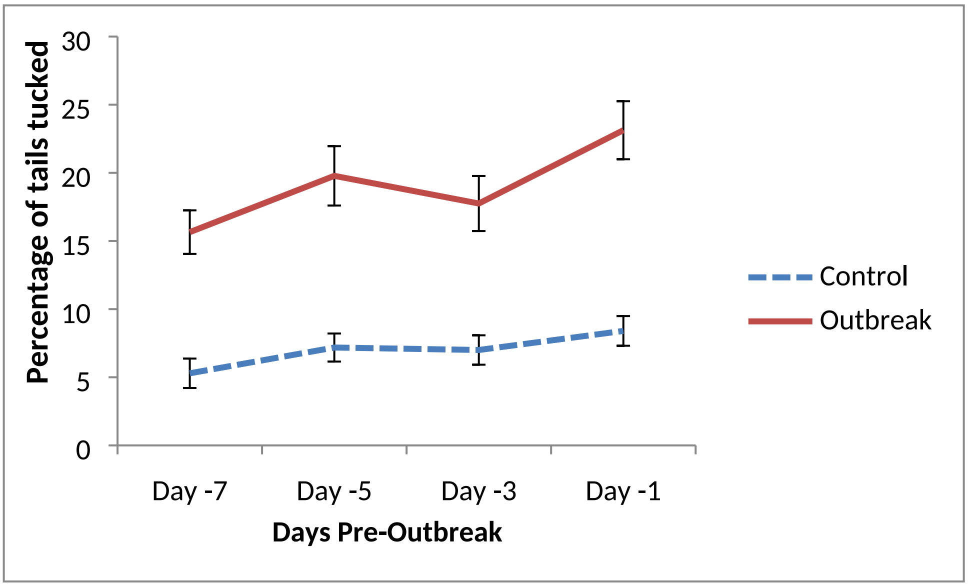
Figure 2. Mean percentage of pigs from outbreak (O) or control (C) groups observed standing (Stand), sitting (Sit), ventral lying (Ven Lie) or lateral lying (Lat Lie) during the week leading up to a tail biting outbreak. Means (± SEM) displayed are from raw data. There were no significant differences between the outbreak or control groups.


Percentage of tails curled
100
90
80
70
60
50
40
30
20
10
0
*
Day -7
Day -5
Day -3
Day -1
Days Pre-Outbreak
Control
Outbreak

a)


Percentage of tails uncurled
100
90
80
70
60
50
40
30
20
10
0
*
Day -7
Day -5
Day -3
Day -1
Days Pre-Outbreak
Control
Outbreak

b)



c)

Figure 1. Mean percentage of (a) curled, (b) uncurled and (c) tucked tails observed during the week leading up to a tail biting outbreak. Means (± SEM) displayed are from raw data. An asterix indicates significant differences between control and outbreak groups on that day ($P < 0.05$) derived from Post-hoc LSD tests after GLMM modelling. N = 604.

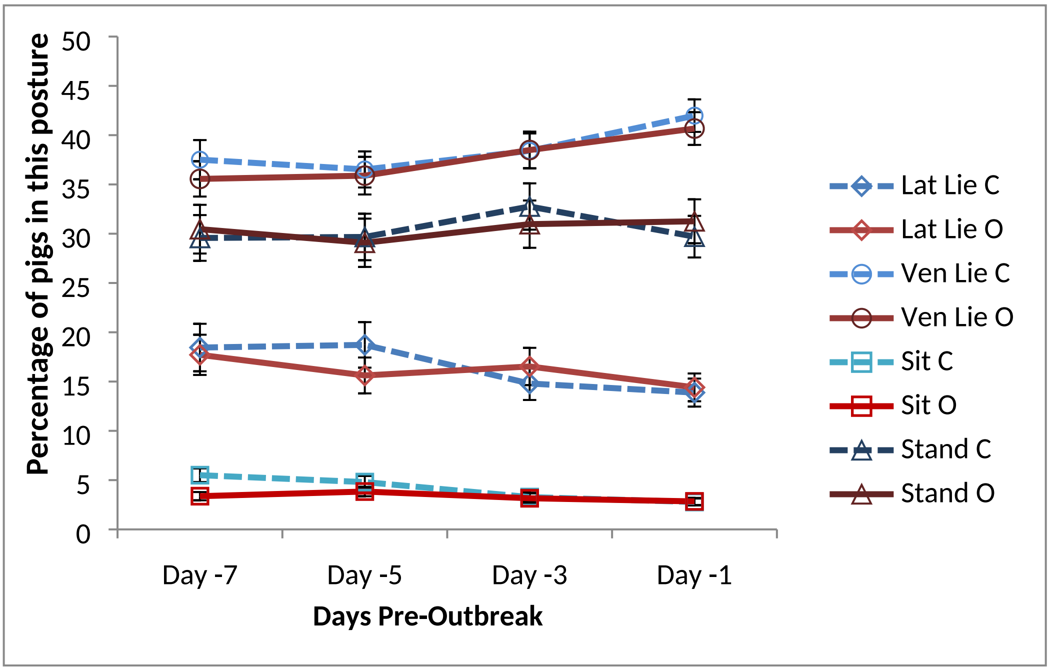


Figure 2. Mean percentage of pigs from outbreak (O) or control (C) groups observed standing (Stand), sitting (Sit), ventral lying (Ven Lie) or lateral lying (Lat Lie) during the week leading up to a tail biting outbreak. Means (± SEM) displayed are from raw data. There were no significant differences between the outbreak or control groups.

Table 1 Ethogram of body and tail postures.

Type of posture	Posture	Sub-posture	Description
Body	Lying laterally	n/a	The animal is lying on its side, with one shoulder having contact with the floor
Body	Lying ventrally	n/a	The animal is lying on its sternum, with shoulder not touching the floor
Body	Sitting/ kneeling	n/a	The body is supported by two bent back legs while the front legs are straight, or, the body is supported by two bent front legs while the back legs are straight
Body	Standing	n/a	The body is supported by four straight legs
Body	Unknown		Body posture cannot be established
Tail	Curled	n/a	The tail forms a loop
Tail	Uncurled		The tail does not form a loop
Tail		High loose	The tail does not form a loop and is held more than 45 degrees away from the buttocks of the pig
Tail		Low loose	The tail does not form a loop and is held less than 45 degrees away from the buttocks of the pig but is not tucked
Tail		Tucked	The tail does not form a loop and is tucked between the buttocks of the pig
Tail	Unknown	n/a	Tail posture cannot be established