Review : The tale of the Finnish pig tail - how to manage non-docked pigs?

Valros, Anna

2022-06

Valros , A 2022 , ' Review : The tale of the Finnish pig tail - how to manage non-docked pigs? ' , Animal , vol. 16 , no. Suppl. 2 , 100353 . https://doi.org/10.1016/j.animal.2021.100353

http://hdl.handle.net/10138/352698
https://doi.org/10.1016/j.animal.2021.100353

Animal 16 (2022) 100353

Contents lists available at ScienceDirect

Animal
The international journal of animal biosciences

Review: The tale of the Finnish pig tail – how to manage non-docked pigs?

A. Valros

Department of Production Animal Medicine and Research Centre for Animal Welfare, Faculty of Veterinary Medicine, P.O. Box 57, 00014 University of Helsinki, Finland

ARTICLE INFO

Article history:
Received 23 April 2021
Revised 3 August 2021
Accepted 13 August 2021
Available online 23 September 2021

Keywords:
Pig production
Pig welfare
Risk factors
Tail biting
Undocked pigs

ABSTRACT

Tail biting is a serious behavioural problem in modern pig production, causing impaired animal welfare and economic losses. In most countries, the detrimental effects of tail biting are counteracted by docking pigs tails. Finland is one of the few countries where tail docking in pigs is totally forbidden. The aim of this paper was to look in detail at features of pig production in Finland in order to try to understand how Finnish producers manage to rear non-docked pigs. The way pigs are housed and managed in Finland is influenced by both European and national legislation, but also by governmental subsidies, industry recommendations and voluntary initiatives. Several features of Finnish pig production might indeed have a preventive role regarding the tail biting risk: these include, among others, a comparably larger space allowance, partly slatted flooring, use of manipulable materials, a good animal health status and meal feeding from long troughs. In addition, Finnish producers are motivated to rear non-docked pigs, which is possibly one of the most important prerequisites for success. The experiences from Finland show that even though tail biting is still a challenge on some farms, in general, it is possible to rear non-docked pigs in intensive production. Potential positive side-effects of enhancing management and housing to facilitate the rearing of non-docked pigs include a good growth rate, a reduced need for antimicrobials and better animal welfare levels.

Implications

Tail biting in pigs is a serious welfare and economic challenge in modern production and is caused by a multifactorial set of farm-specific risk factors. Finland is one of the few countries where tail docking is banned, and some features of Finnish pig production might reduce the risk of tail biting. These include a comparably larger space allowance, partly slatted flooring, use of manipulable materials, a good animal health status, meal feeding from long troughs and motivated producers. Even though tail biting is a challenge on some farms, it is indeed possible to successfully rear non-docked pigs in intensive production.

Introduction

Tail biting is a serious behavioural problem in modern pig production, causing reduced animal welfare and health, as well as economic losses to producers (for a review, see Edwards and Valros, 2021). The problem is also in itself a sign of welfare challenges, as a range of suboptimal management and housing conditions are listed as risk factors for tail biting (European Food Safety Authority (EFSA), 2007 and 2014). The motivational background of tail biting is believed to be multifactorial and related to stress, nutrient deficiencies and health challenges (for a review, see Edwards and Valros, 2021) and thus a wide range of factors, and combinations of these, can cause an outbreak. Tail biting commonly results in lesions to the tail of the recipient pigs. Lesions can range from minor bite marks to loss of the entire tail (Edwards and Valros, 2021). In order to reduce the negative outcome of tail biting, namely tail lesions, most pigs in conventional pig production systems globally are tail docked (EFSA, 2007; de Briyne et al., 2018; Nalon and de Briyne, 2019). Tail docking, however, is a problematic procedure: it is known to cause both acute and chronic pain in the docked pig (for a review, see Valros, 2018), while also masking other welfare problems, by reducing the possibility for pigs to express their stress by biting tails. Producers also report that an intact tail is a good indicator of pig welfare (Valros et al., 2016).

Tail docking as a routine procedure has been banned in the European Union (EU) since 1994 (Nalon and de Briyne, 2019; EU, 2008). According to the EU Pig Directive, other measures to reduce tail docking should be taken before carrying out docking. However,

E-mail address: anna.valros@helsinki.fi

https://doi.org/10.1016/j.animal.2021.100353
1751-7311/

despite this principle tail-docking ban, the absolute majority of pigs are still docked in the EU. Finland is one of the two EU countries (in addition to Sweden) that opted for a stricter ban: in Finland, tail docking was prohibited from the start of 2003 (Animal Welfare Decree 396/1996). Even before this, most producers did not tail dock their pigs, although some did carry out the procedure prior to the ban. There are no official numbers for the proportion of docked pigs prior to the ban in Finland available. However, a study we performed in 2000 at a large Finnish slaughterhouse indicated that a maximum of 23% of the pigs could have been docked, as this was the amount of shortened tails recorded. However, it must be noted that this number is a combination of bitten, but healed tails and docked tails (Valros et al., 2004). This is also in accordance with the anecdotal knowledge on the prevalence for docking (Heinonen et al., 2021, personal communication)

One of the main reasons for why tail docking is so common is that producers do not want to risk tail biting lesions (Valros and Barber, 2019). In some countries, producers even mention that they prefer docking to any tail biting at all (Bracke et al., 2013) and that tail docking can be compared to vaccination (Valros and Barber, 2019). It does seem contradictory that in countries where docking is banned, including Finland and Sweden, pig growth rates are still quite high (Munsterhjelm et al., 2015, Wallgren et al., 2019), use of antimicrobials is comparably low (European Medicines Agency (EMA), 2018) and producers do not see tail biting as a problem (Valros et al., 2016). The aim of this paper was to look in more detail at the way pigs are produced in Finland in order to understand what is behind this apparent contradiction. To support this aim, scientific evidence of prevention of tail biting is considered in the light of features specific to Finnish pig production.

Legislation related to pig welfare in Finland: features relevant for tail biting

The Directive on the protection of pigs (EU, 2008) (hereafter referred to as the EU Pig directive) lays down minimum standards for the keeping of pigs in the EU. It includes some aspects with relevance for reducing the risk for tail biting, as shown by scientific research and anecdotal evidence. Further, the Finnish national legislation, including the Animal Welfare Act (247/1996), the Animal Welfare Decree (396/1996) and the Government Decree on protection of pigs (629/2012) (hereafter collectively referred to as Finnish legislation), implies some additional restrictions, which have potential to further improve the prevention of tail biting. These are addressed in the sections below, and summarised in Table 1.

The EU Pig directive sets a minimum space allowance for pigs, which is dependent on the size of the animals. For example, for a finisher pig up to 110 kg, the minimum space allowance is 0.65 m^2. The Finnish legislation goes beyond this, with a minimum of 0.9 m^2 for a similar sized pig (comes into force in old buildings from 2025). The Finnish legislation further restricts the use of slatted floors (comes into force in old buildings in 2028): for grower-finisher pigs, at least two-thirds of the pen floor should be solid or drained (maximum of 10% draining) flooring, and in the farrowing unit, piglets should be given a fully solid laying area. The EU Pig directive, on the other hand, does not demand solid flooring for pigs.

All grower-finishing pigs in the EU should be 'provided with permanent access to a sufficient quantity of material to enable proper investigation and manipulation activities'. The EU Pig directive further defines this as materials such as straw, hay, wood, sawdust, mushroom compost, peat or a mixture of these. In the EU Commission recommendation 2016/336, it is further defined that the materials should be edible, chewable, investigable and manipulable. In Finland, the competent authority has further defined this as pigs being given either permanent access to rooting material, such as straw, hay, peat or sawdust in an amount making it possible for the pigs to form a small pile, or give bedding-type material twice a day in addition to adding permanent solid manipulable objects to the pen (Finnish Food Authority (Ruokavirasto), 2019). According to Finnish legislation, manipulable materials should be given to all pigs, including piglets in the lactation period. Regarding feeding systems, the EU Pig directive stipulates that all pigs must be able to eat simultaneously, unless they are fed *ad libitum*, or when using individual automatic feeders, and that all pigs should have permanent access to fresh water. The Finnish legislation further defines minimum width for feed troughs, depending on pig weight (Table 1).

The use of antimicrobials as growth promoters or production enhancers is forbidden in Finland (Government Decree 1054/2014; Decree by Ministry of Agriculture and Forestry 2008/14/2014). Only veterinarians are allowed to prescribe antimicrobials to animals, and the treatment must always be motivated by veterinary reasons or the welfare of the animal. Further, veterinarians are not allowed to profit from the sale of medicines. Thus, in Finland, antimicrobials cannot be used as prophylactics without a diagnosed need for the treatment of diseases (Decree by Ministry of Agriculture and Forestry 2008/14/2014). According to the Finnish legislation, there should be a certain amount of sick pen space in each pig farm: at least for 5% of the animal numbers in the herd. There are also some minimum requirements for housing conditions, such as light, air quality and noise. Some of these are summarised in Table 1.

Animal welfare control

The control of compliance with animal welfare legislation in Finland is based on EU regulations (European Commission regulation 882/2004)). A sample of farms are inspected and the results are reported annually to the EU commission (Väärikkälä et al., 2019). One quarter of this sample is based on a random selection, and three quarters based on specific risk factors defined for each animal species separately (Väärikkälä et al., 2019; Ruokavirasto, 2021a). Since 2010, provincial veterinarians employed by the Regional State Administrative Agencies perform the sample-based inspections. The inspections are mainly performed without prior notice to the farmer (Ruokavirasto, 2021a). The number of annually inspected pig farms varied between 20 and 32 farms per year during the last four years (2017–2020) (Ruokavirasto, 2020). During this period, non-compliance was noted on between 15 and 41% of the inspected farms. The most common non-compliances include poor cleanliness of the premises or lack of bedding, and inappropriate enrichment use. Other, less frequently occurring issues included inadequate space allowance and neglected record keeping. For an earlier time period (2010–2015), Väärikkälä et al. (2019) reported that lack of enrichment was the most common non-compliance, and that farrow-to-finish farms had a higher prevalence of non-compliances than other types of pig farms. In addition to the sample-based inspections, farms are inspected based on suspicion of violation. In 2020, 80 facilities housing pigs were inspected. As a whole, approximately 40% of all inspections of production animals led to orders or prohibitions regarding the way the animals were kept (Ruokavirasto, 2021a).

Legislation and voluntary initiatives for collecting data on tail lesions

In order to follow up and improve the tail biting situation in Finland, several measures are implemented, both mandatory and vol-

Table 1
Features of pig production in Finland, with a focus on those potentially related to the risk for tail biting.

	Legislative minimum *EU Pig Directive*[1] Finnish national legislation[2]	Recommendations by competent authority (CA)[3] or legal requirements for animal welfare subsidies[4]	Industry recommendations[5]	Practices or features recorded in studies or based on anecdotal evidence[6]
Tail docking	*Routine tail docking is prohibited, but allowed if there is evidence of injuries, and after preventive measures have been taken*[1] Tail docking prohibted[2]			
Feeding	*All pigs must be fed at least once a day, either ad libitum, by automatic individual feeding or by allowing all pigs in a group access to food at the same time*[1] If pigs are meal-fed, the trough length minimum per pigs is 25 cm for pigs of 25–50 kg and 30 cm for pigs over 50 kg[2]	It is recommended that pigs can feed simultaneously. When using automatic *ad libitum* feeders, at least 2 spaces per each 10 finisher pigs should be ensured. Through length at meal feeding 32 cm/pig for pigs over 95 kg[3]	Feed components should be analysed. Liquid feed from long through is recommended for grower and finisher pigs. Finisher feeding should be unrestricted.	Most pigs, especially finishers (over 85%), are meal-fed from long troughs using liquid feed. Most producers include home-grown grain in the feed and analyse their feed components.
Water provision	*All pigs over 2 week*[1]/1 week[2] *of age must have fresh water continuously available*[1]	At least one drinker per 10 pigs, and at least 2 drinkers in each group of pigs. Water flow at least 0.5–1 l in the weaner unit and 1.5–2 l in the finisher unit[3]	Drinkers should be situated in the dunging area. Each drinker should be checked before arrival of new pigs, and water flow should be checked regularly. Water quality should be tested regularly.	Mean 2.1 drinkers per 10 pigs
Space allowance	*Pigs of 10–85 kg: 0.15 m^2 – 0.55 m^2, depending on size)* *Pigs of > 85–110 kg: 0.65 m^2* *Pigs > 110 kg: 1 m^2* [1] Pigs of 10–95 kg: 0.17 m^2 + (weight kg/130) (eg. 40 kg: 0,32 m^2) Pigs of 95–107 kg: 0.9 m^2 Pigs of 107–130 kg: 1 m^2 [2]		Finishers 0.9–1.0 m^2/pig Growers 0.4 m^2/pig	Mean space allowance for finisher pigs: 1.05 m^2/pig (95 farms)
Group size			Mixing of litters at weaning should be avoided: 1–2 litters per grower pen.	Normally 15–25 pigs (growing unit) and 10–15 pigs (finisher unit). Mean group size for finishers: 11.4 pigs per pen in finishing.
Use of manipulable materials and bedding	*Pigs of all ages must be given enough material to satisfy their need to root and investigate*[1] Either bedding-type material is always available or added twice a day, in addition to some solid object for manipulation[2]	Animal welfare subsidies can cover extra costs for using bedding or use of more manipulable materials than the legal minimum[4]	Sawdust should be added to the lying area in the grower unit.	Most farms use straw or hay. Also sawdust, peat and cardboard or paper are popular. In addition, many farms add chains or (chains with) wooden pieces, and many farms use combinations of different materials. 64% of 95 finishing farms used enrichment only, 28% thin and 7% thick bedding
Flooring	*Limits on slat and gap widths, but not on proportion of slatted floor*[1] At least two-thirds of the flooring in the weaner and finisher unit must be solid or drained. The resting area must be dry, clean, of suitable temperature and drained if necessary[2]		At least 50% of the floor in grower and finisher pens should be solid.	The majority (>80%) of farms have partly slatted flooring
Housing conditions	Ventilation must be adequate to make sure gases, dust, draught or moisture do not harm the animals[2]. Temperature must be suitable. *Noise level cannot continuously exceed 85 dB*[1]/65 dB^2. *Light level must be at least 40 lux for at*		Draught: below 0.2 m/s Ammonia >10 ppm; CO^2 <3 000 ppm Floor and room heating is recommended for both grower and finisher pigs. Temperature: 25–28 °C for growers and 14–18 °C for finishers Two-climate systems with a covered resting area are	

(*continued on next page*)

Table 1 (*continued*)

	Legislative minimum *EU Pig Directive*[1] Finnish national legislation[2]	Recommendations by competent authority (CA)[3] or legal requirements for animal welfare subsidies[4]	Industry recommendations[5]	Practices or features recorded in studies or based on anecdotal evidence[6]
	least 8 h/day[12]. Natural light is compulsory[2]		recommended for grower pigs Light intensity: 100 lux Moisture: 50–80%	
Health and medications	Use of antimicrobials as growth promoters or prophylactics is not allowed[2]	Vaccinations are foremost recommended for parvovirus, erysipelas and *E. coli*[3]	Finishing pigs should be grown in all-in-all out systems.	Finland is free from PRRS, TGE, PRCV and PED. The prevalence of sarcoptic mange, swine enzootic pneumonia, swine dysentery, atrophic rhinitis and salmonella is very low in the country. Most Finnish pig farms (90%) belong to the common health care system Sikava. Use of antimicrobials is comparably low
Sick pens	*Pigs that are aggressive have been attacked or are sick or injured may be kept temporarily on individual pens with enough space to turn around easily*[1] Sick pens of at least 5% of the total floor area required for the number of animals on the farm[2]	Space allowance per pig should be higher in sick pens than in normal pens[3]	Tail biters should be moved to sick pen	
Growth rate			Good growth threshold is defined as 400–500 g/day for grower pigs and 900 g/day for finisher pigs	Mean 923 g, feed conversion ratio 2.64 (on 95 finisher farms).
Farm size				On average, 300 sows and 1200 finisher pig places (producers for one of the major slaughterhouse companies)
Inspection of animals and intervention of tail biting outbreaks	Animal welfare and housing conditions must be inspected at least every day[2]		In cases of tail biting outbreaks, the following actions are recommended: remove biter; give extra feed; give extra salt; place extra, interesting toy in the pen and replace daily; give extra roughage or peat many times a day; check for the real cause.	Producers rated identifying and moving the biter from the pen as most important, followed by adding bedding-type material and removing the biter

PRRS = porcine reproductive and respiratory syndrome, TGE = transmissible gastroenteritis, PRCV = porcine respiratory coronavirus, PED = porcine epidemic diarrhoea.

[1] EU Pig Directive 120/2008/EC.

[2] National legislation, which goes beyond the EU minimum, including the Animal Welfare Act (247/1996), the Animal Welfare Decree (396/1996) and the Government Decree on protection of pigs (629/2012), Government Decree (1054/2014); Decree by Ministry of Agriculture and Forestry (2008/14/2014). Some parts of this legislation only come into force in old building from 2025 or 2028.

[3] Evira, 2014a and 2014b; Ruokavirasto, 2020.

[4] Requirements for animal welfare subsidies 2021.

[5] Based on production guidelines from the two biggest slaughterhouses in Finland, Atria Oyj (AtriaSika, 2012) and HKScan Finland Oy (Vugts, personal comm, 2021).

[6] Munsterhjelm et al., 2015; Valros et al., 2016, Kallio et al., 2018, Heinonen et al., 2021, EMA, 2018; EHK, 2021. Personal communications by Valaja J, 2020; Heinonen, M, 2021; Immonen, N., 2021.

untary. Recording of tail biting has been a mandatory part of meat inspection in its current form since 2013 (Decree by Ministry of Agriculture and Forestry 1371/14/2012). Information on tail lesion prevalence for each batch, as recorded at the slaughterhouse, are sent to the producer on a regular basis. Further, if serious problems occur, such as so-called tail craters (serious tail damage incidences, where the entire tail is missing), or exceptionally high levels of tail lesions, the meat inspection veterinarian is obliged to inform regional animal welfare authorities immediately.

Most pig farms in Finland belong to the Sikava herd health classification system (www.sikava.fi), which is organised by Animal Health ETT ry, an industry-funded voluntary organisation. The Sikava system has been ISO9001:2015 certified since 2014. The national level of Sikava fulfils the national food quality scheme criteria as described in Article 16 of Regulation (EC) No 1305/2013 and was recognised by Finnish Food Safety Authority in 2013. Sikava herd health visits are performed 4–6 times a year, or once for each batch in finishing units, by a trained herd health veterinarian. During this visit, the veterinarian records his/her observations for the herd in the central database, including the incidence of tail biting damage. If a high level of lesions is recorded, the system launches an alert to both the Sikava staff, and the slaughterhouse to whom the producer sells his pigs. In addition, the herd health veterinarian estimates and records the percentage of intact tails.

Pig production in Finland

Finland produced about 175.7 million kg pig meat in 2020 (The Central Union of Agricultural Producers and Forest Owners (MTK), 2021), with the majority being for national consumption (Ruokatieto, 2020). The number of sows in Finland was 82 000 in 2019, and the number of finisher pigs was 495 000. The average farm size for pig farms was about 2 000 pigs, including all types of animals (Ruokatieto, 2020). Based on data from one of the biggest slaughterhouses in Finland, the average sow number is about 300 in piglet producing units, with the majority of pigs being produced on farms above these average sizes. The biggest farm has 3 500 sows. On finisher units, the average number of pig places is 1 200, with the largest farms having approximately 6 000 pig places (Immonen, N, 2021, personal communication). There were about 850 pig farms in Finland in 2020 (MTK, 2021). Almost all pigs in Finland are raised in insulated buildings because of the cold climate. Organic production is very uncommon (only 0.4% of the pork production, Ruokatieto, 2020). The normal pig production cycle is as follows (Finnish Centre for Animal Welfare (EHK), 2021): most sows farrow in farrowing crates, piglets are weaned at approximately 4 weeks, after which they are moved to the growing unit until they are approximately 10 weeks of age, or weigh 25–30 kg. After this, they are moved to the finishing unit, either on the same farm (integrated farms) or sold to a separate finishing farm, and slaughtered at the live weight of about 105–115 kg (EHK, 2021). Most pigs produced in Finland are either Danish (DanAvl) or Norweigan (Topigs Norsvin) genetics, while a smaller proportion is from a Finnish breeding line (Figen).

Typical features of pig farms in Finland

The way pigs are kept in Finland is influenced to a large extent by more or less binding recommendations or production guidelines given by the slaughterhouses to their customer farms. These often go beyond the legislative minimum. Some of these are summarised below and in Table 1. Pigs are typically kept in groups of about 15–25 pigs (growing unit) and 10–15 pigs (finishing unit) (EHK, 2021). In the growing unit, it is common with a roof-covered area to ensure a proper climate for the recently weaned pigs. Large slaughterhouse recommendations for space allowances are above the legal minimum (eg 0.9–1-0 m^2 for finisher pigs (AtriaSika, 2012; Vugts J, 2021, personal communication)). This was also reflected in the study by Munsterhjelm et al. (2015), including 95 units with finisher pigs: the average space allowance for finisher pigs was over 1 m^2 per pig. It must be noted, however, that this study was based on the situation on the specific day of the herd visit, and might not reflect a full picture of the situation on these farms.

Finnish grower-finisher pigs are typically meal-fed with liquid feed from long troughs, especially in the finishing units (85% of farms, Valaja J, 2020, personal communication). If fed from *ad libitum* automatic feeders, the recommendation by the competent authority (CA) is two feeding places for every 10 pigs (Evira, 2014a). The CA recommendations further suggest that there should be at least one drinker per 10 pigs, and at least two drinkers in each group of pigs. Liquid feed does not compensate for fresh water, and water lines cannot be turned off regularly (Evira, 2014a). Finnish pig farms often produce their own feed grain (Kallio et al., 2018), and barley is the most important grain used (Ruokatieto, 2021).

Straw is a commonly used manipulable material (Valros et al., 2016; Heinonen et al., 2021), but very few farms have deep-straw bedding for finisher pigs (Munsterhjelm et al., 2015). The most typical way (over 80%) of keeping pigs is on partly slatted floors (Munsterhjelm et al., 2015; Kallio et al., 2018; EHK, 2021). Thus, most producers add a small amount of straw, or other similar materials, to the pen floor, or use hayracks. Governmental measures to improve pig welfare in Finland include the use of animal welfare subsidies for improving farm conditions: producers can get part of their costs covered if they eg. use bedding or additional manipulable materials on their farms, which goes beyond the legislative minimum (Ruokavirasto, 2020).

As mentioned earlier, most Finnish pig farms (about 90% of the farms, 97% of the production) belong to the common health care system Sikava (www.sikava.fi). This means that the farms are regularly visited by a veterinarian, who compiles a health care plan, as well as checks the housing and animal health situation regularly. The health status of pigs in Finland is good when it comes to infectious diseases. Finland is free of several important pig diseases, such as porcine reproductive and respiratory syndrome (**PRRS**), transmissible gastroenteritis (**TGE**), porcine respiratory coronavirus (**PRCV**) and porcine epidemic diarrhoea (**PED**). The prevalence of sarcoptic mange, swine enzootic pneumonia, swine dysentery, atrophic rhinitis and salmonella is very low in the country and these diseases are controlled in the Sikava system (Heinonen M, 2021, personal communication). The high health status of Finnish pigs is mirrored in the comparably low use of antimicrobials (EMA, 2018). Antimicrobial treatments for finishing pigs are usually due to musculoskeletal conditions, tail biting lesions or infections in the respiratory or digestive tract (Stygar et al., 2020).

Vaccinations officially recommended for pig production include those against parvovirus, erysipelas and *Escherichia coli* (Ruokavirasto, 2020). In addition, most herds are vaccinated against porcine circovirus 2 infection and some against respiratory pathogens, swine influenza and *Actinobacillus pleuropneumoniae* (**APP**) or pathogens in the digestive system, including *Lawsonia intracellularis* and *Clostridium perfringens* (Ruokavirasto, 2020; Heinonen M, 2021, personal communication).

Finnish pigs have a comparably good growth rate, with an average daily gain expectance being over 900 g/day for finisher pigs (AtriaSika, 2012). Regarding production costs, Finland is rather average in comparison to other EU countries. Costs for building and labour are high in Finland, while feed costs are on the lower range (Hoste, 2020).

Prevalence of tail biting lesions in Finland

According to the official statistics from meat inspection (Ruokavirasto, 2021b) the level of tail biting lesions in Finnish pigs was between 0.9 and 1% during the last five years (2016–2020). However, it needs to be noted that only severe cases of biting lesions are recorded as part of meat inspection, and in reality, a much higher number of pigs are bitten. A recent study including over 14 000 pigs at one slaughterhouse during one week showed that only 49.2% of the tails were fully intact, while 36.7% had healed damage and 14.1% fresh damage (of which 2.5% were considered as major wounds) (Valros et al., 2020). An earlier study at the same slaughterhouse, from a period when a proportion of pigs were still tail docked, showed a similar amount of tail damage in 2000: in total 34.6% were scored as damaged, with 11.7% fresh lesions and 1.3% severe lesions (Valros et al., 2004).

On-farm results on tail damage have been reported in a few studies: Results from Sikava herd health visits to 84 finisher farms (Heinonen et al., 2021) showed that the most common recording by veterinarians was that tail damage was present in 1–5% of the pigs (58 herds), followed by none or single animals affected by tail damage (21 herds). No herds were scored as having tail damage in more than 10% of the pigs. Further, the veterinarians scored the percentage of intact tails in these herds to be over 95% in 43 herds, over 80% in 23 herds and over 70% in 17 herds. An on-farm study including detailed assessment of approximately 600 pigs on four farms showed that 64% of the grower pigs and 75% of the finisher pigs had intact tails (Valros, *unpublished data*).

To put these numbers into proportion, they should be compared to other studies with similar data from undocked pigs. It must, however, be noted that recording and scoring systems differ greatly between studies and countries, so results should be compared with caution. In Sweden and Norway, both countries where tail docking is totally prohibited, tail damage levels recorded as part of meat inspection are between 1 and 4% (Wallgren et al., 2019). When researchers recorded tail lesions at slaughterhouses in Sweden, the prevalence was reported to be around 7% (Keeling et al., 2012). Approximately 1.7% of pigs were missing half of the tail. Further, a UK study revealed a 9% tail damage proportion in undocked pigs, with 0.5% missing a part of the tail. These studies do not separate healed tail damage, thus, it seems like Finland is comparable to other non-docking populations. Interestingly, several studies on docked pigs have shown rather high levels of lesions despite the vast majority of the pigs being docked: when researchers have collected the data at the slaughterhouse, the number of non-lesioned tails varied between 28 and 75% (Harley et al., 2012; Harley et al., 2014; Van Staaveren et al., 2016; Lemos Teixeira et al., 2016; Vom Brocke et al., 2018)

Risk factors for tail biting: the Finnish perspective

Feed and water

When talking to Finnish producers, they frequently refer to feeding-related issues as the most important for reducing the risk of tail biting. This was also shown in the questionnaire-based study by Valros et al. (2016). There are, however, few studies that pinpointed which features of feed and feeding are risk factors for tail biting. Regarding feed composition, very few studies report significant effects of specific ingredients; but some of the ingredients mentioned in relation to tail biting include wheat and whey (Kallio et al., 2018), protein (van der Meer et al., 2017), tryptophan (Martinez-Trejo et al., 2009), and fibre (Naya et al., 2019). These studies, however, do not provide any support for the feed used in Finland to be especially protective against tail biting. While liquid feeding is the most common system in Finland, Kallio et al. (2018) actually reported it as a risk factor for tail biting. A more interesting aspect of feeding might be the way feed is given to the pigs, in Finland typically as meal feeding from long troughs. According to some studies, tail biting typically occurs around the feeder (Sutherland et al., 2009; Palander et al., 2012), and *ad libitum* feeders might increase the time pigs spend around feeders. Palander et al. (2013) further suggested an increase in competition for feed in *ad libitum* fed pigs compared to pigs meal-fed from long trough. Especially if the feeder space in *ad libitum* feeding system is low, it does seem to be a risk factor for tail biting (Hunter et al., 2001; Moinard et al., 2003).

Making sure all pigs have access to water was ranked as a very important preventive measure by both Finnish (Valros et al., 2016) and UK producers (Valros and Barber, 2019). The Finnish recommendation of at least two drinkers per pen might reduce the risk that pigs are left without water for a prolonged time, as water delivery disturbances have anecdotally been reported as a big risk for tail biting outbreaks (Valros and Barber, 2019).

Space allowance and group size

There is clear evidence for a link between space allowance and tail biting (eg. Moinard et al., 2003; Munsterhjelm et al., 2015; Scollo et al., 2016; Grümpel et al., 2018), but it is difficult to separate the effect of animal density from other features of the pen causing competition for resources, such as feeder space. Larsen et al. (2018) performed a study, which addressed space allowance specifically and did not find an effect of animal density on the risk of tail biting. However, a combination of decreased density and supplying straw significantly reduced the risk for tail lesions. Additionally, producers in several countries, including UK (Valros and Barber, 2019), The Netherlands (Bracke et al., 2013) and Sweden (Wallgren et al., 2016) ranked space allowance as one of the most important measures when it comes to preventing tail biting. The higher space allowance recommendations in Finland, as compared to, for example, the minimum level according to the EU Pig directive might, regardless if the effect comes from density itself or from interactions with other factors, be a protective factor against tail biting. In the study by Munsterhjelm et al. (2015), tail biting prevalence on-farm decreased when space allowance increased from 0.7 to 1.5 m^2 per finishing pig.

Especially finisher pigs are kept in rather small groups in Finland, while grower pigs are housed in slightly larger groups, often resulting in the mixing of pigs from at least two litters at weaning. There are very few studies of how group size influences the risk for tail biting. Kallio et al. (2018), however, found an increased risk for tail biting on finisher farms with pigs in pens of more than 10 animals. Wallgren et al (2019) proposed several mechanisms for why a small group size might have a preventive effect on tail biting, such as a lower number of potential victims per pen, and better possibilities for identifying biters and victims if tail biting does occur. Finally, it reduces the need for mixing litters when forming the group.

Use of manipulable materials

The use of appropriate manipulable materials is considered one of the most important preventive measures against tail biting by researchers (EFSA, 2007; D'Eath et al., 2014), even though not necessarily by producers (Bracke et al., 2013; Valros et al., 2016; Valros and Barber, 2019). Lack of manipulable material might cause frustration to the pigs, as they cannot fulfil their intrinsic motivation to explore the environment (Edwards and Valros, 2021). Straw is suggested to be the most efficient material in reducing the risk of tail biting (EFSA, 2007; 2014). Indeed, studies

have reported straw to be an efficient preventive measure (Larsen et al., 2018; Wallgren et al., 2019) and the more straw is used, the better (Wallgren et al., 2019). Also producers rank straw as the best material to prevent tail biting (Valros et al., 2016; Valros and Barber, 2019). Some solid manipulable objects reduce the risk of tail biting, including fresh wood (Telkänranta et al., 2014a), branched chains (Bracke and Koene, 2019) and jute sacks (Ursinus et al., 2014a), and can be especially effective if a variation of objects is provided (Chou et al., 2019). However, a recent review by Buijs and Muns (2019) concluded that solid objects are only moderately effective in reducing the tail biting risk.

The way the EU directive on using manipulable materials has been implemented and is enforced in Finland (ie. either bedding-type, rootable material available all the time, or added twice daily in combination with permanently fitted solid objects), as well as the fact that most farms do use straw should effectively reduce the tail biting risk. Straw dispensers are increasingly popular on Finnish farms (personal experience by the author). A couple of studies have found that providing straw in straw dispensers is not very effective in reducing tail lesions (Bulens et al., 2015; Holling et al., 2017). However, the effectiveness of straw racks might be dependent on how easily pigs can remove straw from these: in both these studies, the amount used by pigs was rather small.

In addition to providing a regular possibility to explore, manipulable materials might also have a buffering effect when welfare problems occur, as suggested by Edwards and Valros (2021). In this case, the material works as a distraction or outlet for frustration when pigs are faced with other challenging situations. Some preliminary support for this theory was presented by Heinonen et al. (2021) who found an interactive effect of use of wood as enrichment and leg problems in reducing the risk for tail lesions on Finnish farms. This indicates that wood might buffer the negative effect of leg problems.

Use of manipulable materials is not only important in the current environment of pigs but throughout the lives of pigs. Tail biting lesions have been reported already in lactating piglets (Ursinus et al., 2014b; Hakansson et al., 2020), and both epidemiological evidence (Moinard et al., 2003) and experimental studies (Munsterhjelm et al., 2009; Telkänranta et al., 2014b) show that early access to manipulable material can reduce the risk for tail biting and severe lesions. In Finland, the legislative regulation regarding use of manipulable material is applied to all pigs, independent of housing system or age of the animals, thus including also lactating piglets.

Flooring

A high proportion of slatted flooring is a risk factor for tail biting (Moinard et al., 2003; Kallio et al., 2018). To my knowledge, however, there are no detailed studies on whether the type of slats, or the proportion of drainage, is also important. In Finland, fully slatted flooring is not allowed in new or renovated buildings since 2013, and will be fully banned in 2028. Studies show that partly slatted flooring is the most commonly used system (Munsterhjelm et al., 2015; Kallio et al., 2018), and according to personal experience, both fully slatted and fully solid flooring is very uncommon. However, even after 2028, the so-called solid flooring part of the pen can be partly drained, with the limit for draining being 10% of the floor area. Floors with large holes make it difficult to use bedding-type materials efficiently, which probably is one reason why slatted floors are problematic when it comes to tail biting (EFSA, 2007). Fully slatted floors also make it more difficult for pigs to separate the pen into different activity areas, and might increase the risk for a high level of noxious gases (Schrøder-Petersen and Simonsen, 2001). However, a study by Philippe et al., (2016) actually showed a higher level of gaseous emissions when drainage was lower (2.5 vs 15%), and suggested it might be due to clogging of the smaller holes, thus reducing the drainage capacity of the floor.

Health, medication and production

Recently, more and more evidence has been presented on the link between tail biting and health. It is commonly assumed that tail biting lesions are a risk for secondary infections. Several studies have shown associations between tail lesions and slaughter findings such as abscesses, arthritis and lung lesions (eg. Van Staaveren et al., 2016; Vom Brocke et al., 2018; Valros et al., 2020), while only few studies actually show evidence that these infections have spread from the tail lesion itself (Sihvo et al., 2011). More interesting from the point of view of preventing tail biting is the recent research showing that ill-health might actually increase the risk for developing tail biting behaviour. Nordgreen et al. (2020) suggested that social behaviour might be influenced by immune activation in a recent review. The link could be mediated by cytokines and neurotransmitters, and the outcome could be an increased risk for damaging behaviour. For example, Munsterhjelm et al. (2019) and Veit et al. (2021) showed that an experimentally induced sickness response indeed changes the social behaviour of pigs in a way that can increase the risk for damaging biting. Further, Munsterhjelm et al. (2017) reported that certain spontaneous health problems (respiratory problems and lameness) can increase the risk of both becoming a biter and a victim of biting, while Niemi et al. (2011) showed a temporal association between tail lesion diagnosis and locomotory problems.

Finland is free, or almost free, from some of the major infectious swine diseases, and health was one of the strengths on Finnish farms according to the Welfare Quality® assessment scheme (Munsterhjelm et al., 2014). Thus, as sickness might be a risk factor for tail biting, this relatively good situation regarding infectious diseases might help keep tail biting at an acceptable level. It must be noted, however, that Finnish pigs are by no means free of health problems: slaughter findings from 2020 report significant levels of findings, such as pleuritis (23.8%), pneumonia (3.1%), and arthritis (2.9%) (Ruokavirasto, 2021b). Slaughter findings are scored differently in different countries and even slaughterhouses within the same country: in Finland, this seems to be the case especially for pleuritis (Heinonen et al., 2018). Thus, these numbers should be compared to other similar data with great care.

Even though vaccination can induce a similar immune activation to disease challenges, and could thus be thought to increase the risk for damaging behaviour, the evidence from pigs is somewhat contradictory. Almond and Bilkei (2006) reported reduced 'cannibalism-related waste' in pigs vaccinated against *Lawsonia intracellularis*. Further, ear necrosis was reduced by vaccination against PCV2 (Papatsiros, 2012). Some of the vaccines commonly used in Finland could be effective in reducing the risk for tail biting. Vaccines are applied to prevent respiratory problems (circovirus, APP), which has been proposed to be linked to biting behaviour (Munsterhjelm et al., 2017), and digestive tract infections (eg *Lawsonia intracellularis*). Diarrhoea has been suggested as a potential indicator for poor health that can lead to tail biting (European Commission, 2017) which is anecdotally said to increase the risk for tail biting at least in weaner pigs (Vugts J, 2021, personal communication).

An increase in tail biting lesions will increase the need for antimicrobials (Stygar et al., 2020). However, Diana et al. (2017) showed that antimicrobials *per se* might actually increase damaging behaviours. They reported less ear biting behaviour in pigs not given in-feed antibiotics in comparison to those that were given them. Thus, the relatively low level of antimicrobial use in

Finland (EMA, 2018) could be a positive feature also in this respect. However, the influence of antimicrobial treatment in the study by Diana et al. (2017) was suggested to be due to a higher growth rate, and thus feeding motivation, in the pigs fed antimicrobials, which would be contra-indicatory, as the growth rate of Finnish pigs is rather good. Indeed, a link between a high growth rate and an increased risk for tail biting behaviour has recently been shown in grower pigs and is suggested to be related to a high feeding motivation (Hakansson and Houe, 2020; Valros et al., unpublished data).

The link between growth rate and tail biting is not, however, straightforward: several studies have shown that tail bitten pigs grow less than non-victims (Sinisalo et al., 2012; Marques et al., 2012). Further, small pigs are often anecdotally suggested to be prone to become performers tail biting (Schrøder-Petersen and Simonsen, 2001). Rather few studies have been able to support this, however: Munsterhjelm et al. (2016) reported that piglets that were to become performers of so-called tail-in-mouth-behaviour were smaller at birth and Beattie et al. (2005) reported a lower weight at weaning and at 7 wks of age in pigs that showed much tail biting behaviour.

Farm size

The herd size of Finnish farms is moderate. Even though herd size has not directly been linked to the risk for tail biting by experts (EFSA, 2007), this might still indirectly influence the risk of tail biting. According to the questionnaire study to producers in Finland, farm size correlates positively with how serious a problem producers perceive tail biting to be, and how willing they would be to dock (Valros et al., 2016). Similar findings regarding the willingness to dock were also reported by Bracke et al. (2013). One explanation for this might be that on large farms, there is a reduced caretaker/pig ratio, which makes it challenging to find time for observation of animals and intervening appropriately when tail biting occurs (D'Eath et al., 2016). Indeed, in the questionnaire study by Valros and Barber (2019), a negative correlation between reported tail biting prevalence and ratio of staff per animal was found. The fact that farm size is related to the possibilities to observe animals efficiently is further supported by the finding by Munsterhjelm et al. (2015) that 'found dead' – type mortality rate was higher on larger farms.

Climate and housing conditions

The climate in Finland is rather cold, and characterised by rather large variations between and within seasons (Finnish meteorological institute, 2021). Thus, pig houses need to be insulated and there are high demands on the climate control systems, which are normally artificial. There is some evidence of artificial ventilation systems reducing the tail biting risk Hunter et al. (2001). Holling et al. (2017) presented some evidence that several factors related to indoor climate, including air velocity, temperature and temperature range, as well as ammonia level, were related to the risk of tail lesions. Also producers perceive appropriate temperature, eliminating draughts and maintaining a good air quality as important measures for preventing tail biting (Valros et al., 2016; Valros and Barber, 2019).

Intervention of tail biting outbreaks

Efficient intervention when tail biting outbreaks do occur is important to avoid extensive tail damage (reviewed by Edwards and Valros, 2021). In a practical book aimed at producers and other stakeholders, I suggested (Valros, 2020) that every farm should plan a tailor-made intervention strategy, including having a so-called 'first-aid kit' with novel manipulable materials readily available. Producers have ranked removing biters from pens with tail biting outbreaks as the most effective (Valros et al., 2016; Valros and Barber, 2019) or the most commonly used intervention method (Wallgren et al., 2016). Also, the study by Chou et al. (2019) indicated this to be as efficient as adding ropes. However, they did note that it is challenging to identify the biter, and thus, this method might not be feasible in practice. The fact that sick pens are obligatory according to Finnish legislation probably makes it feasible to remove biters when these are observed, as well as severely bitten victims of tail biting. Further, as discussed previously, as group sizes are normally rather small, and farm size moderate, detecting tail biting in time might help Finnish producers avoid serious tail biting outbreaks by intervening early enough. In addition, tail biting outbreaks might be easier to spot in intact tails, as tucked tails are an important early warning sign (for reviews, see Larsen et al., 2016; Edwards and Valros, 2021).

Producer perceptions

There are a few studies on producer perceptions regarding tail biting from different countries. These provide interesting information on how perceptions are linked to practices and the current situation. An interesting observation from a producer questionnaire study from Finland is that most producers said they would probably not want to dock even if it was legal (Valros et al., 2016). On the other hand, in a similar study of UK producers, many producers specifically commented on the importance of docking (Valros and Barber, 2019). Further, Dutch producers, also used raising docked pigs, showed a high agreement with the statement 'It is better to dock all tails than to run the risk of tail biting even if it concerns just one bitten pig' (Bracke et al., 2013). Further, these studies revealed that producers used very similar arguments to motivate their current practices, even when these were opposite: some UK producers said docking is a welfare-promoting measure, comparable to vaccinations, and thus *not docking* was thought of as cruel to the animals (Valros and Barber, 2019). Oppositely, some Finnish producers said that they did not want to dock as *docking* is cruel to the pig (Valros et al., 2016). Another indication of producers accepting the current state is that in the study by Valros et al. (2016), there was a positive correlation between how much tail biting occurred on the farm and the limit for what was thought to be acceptable.

General discussion and conclusions

As discussed above, several features of Finnish pig production might aid in the successful rearing of undocked pigs, and some of these measures might be useful to consider also in countries where there is a policy to reduce the need for docking. Of course, some features are inherent to the local conditions, and cannot easily be changed, while others are such that they can more easily be influenced by recommendations and legislation. Wallgren et al. (2019) suggested that in order for other EU countries to be able to stop docking pigs, the EU legislation should better match the needs of the pigs, as they claim Swedish legislation does. The same can, even though to a somewhat lesser degree, be stated for the Finnish legislation, but as discussed above also several non-compulsory features of pig production in Finland are of potential value for reducing the risk for tail biting. For example, the comparably larger space allowance, smaller group size, feeding system, use of manipulable materials and reasonable health status in Finland potentially reduce the risk for tail biting. It is, however, important to remember that due to the multifactorial nature of tail biting (EFSA, 2014),

measures need to be tailored to local conditions, taking into account, for example climate, pig breed and building practices.

It must be noted that even though Finnish producers do not appear to perceive tail biting as a very serious problem (Valros et al., 2016), tail biting occurs at significant levels, and there is a need to keep addressing the problem. The study by Heinonen et al. (2021) shows a large variation between farms in tail lesion prevalence, showing that it is possible to achieve good results even without docking pigs, but that there are also farms with challenges. Legislation and recommendations do not always fully reflect the reality, as also evident by the animal welfare inspection results reported above (Ruokavirasto, 2021a; Väärikkälä et al., 2019). Non-compliance with legislation or recommendations on a proportion of farms might explain part of the between-farm variation. Further, studies, from countries where docking is the norm, show that docking does not resolve the problem: studies including only docked pigs show comparable levels of tail lesions to the Finnish undocked population.

One of the important reasons why tail docking is still commonly performed is probably that producers are reluctant to try non-docking (Nalon and de Briyne, 2019; Bracke et al., 2013). Zonderland and Zonderland-Thomassen (2016) suggested that to change this reluctance, there is a need to both increase the motivation of the producers, and their knowledge about how to prevent tail biting and deal with outbreaks Based on this, it can be suggested that the producer is key here: if producers believe they can handle undocked pigs, the need for docking will automatically be reduced. An important part of this process is accepting that tail biting will likely never disappear from modern pig production without very substantial changes in the way pigs are produced. Thus, producers need to accept that continuous actions to prevent tail biting and intervene with outbreaks will be needed. The fact that most farms in Finland belong to the Sikava system means that producers are in regular contact with their veterinarian, which might already provide them with support and motivation to keep improving management on their farms. To aid this process further, I have earlier suggested a farm-specific action plan for systematically reducing the occurrence of tail biting lesions (Valros, 2020). Such a plan should include both the systematic follow-up of tail lesion prevalence as a measure of success of prevention measures, and plans for early detection and intervention. Finally, we have previously suggested that it is important to understand that if producers think they can only revert to non-docking if there is no biting at all, they will never be motivated to do so (Valros and Heinonen, 2015; Valros and Barber, 2019). More importantly, as shown by the Finnish example, an acceptable and manageable level of tail biting can indeed be reached.

It is, of course, impossible to separate the effect of the non-docking policy in Finland from other factors on the outcome measures of the pig production. However, looking at the production results, need for antimicrobial treatments and tail biting lesions, it can be concluded that it is possible to successfully rear pigs without docking their tails in intensive pig production systems. This is further supported by a study using the Welfare Quality® – assessment system on finisher pig farms in Finland: the welfare state of the pigs in Finland was on a higher level compared to other EU countries with comparable data (Spain, Germany, France, UK) (Munsterhjelm et al., 2014).

Ethics approval

Not applicable.

Data and model availability statement

None of the data sources were deposited in an official repository. More information on data sources not publicly available used in the paper can be requested from the author.

Author ORCID

Anna Valros: https://orcid.org/0000-0002-4431-3346.

Author contributions

Anna Valros: conceptualization, methodology, analysis review of literature and other data sources, writing, reviewing and editing the manuscript.

Declaration of interest

None.

Acknowledgements

I thank Mari Heinonen and Camilla Munsterhjelm for constructive comments on manuscript drafts.

Financial support statement

This research received no specific grant from any funding agency, commercial or not-for-profit section.

Transparency Declaration

This article is part of a supplement entitled *Manipulating Pig Production XVIII: Proceedings of the Eighteenth Biennial Conference of the Australasian Pig Science Association (APSA)* supported by the Australasian Pig Science Association.

References

Agricultural Producers and Forest Owners (MTK), 2021. Sianlihantuotanto (Production of pig meat) Retrieved on 23 April 2021, from https://www.mtk.fi/-/sianlihantuotanto-1.

Almond, P.K., Bilkei, G., 2006. Effects of oral vaccination against *Lawsonia intracellularis* on growing-finishing pig's performance in a pig production unit with endemic porcine proliferative enteropathy (PPE). DTW. Deutsche tierarztliche Wochenschrift 113, 232–235.

AtriaSika, 2012. AtriaSika Tuotanto-ohjeet (AtriaPig production guidelines). Retrieved on 23 April 2021, from https://docplayer.fi/790639-Atriasika-tuotanto-ohjeet.html.

Beattie, V.E., Breuer, K., O'Connell, N.E., Sneddon, I.A., Mercer, J.T., Rance, K.A., Sutcliffe, M.E.M., Edwards, S.A., 2005. Factors identifying pigs predisposed to tail biting. Animal Science 80, 307–312.

Bracke, M.B.M., De Lauwere, C.C., Wind, S.M.M., Zonderland, J.J., 2013. Attitudes of Dutch pig farmers towards tail biting and tail docking. Journal of Agricultural and Environmentel Ethics 26, 847–868.

Bracke, M.B.M., Koene, P., 2019. Expert opinion on metal chains and other indestructable objects as proper enrichment for intensively-farmed pigs. PLoS ONE 14, e0212610.

Buijs, S., Muns, R., 2019. A review of the effects of non-straw enrichment on tail biting in pigs. Animals 9, 824.

Bulens, A., van Beirendonck, S., van Thielen, J., Buys, N., Driessen, B., 2015. Straw applications in growing pigs: effects on behavior, straw use and growth. Applied Animal Behaviour Science 169, 26–32.

Chou, J.-Y., Drique, C.M.V., Sandercock, D.A., D'Eath, R.B., O'Driscoll, K., 2019. Rearing undocked pigs on fully slatted floors using multiple types and variations of enrichment. Animals 9, 139.

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., Vosough Ahmadi, 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., Sandoe, 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.

De Briyne, N., Berg, C., Blaha, T., Palzer, A., Temple, D., 2018. Phasing out pig tail docking in the EU—present state, challenges and possibilities. Porcine Health Management 4, 1–9.

Diana, A., Manzanilla, E.G., Calderón Díaz, J.A., Leonard, F.C., Boyle, L.A., 2017. Do weaner pigs need in-feed antibiotics to ensure good health and welfare? PLoS ONE 12, e0185622.

Edwards, S., Valros, A., 2021. Understanding and preventing tail biting in pigs. In: Edwards, S. (Ed.), Understanding the behaviour and improving the welfare of pigs. Burleigh Dodds Science Publishing, Cambridge, UK, pp. 361–400.
European Food Safety Authority (EFSA), 2007. Scientific opinion of the panel on animal health and welfare on a request from Commission on the risks associated with tail biting in pigs and possible means to reduce the need for tail docking considering the different housing and husbandry systems. EFSA Journal 611, 1–13.
European Food Safety Authority (EFSA), 2014. Scientific opinion concerning a multifactorial approach on the use of animal and non-animal-based measures to assess the welfare of pigs. EFSA Journal 12, 3702.
European Commission, 2017. Cutting the need for tail docking. Retrieved on 23 April 2021, from https://ec.europa.eu/food/sites/food/files/animals/docs/aw_practice_farm_pigs_tail-docking_eng.pdf.
European Medicines Agency, 2018. Sales of veterinary antimicrobial agents in 30 European countries in 2016. Retrieved on 23 April 2021, from https://www.ema.europa.eu/en/documents/report/sales-veterinary-antimicrobial-agents-30-european-countries-2016-trends-2010-2016-eighth-esvac_en.pdf.
European Union. Council Directive 2008/120/EC of 18 December 2008 laying down minimum standards for the protection of pigs (Codified version). Off. J. Eur. Union 2009, L47, 5–13. [Google Scholar]
Evira, 2014a. Sian ruokinta (Pig feeding) Retrieved on 23 April 2021, from https://www.ruokavirasto.fi/globalassets/tietoa-meista/julkaisut/esitteet/elaimet/sian_ruokinta_ja_juotto_fi.pdf.
Evira, 2014b. Sairaan sian hoito ja lopettaminen (Care and euthanasia of sick pigs). Retrieved on 23 April 2021, from https://www.ruokavirasto.fi/globalassets/tietoa-meista/julkaisut/esitteet/elaimet/sairaan-sian-hoito-ja-lopettaminen.pdf.
Finnish Animal Welfare Centre (EHK), 2021. Eläintieto.fi. Sika tuotantoeläimenä (The pig as a production animal). Retrieved on 23 April 2021, from https://www.elaintieto.fi/sika/sika-tuotantoelaimena/.
Finnish Food Authority, 2019. Eläintukien valvontaohje vuodelle 2019 (Instructions for inspections of animal subsidies 2019). Retrieved on 23 April 2021, from https://www.ruokavirasto.fi/globalassets/tietoa-meista/asiointi/oppaat-ja-lomakkeet/viljelijat/tuet-ja-rahoitus/valvonta/elaintukien-valvontaohje.pdf.
Finnish Food Authority, 2020. Sikarokotteet (Pig vaccinations). Retrieved on 23 April 2021, from https://www.ruokavirasto.fi/yritykset/elainlaakarit/palvelut-elainlaakareille/rokoteneuvonta/elainlajikohtaiset-rokotteet-ja-rokotussuosituksia/sikarokotteet/.
Finnish Food Authority, 2021a. Animal welfare control. Retrieved on 21 June 2021, from https://www.ruokavirasto.fi/en/farmers/animal-husbandry/animal-welfare/animal-welfare-control/.
Finnish Food Authority, 2021b. Lihantarkastustilastoja (Meat inspection statistics). Retrieved on 23 April 2021, from https://www.ruokavirasto.fi/yritykset/elintarvikeala/teurastus/lihantarkastus/tilastointi/.
Finnish Meteorological Institute, 2021. Climate in Finland. Retrieved on 23 April 2021, from https://en.ilmatieteenlaitos.fi/.
Grümpel, A., Krieter, J., Veit, C., Dippel, S., 2018. Factors influencing the risk for tail lesions in weaner pigs (Sus scrofa). Livestock Science 216, 219–226.
Hakansson, F., Lahrmann, H.P., Forkman, B., 2020. A longitudinal study of pre-and post-weaning tail damage in non-docked pigs. Animal 14, 1–18.
Hakansson, F., Houe, H., 2020. Risk factors associated with tail damage in conventional non-docked pigs throughout the lactation and rearing period. Preventive Veterinary Medicine 184, 105160.
Harley, S., More, S.J., O'Connell, N.E., Hanlon, A., Teixeira, D.L., Boyle, L.A., 2012. Evaluating the prevalence of tail biting and carcase condemnations in slaughter pigs in the Republic and Northern Ireland, and the potential of abattoir meat inspection as a welfare surveillance tool. Veterinary Record 171, 621.
Harley, S., Boyle, L.A., O'Connell, N.E., More, S.J., Teixeira, D.L., Hanlon, A., 2014. Docking the value of pigmeat? Prevalence and financial implications of welfare lesions in Irish slaughter pigs. Animal Welfare 23, 275–285.
Heinonen, M., Bergman, P., Fredriksson-Ahomaa, M., Virtala, A.-M., Munsterhjelm, C., Valros, A., Oliviero, C., Peltoniemi, O., Hälli, O., 2018. Sow mortality is associated with meat inspection findings. Livestock Science 208, 90–95.
Heinonen, M., Välimäki, E., Laakkonen, A.-M., Toppari, I., Vugts, J., Fàbrega, E., Valros, A., 2021. Evaluation of tail lesions of finishing pigs at the slaughterhouse: associations with herd-level observations Frontiers in Veterinary. Science. https://doi.org/10.3389/fvets.2021.650590.
Holling, C., Grosse Beilage, E., Vidondo, B., Nathues, C., 2017. Provision of straw by a foraging tower – effect on tail biting in weaners and fattening pigs. Porcine Health Management 3, 4.
Hoste, R., 2020. International comparison of pig production costs 2018; Results of InterPIG. Report 2020-007. Wageningen Economic Research, Wageningen, The Netherlands.
Hunter, E.J., Jones, T.A., Guise, H.J., Penny, R.H.C., Hoste, S., 2001. The relationship between tail biting in pigs, docking procedure and other management practices. Veterinary Journal 161, 72–79.
Kallio, P.A., Janczak, A., Valros, A.E., Edwards, S.A., Heinonen, M., 2018. Case control study on environmental, nutritional and management-based risk factors for tail-biting in long-tailed pigs. Animal Welfare 27, 21–34.
Keeling, L.J., Wallenbeck, A., Larsen, A., Holmgren, N., 2012. Scoring tail damage in pigs: an evaluation based on recordings at Swedish slaughterhouses. Acta Veterinaria Scandinavica 54, 32.
Larsen, M.L.V., Andersen, H.M.L., Pedersen, L.J., 2016. Can tail damage outbreaks in the pig be predicted by behavioural change? Veterinary Journal 209, 50–56.
Larsen, M.L.V., Andersen, H.M.L., Pedersen, L.J., 2018. Which is the most preventive measure against tail damage in finisher pigs: Tail docking, straw provision or lowered stocking density? Animal 12, 1260–1267.
Lemos Teixeira, D.L., Harley, S., Hanlon, A., O'Connell, N.E., More, S.J., Manzanilla, E. C., Boyle, L.A., 2016. Study on the association between tail lesion score, cold carcass weight, and viscera condemnations in slaughter pigs. Frontiers in Veterinary Science 3, 24.
Marques, B.M.F.P.P., Bernardi, M.L., Coelho, C.F., Almeida, M., Morales, O.E., Mores, T. J., Borowski, S.M., Barcellos, D.E.S.N., 2012. Influence of tail biting on weight gain, lesions and condemnations at slaughter of finishing pigs. Pesquisa Veterinaria Brasileira 32, 967–974.
Martinez-Trejo, G., Ortega-Cerrilla, M.E., Rodarte-Covarrubias, L.F., Herrera-Haro, J. G., Figueroa-Velasco, J.L., Galindo Maldonado, F., O., Sánchez-Martínez, Lara-Bueno, A., 2009. Aggressiveness and productive performance of piglets supplemented with tryptophan. Journal of Animal Veterinary Advances 8, 608–611.
Moinard, C., Mendl, M., Nicol, C.J., Green, L.E., 2003. A case control study of on-farm risk factors for tail biting in pigs. Applied Animal Behaviour Science 81, 333–355.
Munsterhjelm, C., Peltoniemi, O.A.T., Heinonen, M., Halli, O., Karhapaa, M., Valros, A., 2009. Experience of moderate bedding affects behaviour of growing pigs. Applied Animal Behaviour Science 118, 42–53.
Munsterhjelm, C., Valros, A., Kuismin, A., 2014. Loppuraportti: Sikojen hyvvnvointi kilpailuvaltiksi – Welfare Quality® - järjestelmän pilotointi Suomessa. Retrieved on 23 April 2021, from https://finnishpigwq.edublogs.org/files/2014/02/WELFARE-QUALITY-LOPPURAPORTTI-2013_Lopullinen-ycahip.pdf.
Munsterhjelm, C., Heinonen, M., Valros, A., 2015. Application of the Welfare Quality® animal welfare assessment system in Finnish pig production, part II: Associations between animal-based and environmental measures of welfare. Animal Welfare 24, 161–172.
Munsterhjelm, C., Heinonen, M., Valros, A., 2016. Can tail-in-mouth -behaviour in weaned piglets be predicted by behaviour and performance? Applied Animal Behaviour Science 184, 16–24.
Munsterhjelm, C., Nordgreen, J., Aae, F., Heinonen, M., Olstad, K., Aasmundstad, T., Janczak, A.M., Valros, A., 2017. To be blamed or pitied? The effect of illness on social behavior, cytokine levels and feed intake in undocked boars. Physiology and Behaviour 179, 298–307.
Munsterhjelm, C., Nordgreen, J., Aae, F., Heinonen, M., Valros, A., Janczak, A.M., 2019. Sick and grumpy: Changes in social behaviour after a controlled immune stimulation in group-housed gilts. Physiology and Behaviour 198, 76–83.
Nalon, E., de Briyne, N., 2019. Efforts to ban the routine tail docking of pigs and to give pigs enrichment materials via EU law: where do we stand a quarter of a century on? Animals 9, 132–137.
Naya, A., Gertz, M., Hasler, M., Große Beilage, E., Krieter, J., 2019. Does a higher content of fibre in the piglet diet have an influence on tail biting in growing pigs? Livestock Science 223, 133–137.
Niemi, J.K., Sinisalo, A., Valros, A., Heinonen, M., 2011. The timing and treatment of tail biting in fattening pigs. In: Proceedings of the 24th NJF Congress "Food, Feed, Fuel and Fun - Nordic Light on Future Land Use and Rural Development", 14–16 June 2011, Uppsala, Sweden, pp. 50–55.
Nordgreen, J., Edwards, S.A., Boyle, L.A., Bolhuis, J.E., Veit, C., Sayyari, A., Marin, D.E., Dimitrov, I., Janczak, A.M., Valros, A., 2020. A proposed role for pro-inflammatory cytokines in damaging behaviour in pigs. Frontiers in Veterinary Science 7, 646.
Palander, P.A., Valros, A., Heinonen, M., Edwards, S.A., 2012. Supplementary feed offered to a tail biting pen changes feeding behaviour, feed intake, growth and tail health of fattening pigs. In: Proceedings of the 46th Congress of the International Society for Applied Ethology, 31 July – 4 August 2012, Vienna, Austria, p. 156.
Palander, P., Heinonen, M., Simpura, I., Edwards, S., Valros, A., 2013. Jejunal morphology and blood metabolites in tail biting, victim and control pigs. Animal 7, 1523–1531.
Papatsiros, V., 2012. Ear necrosis syndrome in weaning pigs associated with PCV2 infection: A case report. Veterinary Research Forum. 3, 217–220.
Philippe, F.X., Laitat, L., Wavreille, J., Nicks, B., Cabaraux, J.F., 2016. Floor slat openings impact ammonia and greenhouse gas emissions associated with group-housed gestating sows. Animal 10, 2027–2033.
Ruokatieto, 2020. Tietohaarukka 2020. Retrieved on 23 April 2021, from https://www.ruokatieto.fi/sites/default/files/media/ruokafakta/tietohaarukan_taulukot/tietohaarukka_2020_englanti.pdf.
Ruokatieto, 2021. Sika (Pig). Retrieved on 23 April 2021, from https://www.ruokatieto.fi/ruokakasvatus/ruokaketju-ruuan-matka-pellolta-poytaan/maatila/kotielaimet/sika.
Schrøder-Petersen, D.L., Simonsen, H.B., 2001. Tail biting in pigs. Veterinary Journal 162, 196–210.
Scollo, A., Contiero, B., Gottardo, F., 2016. Frequency of tail lesions and risk factors for tail biting in heavy pig production from weaning to 170 kg live weight. Veterinary Journal 207, 92–98.
Sihvo, H.-K., Simola, O., Munsterhjelm, C., Syrjä, P., 2011. Systemic spread of infection in tail-bitten pigs. In: Proceedings of the 29th meeting of the European Society of Veterinary Pathology, 7-10 September 2011, Uppsala, Sweden, p. 119.
Sinisalo, A., Niemi, J.K., Heinonen, M., Valros, A., 2012. Tail biting and production performance in fattening pigs. Livestock Science 143, 220–225.
Stygar, A.H., Chantziaras, I., Toppari, I., Maes, D., Niemi, J.K., 2020. High biosecurity and welfare standards in fattening pig farms are associated with reduced antimicrobial use. Animal 14, 2178–2186.

Sutherland, M., Bryer, P.J., Krebs, N., McGlone, J.J., 2009. The effect of method of tail docking on tail-biting behaviour and welfare of pigs. Animal Welfare 18, 561–570.
Telkänranta, H., Bracke, M., Valros, Al, 2014a. Fresh wood reduces tail and ear biting and increases exploratory behaviour in finishing pigs. Applied Animal Behaviour Science 161, 50–59.
Telkänranta, H., Swan, K., Hirvonen, H., Valros, A., 2014b. Chewable materials before weaning reduce tail biting in growing pigs. Applied Animal Behaviour Science 157, 14–22.
Ursinus, W.W., Wijnen, H.J., Bartels, A.C., Dijvesteijn, N., van Reenen, C.G., Bolhuis, J. E., 2014a. Damaging biting behaviors in intensively kept rearing gilts: The effect of jute sacks and relations with production characteristics. Journal of Animal Science 92, 5193–5202.
Ursinus, W.W., Van Reenen, C.G., Kemp, B., Bolhuis, J.E., 2014b. Tail biting behaviour and tail damage in pigs and the relationship with general behaviour: Predicting the inevitable? Applied Animal Behaviour Science 156, 22–36.
Valros, A., 2018. Tail biting. In: Spinka, M. (Ed.), Advances in Pig Welfare. Woodhead Publishing Sawston, UK, pp. 137–166.
Valros, A., 2020. Tail biting. In: Camerlink, I. (Ed.), Pigs: Welfare in Practice. 5m Publishing, Sheffield, UK, pp. 116–121.
Valros, A., Ahlstrom, S., Rintala, H., Hakkinen, T., Saloniemi, H., 2004. The prevalence of tail damage in slaughter pigs in Finland and associations to carcass condemnations. Acta Agriculturae Scandinavica A 54, 213–219.
Valros, A., Heinonen, M., 2015. Save the pig tail. Porcine Health Management 1, 2. https://doi.org/10.1186/2055-5660-1-2.
Valros, A., Munsterhjelm, C., Hänninen, L., Kauppinen, T., Heinonen, M., 2016. Managing undocked pigs – on-farm prevention of tail biting and attitudes towards tail biting and docking. Porcine Health Management 2, 2. https://doi.org/10.1186/s40813-016-0020-7.
Valros, A., Barber, C., 2019. Producer perceptions of the prevention of tail biting on UK farms: association to bedding use and tail removal proportion. Animals 9, 628.
Valros, A., Välimäki, E., Nordgren, H., Vugts, J., Fàbrega, E., Heinonen, M., 2020. Intact tails as a welfare indicator in finishing pigs? Scoring of tail lesions and defining intact tails in undocked pigs at the abattoir. Frontiers in Veterinary Science 7, 405.
van der Meer, Y., Gerrits, W.J.J., Jansman, A.J.M., Kemp, B., Bolhuis, J.E., 2017. A link between damaging behavior in pigs, sanitary conditions, and dietary protein and amino acid supply. PloS One 12, e0174688.
Van Staaveren, N., Vale, A.P., Manzanilla, E.G., Teixeira, D.L., Finol, C.L., Hanlon, A., Boyle, L.A., 2016. Relationship between tail lesions and lung health in slaughter pigs. Preventive Veterinary Medicine 127, 21–26.
Veit, C., Janczak, A.M., Ranheim, B., Vas, J., Valros, A., Sandercock, D.A., Piepponen, P., Dulgheriu, D., Nordgreen, J., 2021. The effect of LPS and ketoprofen on cytokines, brain monoamines and social behavior in group-housed pigs. Frontiers in Veterinary Science 7, 617634.
Vom Brocke, A.L., Karnholz, C., Madey-Rindermann, D., Gauly, M., Leeb, C., Winckler, C., Schrader, L., Dippel, S., 2018. Tail lesions in fattening pigs: relationships with postmortem meat inspection and influence of a tail biting management tool. Animal 13, 835–844.
Väärikkälä, S., Hänninen, L., Nevas, M., 2019. Assessment of welfare problems in Finnish cattle and pig farms based on official inspection reports. Animals 9, 263.
Wallgren, T., Westin, R., Gunnarson, S., 2016. A survey of straw use and tail biting in Swedish pig farms rearing undocked pigs. Acta Veterinaria Scandinavica 58, 84.
Wallgren, T., Larsen, A., Lundeheim, N., Westin, R., Gunnarsson, S., 2019. Implication and impact of straw provision on behaviour, lesions and pen hygiene on commercial farms rearing undocked pigs. Applied Animal Behaviour Science 210, 26–37.
Zonderland, J.J., Zonderland-Thomassen, M.A., 2016. Behavioural change by pig producers is the key factor in raising pigs with intact tails. Veterinary Journal 211, 1–2.