**Injurious tail biting in pigs: how can it be controlled in existing systems without tail docking?**

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**Supplementary material S1:** *Figure 1: Detail of postulated relationships between the underlying processes of tail biting and various known or suspected risk factors*

The processes represented by each numbered arrow in Figure 1 are as follows: 1a) Stocking density affects the thermal environment and air quality, and affects the extent to which behavioural thermoregulation is possible (e.g. choosing to lie apart from other pigs to keep cool). The thermal environment affects competition for lying space: 1b) When cold, pigs huddle and might compete for warmor draft free (Scheepens *et al.*, 1991) lying areas, when hot pigs will try to keep apart, and compete for cool lying areas. 2) Stocking density increases the chances of pigs encountering tails rather than non-tail objects. 3) High stocking density (directly and through its effect on pen hygiene) increases the chances of disease and parasite transmission between pigs. 4) Stocking density increases the number of pigs competing for resources such as food (a) and lying space (b), which in turn affects the intensity of competition for these. 5) Stocking density could increase activity, because densely stocked pigs are more likely to disturb one another, and less likely to be able to lie quietly in one part of the pen, avoiding active pigs in another part of the pen. 6) Hunger (Beattie and O'Connell, 2002; Day *et al.*, 1995; Zwicker *et al.*, 2013) or gastro-intestinal discomfort, resulting from the type of feeding system or from nutrient imbalance (Taylor *et al.*, 2010) could increase activity, and in particular foraging activity. Certain amino acids such as tryptophan affect activity and behaviour (Edwards, 2006; Fraser *et al.*, 1991). 7) Appetite for salt, protein or specific amino acids could increase the positive feedback that pigs get from encountering blood once tail biting begins (Fraser, 1987; Fraser *et al.*, 1991; McIntyre and Edwards, 2002a; McIntyre and Edwards, 2002b). Initially this applies to biting pigs, but non-biting pigs in the pen will also encounter blood so may begin biting themselves (b). 8) Availability of substrates increases the proportion of investigatory/foraging activity pigs direct towards the substrates, rather than towards non-substrate objects, including tails (see Table 1). 9) Disease (including parasitism) could result in increased discomfort or restlessness, and thus increase activity. 10) Disease could result in inactivity (‘sickness behaviour’) meaning that victim pigs do not respond to tail manipulation or biting (Jensen *et al.*, 2004; Kritas and Morrison, 2004). External parasites such as mites could mean that victim pigs have itchy skin and initially like being manipulated. 11) High energy-density diets in weaners could result in endotoxin build-up, causing tail necrosis, which then attracts biting and this biting is initially tolerated by affected pigs (Jaeger, 2013). 12) Changes in weather outside can affect ventilation and/or temperature experienced by pigs inside, since ventilation and heating systems usually do not maintain a completely standard environment and airflow for pigs all year round. This could be one explanation for effects of season on tail biting 13) As pigs compete for comfortable lying areas, they disturb one another more, resulting in increased activity. 14) Limited feeder space, or food which is only available at certain times of day could increase the intensity of food competition. 15) Competition for food could result in hunger, which in turn results in increased foraging activity. 16) Competition for food could result in an increase in activity because aggression creates disturbance and/or because pigs are feeding over a longer period of time17) Availability of certain substrates (such as deep straw provided on the floor) will affect pigs’ thermal comfort, and their ability to respond to environmental challenges by showing behavioural thermoregulation (e.g. nesting in deep straw to keep warm). 18a) Low availability of enrichment might increase competition, leading to increased activity (Scott *et al.*, 2007b). This is perhaps more likely for a ‘point-source’ enrichment than for substrates provided on the floor(Van de Perre *et al.*, 2011; Zwicker *et al.*, 2012), particularly if it is highly attractive to pigs (such as a hanging edible item). 18b) Conversely, the opportunity to obtain some satisfaction from eating enrichment materials such as straw could reduce frustration in subordinate pigs unable to compete for feeder access (Scott *et al.*, 2007a). 19) Pigs may eat substrates such as straw, which although it provides no digestible energy, does provide some form of nutritional feedback in terms of gut fill, or it may relieve gastro-intestinal discomfort (Taylor *et al.*, 2010). 20) If tail-biting spreads to other pigs in the group by observational learning as suggested by Blackshaw (1981), then stocking density could affect the likelihood that another pig witnesses a tail biting event. 21) For pigs which have not yet begun to tail bite, the extent to which the novelty, taste and destructibility of damaged tails makes them attractive for those pigs to investigate may depend on the other opportunities available (affected by substrates, stocking density etc.). 22) In a similar way to the previous point (21), the availability of damaged tails vs. other possible outlets for foraging/investigation might affect the rate of escalation once tail-biting begins. 23) Tail docking might be effective at reducing tail biting becauseitmakestails less attractive as a foraging substrate, or by 24) making tails sensitive to manipulation by other pigs, reducing the tolerance of the victim for tail manipulation(Simonsen *et al.*, 1991) or 25) because shorter tails are harder for pigs to bite on using their cheek teeth (Paoli *et al.*, 2014). 26) Dietary imbalance could lead to increased ‘specific’ hungers which could affect food competition as pigs eat more.

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