CAUSES AND PREVENTION OF TAIL BITING IN GROWING PIGS: A REVIEW OF RECENT RESEARCH

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INTRODUCTION

The problem of tail biting has probably been around for as long as pigs have been raised indoors. A recent review of the literature cites mention of the problem going back as far as 1896 but reports of tail-biting first appeared in veterinary journals in the 1940's (Schroder-Petersen and Simonsen, 2001). While the causes and "remedies" for tail biting are often discussed in veterinary texts, journals and practical husbandry guides, there really have been very few studies that have systematically investigated the development of tail biting or its underlying behavioural mechanisms. This is probably due to the very nature of tail biting - outbreaks are sporadic and unpredictable- which makes it very difficult to study in a research setting. Consequently, many of our accepted notions for why it occurs, and the measures that can be taken to prevent or alleviate tail biting are based on conventional wisdom or speculation. When tracing back some of these notions through the literature one finds that certain "facts" about the behaviour are based on observations made of a single case study.

Tail-biting has been attributed to a variety of perplexing factors including dietary deficiencies, crowding, poor air quality, uncomfortable environmental temperature (too hot and too cold), lack of bedding or other rootable substrate, floor type, feeding method, insufficient water supply, stray voltage, neon strip lighting, parasite infestation and breed type (Sambraus, 1985; Smith and Penny, 1986). It is considered to be multi-factorial in that some combination of factors is required to set off an outbreak of tail biting. One advisory report by Aherne and Deen (1998) listed over 30 dietary and management adjustments suggested as "cures" for tail biting but noted that the condition can recede spontaneously so that a treatment that seemingly works on one occasion may not work on another.

By far the most common preventative measure for tail biting is the docking of pigs' tails. While this practice does appear to significantly reduce the prevalence of tail biting it certainly does not eliminate the problem. A recent review citing data obtained from European abattoirs suggests that the frequency of pigs diagnosed with bitten tails is increasing (Schroder-Petersen and Simonsen, 2001). Routine procedures such as tail docking are also coming under scrutiny because of animal welfare concerns. In the UK, for example, producers are no longer allowed to routinely dock the tails of pigs without written permission from a veterinarian. These trends are stimulating new research in the area of tail biting in an effort to identify the causes and determine other preventative measures. The objective of this paper is to review some of the approaches that are used to study tail biting and to summarize the results of recent scientific investigations into its causation.

APPROACHES TO STUDYING TAIL BITING

Surveys of abattoirs and farms

A number of studies conducted in the UK have used data from slaughter plants to determine the prevalence and severity of bitten tails and any associations with factors such as gender, season of the year, docking or other carcass damage such as bitten ears. A related approach uses survey questionnaires sent to producers with questions aimed at identifying farm level associations between farm management practices and the occurrence of tail biting. These studies provide a broad picture of the prevalence of the behavior problem and give an indication of some factors associated with it, however, they do not tell us exactly how these factors can cause a pig to chew and bite on their pen-mates' tails. Behavioural studies investigating pigs' motivation for chewing or biting on pen-mates provide additional understanding of how and why the behaviour occurs and insight into how it might be prevented.

Behavioural studies to determine causation

A few early attempts to induce tail biting experimentally were unsuccessful. Therefore, many behavioural studies usually do not involve incidents of tail biting, per se, but instead examine the underlying motivation for chewing, biting or attraction to blood or other stimuli.

When studying animal motivation, behavioural scientists consider how the combination of internal factors and external stimuli interact to cause an animal to perform a particular behaviour at a particular time. Internal factors might include such things as an animal's genetic predisposition to engage in certain types of behaviour, hormone levels, physiological changes or emotional states such as fear or frustration. External stimuli include visual, olfactory (odour) or taste cues that animals find attractive (or repulsive) leading them to direct behaviour at particular objects in their environment. The animal's housing environment and management practices can alter both the internal states and external stimuli that motivate behaviour. For a complete understanding of why an animal performs a particular behaviour, scientists attempt to identify what the various motivational factors are and their relative importance in stimulating behaviour.

David Fraser (1987a, 1987b) was one of the first investigators to examine factors that may lead to tail biting in this way. He classified the tail-biting behaviour occurring in two stages. The first stage is the pre-injury stage before any wound on the tail is present. This stage might involve normal exploratory behaviour and mutual chewing or biting on pen-mates bodies that can lead to injury. The second stage occurs after a tail becomes injured and is bleeding. In this second stage both the behaviour of the recipient and the wounded tail result in very different external stimuli, which can cause the behaviour to escalate.

Fraser developed a model to study pigs' tendencies to chew using a cotton braid rope that could be soaked in blood or other substances. Other investigators have adopted Fraser's tail-model to study various factors that may lead to tail biting. But is chewing at a rope tail model really predictive of tail biting behaviour? Breuer et al. (2000) recently investigated whether

the use of a rope chew test was valid measure of pigs' tendencies to direct harmful behaviour at pen-mates. They subjected pigs to a rope chew test at 4 weeks of age and also measured the frequencies and durations of nosing and biting the ears and tails of other pigs from videotapes made of pigs in groups in their home pens. They found that pig-directed behaviour in the home pen was positively correlated with rope directed behaviour during the tests and concluded that pigs that perform a high level of rope directed behaviour may be more likely to perform harmful social behavior in their resident pens. Their results suggest that using rope "tail models" is a valid method for investigating the tendencies of pigs to engage in tail biting.

In other studies, investigators have measured the effects of various factors on pigs' tendencies to direct rooting or chewing on objects (Day et al., 1995; 1996) or on pen-mates bodies (Beattie et al., 1996; 2001) in order to identify behavioural mechanisms that may be related to the pre-injury stage of tail biting. One Danish group is examining what they call "Tail-In-Mouth" (TIM) behaviour in younger pigs and have suggested that TIM may be a precursor for the damaging tail biting that occurs in older pigs (Schroder-Petersen et al, 2000, 2001).

The many factors that are said to be associated with tail biting can be classified into genetic, environmental/husbandry and dietary. Genetic factors include breed or line differences, but also might involve inherent sex differences. Factors falling into the environment/husbandry category are housing conditions such as crowding, lack of rooting substrate or uncomfortable temperatures thought to cause "stress". Dietary factors involve nutrient deficiencies (which are probably pretty uncommon these days) but might also include salt or minerals that are thought alter behaviour. So what have the various scientific investigations taught us about the factors that may lead to tail biting?

THE NATURE OF PIGS AND TAIL BITING

All of us who know pigs can attest to the fact that the creatures are built to root, and chew and to explore the environment with their mouths and snouts. A large part of this rooting and chewing behaviour may be associated with natural feeding and foraging motivation (Day et al., 1996). Some is probably associated with the pig's natural tendency to explore their environment and their group mates (Feddes and Fraser, 1994). Pigs also tend to be rather aggressive animals, and engage in intense fighting when establishing their social hierarchy or when competing for a limited resource such as food or water. So where does tail biting fit in? Tail biting is generally not considered an aggressive behaviour in that it involves different motor patterns and signals than those used in aggressive interactions or fighting, and the recipients are generally thought not to respond. The most common behavioural hypothesis for tail biting is that it involves normal behaviour, such as foraging and exploration that becomes redirected or misdirected to the tails of pen-mates when something in the environment is lacking (Schroder-Petersen and Simonsen, 2001). This redirected behaviour may intensify when pigs become stressed or frustrated. It is sometimes suggested that tail biting occurs when there is competition for resources such as feeder space or lying areas. Whether the behaviour occurs when pigs are actually fighting to get access to the resource, or in another context when a pig is frustrated because it is prevented from obtaining the resource is unclear.

It may be that the underlying behavioural mechanism for tail biting differs depending on the situation.

GENETIC EFFECTS ON TAIL-BITING

While it is common to see mention of genetics in relation to tail biting (Sambraus, 1985), this is one area that we know very little about. Fraser (1987a) found large individual differences in pigs' tendencies to chew on plain or blood soaked tail models and this observation is supported by some of the more recent work using tail models (Breuer et al., 2001, Jankevicius and Widowski, 2001b). Some pigs chew on the models almost continuously during the tests while others hardly touch the models. Individual differences have also been observed in pigs engaging in other types of oral/nasal pig directed behaviour (i.e. belly-nosing) but most observations related to actual tail biting incidents are anecdotal. Although it has been suggested that some genotypes may be "less irritable than others" and therefore less likely to perform tail biting (Aherne and Deen, 1998), there are no controlled genetic comparisons to be found in the literature.

SEX DIFFERENCES AND BITTEN TAILS

Results from several surveys conducted at abattoirs in the UK have shown that there is a significant link between gender and the prevalence and severity of bitten tails on pig carcasses, with males being much more likely to have bitten tails than females. Comparisons of the percentages of male versus female carcasses with bitten tails were 15.7 % of castrated males and 7.7% of females (Penny and Hill, 1974), and 4.58 % of boars versus 3.37% of gilts (Hunter et al, 1999). Lee and Veary (1993 as cited in Schroder-Peterson and Simonsen, 2001) found that not only were males more likely to have bitten tails, the severity of tail wounds were greater in males. Data used in these various studies were collected on populations of both docked and undocked pigs but the effect of sex appears to be consistent in both groups.

While carcass data indicate a consistent trend in sex differences and tail biting few studies have addressed why this sex difference may occur. Nor is it known whether same sex or mixed sex penning has an effect on tail biting. In one survey of management practices on 450 farms, pigs in single sex pens were more likely to be bitten than those on farms using mixed sex groupings (Hunter et al., 2001). In contrast, "Tail-in-mouth" behaviour was found to be greater in mixed-sex pens than in pens with only barrows or gilts (Schroder-Peterson et al, 2000) but only 3 groups of pigs per penning system were observed in this study. An early study focussing on ear and tail directed behaviour of pigs, indicated no effect of sex on pigs' tendencies to be either the perpetrators or the recipients of biting behaviour (Blackshaw, 1981).

At this point the reasons for the sex difference in bitten tails are purely speculative. All of the abattoir surveys were conducted in the UK and therefore include some data from both castrated and intact males. It has been suggested that gilts are more active than barrows and therefore gilts may be more likely to be the tail biters, and barrows easier targets, when they

are housed in mixed-sex pens. However this does not explain the high prevalence of tail-bitten males coming from single-sex pens (Hunter et al., 2001). It has been suggested that penning groups of young intact boars together can results in higher levels of aggression, but whether this would result in an increase of tail-biting is not known.

NUTRITIONAL FACTORS AND THE TASTE FOR SALT OR BLOOD

Many of the earliest discussions on tail biting suggested that dietary deficiencies contributed to the problem. Fraser et al (1991) outlined three ways in which diet and nutrition could affect a pig's motivation to bite tails. One is that many of the neurotransmitters and hormones that control behaviour are derived from amino acid precursors and therefore dietary deficiencies or imbalances could potentially lead to alterations in behaviour. Fraser also pointed out that a pig's dissatisfaction with the diet may lead to increased restlessness and foraging behaviour that could result in tail-biting if pigs redirected that behaviour to the bodies of their pen-mates. It has been demonstrated that feed deprivation in growing pigs does in fact decrease the amount of time spent lying and increases the amount of rooting and foraging directed at woodbark/foraging substrate in controlled tests (Day et al., 1995). The third reason Fraser suggested was that dietary deficiency might cause a specific appetite for some nutrient that is available in blood making it more attractive if the second stage of tail biting occurs. A specific appetite refers to animal's tendency to seek out and ingest a particular nutrient that may be deficient in the body but that might be present in the environment. Sodium appetite, for example, is a state of increased motivation to seek out and ingest salty substances in the environment.

Using a blood-treated tail model Fraser and his colleagues found that pigs fed mineral (1987b) and protein deficient diets (1991) directed significantly more chewing at the blood treated model than pigs fed control diets. However more recent studies do not support Fraser's findings. McIntyre and Edwards (2001) found that chewing directed at blood-treated or plain tail models were not different among pigs fed either a low protein, low energy diet or control diet over a 6 week period. In another study, Beattie et al. (2001) found that feeding pigs a salt deficient diet for 2 weeks did not lead to an increase in chewing directed at rope models treated with sodium chloride, but they did not offer a blood-treated model in this study. However, they did find that the pigs were more active and engaged in more rooting behaviour during the period of salt deficiency.

Other nutritional factors have been suggested as causes or cures for tail biting. It has been suggested that feeding a high energy, low fibre diet might stimulate tail biting, but one experimental attempt to induce the behaviour in this way was unsuccessful (Ewbank, 1973). Dietary magnesium supplements, thought to have an "anti-stress effect" has also been suggested (Smith and Penny, 1986). However the one study in the literature examining the effects of magnesium supplementation and space allocation on the behaviour of pigs showed no effect of adding magnesium (Krider et al., 1975).

STRESS AND THE TASTE FOR SALT OR BLOOD?

One of the common remedies suggested for reducing tail biting is the addition of salt or potassium to the diet (Smith and Penny, 1986; Aherne and Deen, 1998). Presumably the logic behind this stems from some of the earlier work on salt and mineral deficiencies and the pig's attraction to blood. Although it is logical that dietary deficiencies might increase exploratory chewing or a taste for blood, it is less clear how environmental stressors may elicit this behaviour. Interestingly, a variety of physical and environmental stressors such as crowding, restraint and immobilization, cold stress and exposure to social intruders have been shown to stimulate a sodium appetite in mice, rats and rabbits (Denton et al., 1999). One model of the stress response that has been widely used is the injection of adrenocorticotrophic hormone (ACTH), one of the many hormones released during stress. In mice, rats, rabbits and sheep treatment with ACTH causes a pronounced sodium appetite. Fraser (1987) suggested that if pigs show a similar response to stress, an appetite for salt could increase their attraction to blood and contribute to tail biting. This is one area that we have been exploring recently in my laboratory.

In our first study, we adopted the traditional method of measuring sodium appetite that has been used in other species, offering salt solutions and measuring ingestion of those solutions (Jankevicius and Widowski, 2001a). Growing pigs (45 kg) were offered different concentrations of sodium chloride and potassium chloride solutions and their intakes were measured before, during and after a 5-day period of ACTH injections. During the injection period, the pigs significantly increased their water and feed intakes and had elevated salivary cortisol, indicating that they were responding physiologically to the hormone injections. However, they did not increase their intake of sodium solutions. In fact, some of the pigs that were drinking the more dilute salt solutions during the pre-treatment period decreased sodium intake during the injection period.

We thought that perhaps offering salt in solution was not an appropriate vehicle for delivering salt to pigs. Therefore we conducted a second study in which pigs were treated with ACTH and offered rope tail models soaked in whole pig's blood, a salt solution having the same salt content as blood or plain water (Jankevicius and Widowski, 2001b). As in the first study, pigs did not show an increased attraction to blood or the salty tail during the period of ACTH injections. Overall, the activity of the pigs and their chewing behaviour directed at the rope models decreased during treatment. Results of both of these studies indicate that pigs do not develop a sodium appetite or attraction to blood in response to the stress hormone ACTH. However it should be noted that ACTH release is only one of the many physiological responses to stress and may not be the appropriate model for studying whether pigs develop a stress-induced sodium appetite.

PIG'S ATTRACTION TO BLOOD

Fraser's early study (1987) using blood-treated tail models indicated that pigs are strongly attracted to blood flavoured models compared to plain rope "tails". But what is it about blood that is so attractive to pigs? McIntyre et al (2001) compared the preferences of growing pigs

fed standard diets to rope models treated in whole blood, the cellular fraction of blood, the protein plasma fraction of blood or Na Cl solution. They found that pigs preferred to chew on models treated in whole blood or sodium solution and were not attracted to the other fractions of blood. In our ACTH trials, pigs showed a significant preference for blood-treated tails compared to NaCl or water treated models, regardless of hormone treatment (Jankevicius and Widowski, 2001b).

In all of the studies involving blood soaked tails, the colour and appearance of the tail models are considerably different depending on what they are treated with. Pigs might simply be attracted to the tail that is darker in colour. To rule out the effect of colour or appearance on pig's attraction to blood-treated models, we treated tail models with red food dye as well as blood, salt or water and used a colourmetric system used for meat studies to closely match the colours of the tails treated in the different substances. When all tail models were similar in colour pigs still showed a strong preference for tail treated with blood + food dye, compared to salt solution + food dye or simple food dye. Together these studies indicate that pigs are using some olfactory or taste cues to discriminate among the tails. Our studies suggest that it is not the salt content of blood that is attracting pigs to the models, at least not when they are fed diets that meet their nutritional requirements. On the other hand, McIntyre's study suggests that pigs are attracted to salty tail models, but they used a much higher concentration of salt solution to treat the tail models.

Overall, the body of recent research suggests that salt isn't that attractive to pigs and that a taste for salt is not contributing to the development of tail biting. In addition, Beattie and Weatherup (2000) found that supranutritional salt supplementation did not reduce the frequency of nosing other pigs or tail biting compared to pigs fed a control diet. It is reasonable to conclude that there is no benefit to adding salt to the feed or by providing salt-treated objects to the pen in order to curb tail biting when pigs are fed a nutrient sufficient diet.

EFFECTS OF MANAGEMENT FACTORS

Chambers et al (1995) surveyed management practices on 47 farms in the UK to identify those associated with producer reports of tail biting. Tail biting was reported to have occurred on 66 percent of the farms surveyed. From this sample, reports of tail biting appeared to differ with provision of bedding, slatted floors and methods of feeding. Tail biting was less likely to occur on farms at which straw was provided and when pigs were fed manually rather then via automatic systems. There were no associations with pen size, number of pigs per pen, stocking density, or type of ventilation system. These results should be viewed with some caution considering the relatively small number of farms sampled and the large number of variables considered.

Hunter et al (2001) followed up an abattoir survey (Hunter et al 1999) with a questionnaire sent to producers with questions relating to housing type, straw provision, ventilation, mixed or single sex grouping and feeding methods. Data were collected from 450 farms representing 27, 870 pigs sampled at the abattoir. Of units included in the study, 18.8% provided deep

straw, 29.9% light straw, 3.6% a mix of deep and light straw and 41.4% no straw. As this study was conducted in the UK, natural ventilation systems were most common, accounting for 53.4% of the units surveyed. Provision of straw significantly affected probability of tail biting. For both docked and undocked pigs, tail biting was lowest in the systems with light straw and highest in the units where no straw was provided. Natural ventilation also reduced the probability of tail biting but in most naturally ventilated units, straw was also provided. Feeding level (restricted, to appetite or ad lib) did not affect the probability of bitten tails. Method of feed delivery only affected the probability of bitten tails in undocked pigs. Probability of tail biting was highest in pigs fed pellets, (versus meal or liquid feeding) and in pigs fed on floor, or in single-spaced feeders (versus double or multi space feeders).

Specific climatic factors

In their review, Schroder-Petersen and Simonson (2001) noted that although both indoor climate and season have been suggested to lead to tail biting the scientific evidence for this is inconsistent and contradictory. Depending on the study, tail biting has been observed to be greater when indoor temperature was below 17^{o}C, greater when indoor temperature was above 20 ^{o}C, greater at 35 ^{o}C compared to 25 ^{o}C, and greater at 23 ^{o}C than at 28 ^{o}C. Seasonal effects based on abattoir studies have been reported to be highest during summer months in one report and highest during winter months in another.

Ventilation is also claimed to affect tail biting but nearly all of the evidence for this is based on case study or anecdotal report and the survey data are inconsistent (Chambers et al, 1995; Hunter et al, 2001). Reasons given for why poor ventilation might elicit tail biting include both poor air quality and draft. There have been no studies specifically addressing air quality on pigs' tendencies to engage in harmful behaviour. While subjecting pigs to cold draft has been shown to stimulate fighting and ear lesions, there is little direct evidence on the tendency for pigs to bite tails. One area that we are currently addressing in my laboratory is whether drafty conditions in different environmental temperatures can stimulate chewing on rope tail-models in growing pigs.

Substrate for rooting and chewing

Both of the UK farm survey studies reviewed here (Chambers et al,. 1995; Hunter et al., 2001) indicated that regular provision of straw significantly reduced the probability of observing tail biting on farms. The benefits derived from straw may relate to its effects on thermal comfort, or the recreational and nutritional opportunities straw provides. Results from a number of behavioural studies measuring pigs' tendencies to direct rooting and chewing at other pigs have shown that provision of straw or some other rootable/chewable substrate is an effective means of directing harmful behaviour away from other pig's bodies. In housing systems that do not allow for use of straw, providing objects or small amounts of substrate that pigs can root or chew can be effective. Feddes and Fraser (1994) demonstrated that the type of "enrichment" object can significantly affect pigs' attraction to it, pigs directed much more chewing at objects that were "destructible" and that they could more easily grasp and chew on. Recent work by Beattie et al. (1996, 2001) has shown that suspending a tray filled

with mushroom compost in pens with fully slatted floors can significantly reduce nosing and tail biting behaviour.

CONCLUSIONS

- Results from abattoir surveys indicate that bitten tails are more common in males than in females but the behavioral mechanisms for this are currently unknown.
- In pigs receiving adequate diets, there appears to be no benefit of adding salt or other nutritional supplements to the diet for reducing tail biting.
- Provision of straw or other rootable/chewable substrates appears to be the most effective means of reducing pig-directed behaviour that can lead to tail biting.
- Further research is needed to determine how environmental stressors such as thermal discomfort or air quality and how genetics increase pigs' tendencies to engage in biting behaviour.

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