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Review

Assessing tail-biting in slaughtered pigs – a comprehensive overview

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Abstract

Tail-biting is a damaging behaviour in pigs, and its occurrence is widely regarded as a reliable indicator of impaired animal welfare. Tail-docking has been the most widespread preventive measure; however, it causes acute pain, and therefore represents a welfare concern in itself. European Union legislation prohibits the routine tail-docking. Nevertheless, compliance remains inconsistent, and tail-docking continues to be widely practiced in many Member States, as well as in major pig-producing countries outside the European Union. There is growing interest in using abattoirs as suitable and cost-effective tools for monitoring pig health and welfare. Despite this, inconsistencies in recording practices hinder the reliable use of meat inspection data for animal welfare surveillance. This review provides an updated overview of tail-biting assessment at slaughter, with particular focus on the main features of available scoring methodologies, which could serve as a basis for developing an effective and widely accepted scoring system.

Keywords

pig, slaughterhouse, tail-biting, tail-docking, lesions, scoring methods

Introduction

Animal welfare is a cornerstone of livestock production, deeply influencing animal health, herd productivity, and the quality and safety of animal-derived products (Broom, 2010; Fraser, 2008). Beyond its role in production systems, animal welfare has become a societal priority. Increasing concern for the ethical treatment of farm animals has led to the adoption of stringent welfare standards, which are essential for maintaining consumer trust and securing market access (Miele et al., 2011). Within the European Union (EU), this has made animal welfare a central policy objective, driving the development of comprehensive legislation and the continuous refinement of husbandry practices (Alonso et al., 2020).

Although ideas about animal sentience and moral duty to prevent suffering trace back to the Enlightenment, animal welfare emerged as a distinct scientific field in the mid-20th century. A turning point came with Ruth Harrison's book "Animal Machines" (1964), which exposed the conditions of intensively farmed animals to the public. The resulting Brambell Committee report (Brambell, 1965) laid the groundwork for modern animal welfare science and policy.

At present, animal welfare is regarded as a multidimensional concept shaped by ethical perspectives, societal expectations, and scientific progress. Despite decades of study, no globally accepted definition exists. A prevailing view holds that welfare depends on the balance between positive and negative experiences, both of which must be evaluated to determine whether an animal has a "life worth living" (Reimert et al., 2023).

In contemporary scientific discourse, animal welfare is understood as an intrinsic, dynamic state that fluctuates over time and can be evaluated through multiple indicators. These are both context- and species-specific, and usually grouped into three main categories:

- Resource-based measures related to the physical and structural environment, such as space allowance or flooring type.

- Management-based measures reflecting human practices, such as mutilation procedures (e.g., castration, tail-docking) or preventive health programmes.

- Animal-based measures (ABMs) directly assessing the animal's state, such as lameness scoring or postmortem lesion recording. Thus, ABMs capture the animal's response to both resources and management, being generally considered as the most informative ones. However, they can be time-consuming to apply and may pose challenges to objective interpretation. Among ABMs are included "abattoir-based-measures", data collected from slaughtered animals and valuable to assess health, welfare, or production performance at the population level (Alonso et al., 2020; Botreau et al., 2009; Czycholl et al., 2015; De Luca et al., 2021).

Tail-biting: basic knowledge and key features

Tail-biting is a damaging behaviour in pigs, commonly defined as the oral manipulation of the tail leading to visible lesions and/or avoidance responses in the victim. This behaviour has become increasingly evident after the expansion of indoor pig farming, and it is frequently reported in herds characterized by high stocking density, barren environments (e.g., lack of manipulable substrates, inadequate ventilation), suboptimal nutrition, or poor health status. Therefore, the occurrence of tail-biting is widely regarded as a reliable indicator of impaired animal welfare (Schrøder-Petersen & Simonsen, 2001; Taylor et al., 2010).

Tail-biting is a heterogeneous and multifactorial issue, and three main forms are commonly distinguished:

a) Two-stage tail-biting – During the "pre-damage" phase, one pig gently manipulates the tail of a conspecific, usually when both animals are resting or standing quietly, without any apparent discomfort to the recipient. This behaviour is often interpreted as a redirection of pigs' intrinsic exploratory and foraging tendencies. In some cases, oral manipulation may injure the skin, and subsequent bleeding can trigger further biting episodes, escalating into the "damaging" stage (Taylor et al., 2010).

b) Sudden-forceful tail-biting – This form onsets abruptly, often with a single forceful bite that produces severe injury. It is less common than the two-stage type and typically arises when pigs are active and competing for limited resources, such as feed or water (Bagaria et al., 2022).

c) Obsessive (or fanatical) tail-biting – In this case, one or a few individuals persistently search for and bite tails, often causing extensive damage, irrespective of resource availability or environmental conditions. The relationship with the above two forms of tail-biting remain unclear, though a link cannot be ruled out (Bagaria et al., 2022).

Accurate classification of tail-biting outbreaks is crucial for effective prevention and control. For instance, the prompt removal of biters is essential in cases of obsessive tail-biting, whereas improving access to feeders and drinkers may contribute to resolving sudden-forceful episodes (Taylor et al., 2010).

Tail-docking - i.e. the partial amputation of piglets' tails, shortly after birth - has been the most widespread preventive measure, as it reduces the risk of tail-biting (Hunter et al., 1999; Sutherland & Tucker, 2011). Nevertheless, 30-70% of European farms have some degree of tail-biting despite tail-docking (EFSA, 2007). Moreover, this practice is associated with acute pain and possible long-term hypersensitivity, and it is therefore considered a relevant welfare concern (Noonan et al., 1994; Simonsen et al., 1991).

Within the EU, Council Directive 2008/120/EC banned the routine tail-docking, allowing it as the last resort after environmental and management improvements have been implemented. Nevertheless, compliance remains inconsistent, and tail-docking continues to be widely practised in many Member States (EFSA, 2007; Harley et al., 2014). At present, tail-docking is strictly forbidden in Finland and Sweden. Beyond the EU, less than 5% of pigs are tail docked in Norway and Switzerland (De Briyne et al., 2018; EFSA, 2007), whereas the procedure is allowed and routinely performed in major pig-producing countries, such as the USA, Brazil, and China (FAO, 2020).

Tail-biting lesions are primarily traumatic in nature, and their gross morphology is influenced by multiple factors, including tail length (docked *vs.* undocked), outbreak severity, the time elapsed between onset and observation, the occurrence of secondary infections, and slaughtering methods (Schrøder-Petersen & Simonsen, 2001). Explanatory images of the most common tail-biting lesion patterns are shown in Figure 1.

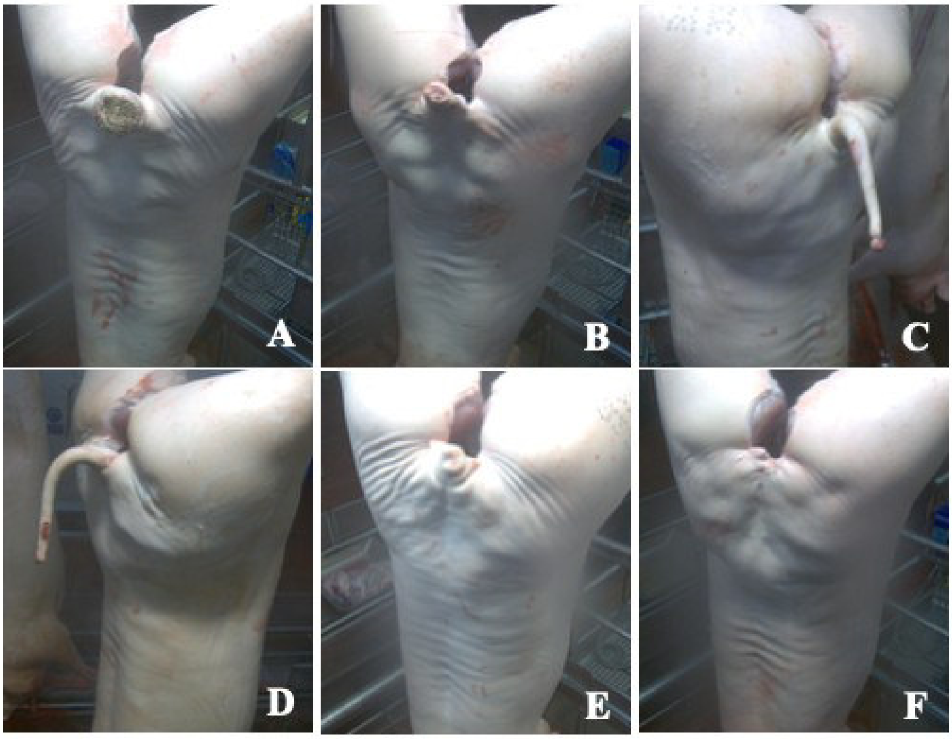

Figure 1. Tail-biting lesions in slaughtered pigs. Large necrotic–ulcerative lesions on the tip of the tail stump (A, B). An undocked tail missing its flat tip, which is scarred and deformed (C). Ulcerative lesion on the lateral surface of the tail (D). Healed partial (E) and complete (F) tail loss.

The assessment of pig welfare at the slaughter

Although useful and somewhat irreplaceable, the on-farm assessment of welfare is labour-intensive and time-consuming. Therefore, there is a growing interest in meat inspection at abattoirs as a suitable and cost-effective tool to monitor pig health and welfare, under relatively standardized and controlled conditions (De Luca et al., 2021; Grandin, 2017; Harley et al., 2014). Notably, abattoir-based assessments reduce the need for on-farm visits thereby enhancing biosecurity, an aspect of increasing relevance in the context of recurrent animal health emergencies such as African swine fever, foot-and-mouth disease, and lumpy skin disease (Brünger et al., 2019; Carroll et al., 2016).

At slaughter, most of the detectable lesions are chronic in nature, compatible with animal survival and often still visible weeks or months after their onset (Luppi et al., 2013). This consideration is essential when selecting suitable abattoir-based measures and interpreting their significance. Furthermore, available datasets are often subject to intrinsic biases: they typically originate from large abattoirs, emphasize severe conditions (e.g., carcass condemnations), and are influenced by slaughtering procedures (Brünger et al., 2019; Harley et al., 2014). Despite these limitations, abattoir data remain a valuable source of epidemiological information, particularly when integrated with farm-level records.

This review provides an updated overview of tail-biting assessment at slaughter, with a particular focus on available scoring methodologies. Overall, 54 scientific papers were selected and analysed in depth (see Table 1 for details).

Main features of studies investigating tail-biting in slaughtered pigs

Geographic and temporal distribution of investigations

Articles were classified according to the country where each investigation was carried out, rather than to the authors' affiliations, although these two variables often overlapped. As reported in Table 1 and illustrated in Figure 2, most studies were conducted in Western Europe, particularly within the EU Member States.

Regarding the temporal distribution of studies, data are summarized in Figure 3. Using 2008 – i.e., the year of the EU ban on routine tail-docking – as a reference point, it is noteworthy that 49 out of 54 reviewed papers were published thereafter. These findings suggest that, although tail-biting substantially affects farm profitability and meat quality, EU animal welfare legislation has been a major driving force behind scientific research on tail lesions in slaughtered pigs.

Figure 2. Heat map showing the geographic distribution of investigations about tail biting assessment in slaughtered pigs. It appears evident that almost all studies have been carried out in Western Europe.

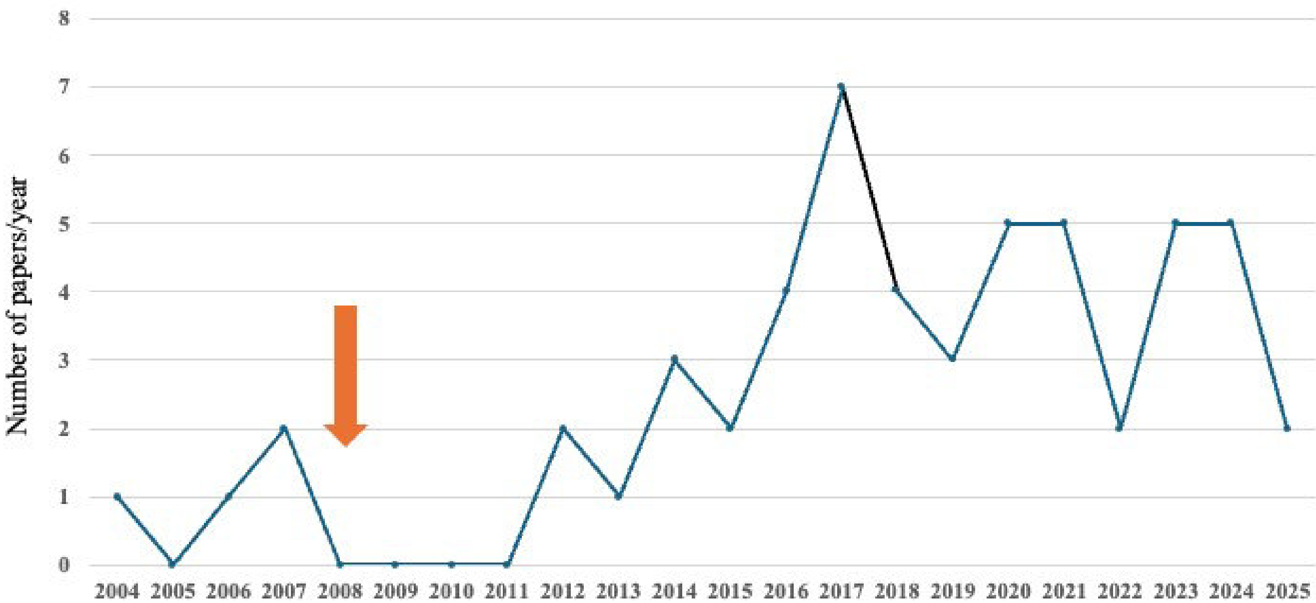

Figure 3. Temporal distribution of investigations about tail biting assessment in slaughtered pigs. Most of papers have been published after 2008 (red arrow).

Sample size, main features of tails (undocked vs. docked) and prevalence of lesions

The number of investigated pigs varied widely, ranging between 141 and 20,468,000 animals, thus reflecting the heterogeneous nature and aims of the studies (Table 1). In some cases, data were obtained from experimental studies involving relatively small cohorts, whereas others relied on large-scale surveillance datasets routinely collected at slaughter, encompassing millions of animals.

Studies including more than one million pigs reported very low prevalences (0.18–3%), whereas those involving fewer than 10,000 pigs reported mean prevalences exceeding 20%. As noted by several authors, data routinely collected at slaughter tend to underestimate the true prevalence of lesions due to multiple, interrelated factors: (a) the huge number of pigs processed daily; (b) the high speed of slaughter lines in high-throughput abattoirs (up to 700–800 pigs per hour); (c) the scoring systems employed, which are often binary and focus primarily on severe lesions (Alban et al., 2013; Alban et al., 2015; D'Alessio et al., 2023b; Harley et al., 2012; Keeling et al., 2012). As an example, in Sweden tail lesions are routinely recorded when at least half of the tail is missing, or clear signs of bite damage are seen (Keeling et al., 2012; Wallgren et al., 2024).

Tail-docking represents a critical factor when evaluating tail-biting prevalence at slaughter. As shown in Table 1, this information was explicitly reported in 36 articles: 8 studies examined pigs with undocked tails, 19 focused exclusively (or almost exclusively) on docked pigs, and 9 included both categories.

The comparison of datasets is challenging and strongly influenced by methodological choices, such as the definition of a "healthy" tail. Therefore, the absence of a statistically significant difference between docked and undocked pigs is not unexpected when prevalence rates are interpreted at face value, without applying any additional selection criteria (Figure 4). Nevertheless, studies directly comparing the two categories consistently report a higher prevalence of lesions in undocked pigs (Amatucci et al., 2023; Gomes et al., 2022; Gomes-Neves et al., 2024; Lahrmann et al., 2017; Menegon et al., 2025; Scollo et al., 2023; Teixeira et al., 2024).

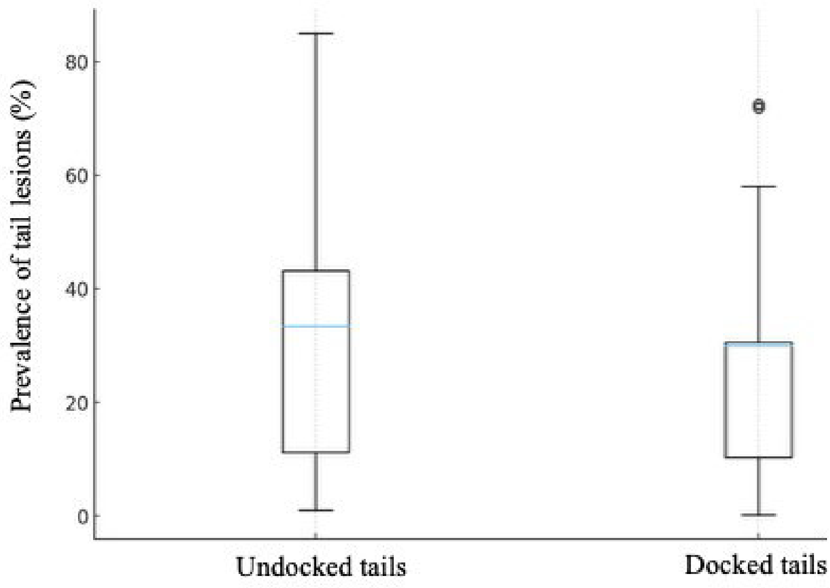

Figure 4. Prevalence of tail biting lesions in slaughtered pigs. Overall, no significant difference has been observed between pigs with docked or undocked tails (Mann–Whitney U test, U=155.5; p=0.423).

Scoring methods adopted

Overall, 12 distinct scoring systems were identified (see Tables 2 and 3 for details), and this number would be even higher if minor modifications proposed by individual authors were also considered. Such an intricate landscape hampers the comparative analysis of the data (Keeling et al., 2012; Valros et al., 2020). The following sections aim to bring some clarity to this complex field of investigation, by outlining the most notable features of each method.

Methods targeting undocked tails

A total of 3 scoring systems have been specifically developed for assessing tail lesions in pigs with undocked tails (Gerster et al., 2022; Keeling et al., 2012; Valros et al., 2020). All these methods focus on tail length (i.e., the percentage of tail loss) as a key parameter for evaluating tail-biting severity on-farms. Among the most comprehensive ones is that proposed by Valros et al. (2020), which has been developed in Finland and thereafter adopted by other authors (Heinonen et al., 2021). This method combines the visual inspection of the entire tail with the palpation of the tail tip. Notably, Valros et al. (2020) critically discussed some points, which should be carefully considered when applying or comparing tail-lesion scoring systems:

- Arbitrary lesion size threshold - the 2 cm cut-off used to classify acute lesions as "minor" or "major" is likely inappropriate, as most lesions are considerably smaller.

- Definition of a healthy tail – although apparently easy, this definition is often subjective and difficult to apply consistently. The distinction between healthy and bitten tails should be based on palpation of the last caudal vertebra, which is typically flat in pigs. However, this approach is unfeasible in high-throughput slaughterhouses and incompatible with automated lesion detection systems using computer vision. Valros et al. (2020) concluded that the definition of a healthy tail represents a compromise, which could reasonably apply to tails longer than 24 cm (i.e., >75% of the average length) and without severe acute lesions or bite marks.

- Exclusion of swelling - unlike other scoring systems (e.g., Keeling et al., 2012), swelling was excluded from the Valros et al. (2020) method, as it was difficult to assess reliably and characterized by high inter-observer disagreement.

Gerster et al. (2022) and Keeling et al. (2012) likewise emphasized the importance of tail loss in undocked pigs. Interestingly, Gerster et al. (2022) focused exclusively on lesions located at the tip of the remaining tail, considering fully healed lesions as milder. This approach sounds simplified but very practical, as tail-biting damage most commonly occurs at the tip.

The method proposed by Keeling et al. (2012) is among the most detailed. However, scores were grouped for data analysis purposes (score 0-to-2 = no injury; score 3-to-5 = injury). In addition, it classified "small" and "major" sores based on their length and depth, following a shared understanding among observers but without a clear definition, thus making it difficult its adoption by other investigators.

Methods developed regardless of tail-docking

The most widely adopted system is that proposed by Kritas and Morrison (2007), originally developed by the same authors to assess tail-biting in pigs under farm conditions (Kritas & Morrison, 2004). Its broad use underscores both its robustness and practical relevance. Nonetheless, several authors have modified this method to better fit their research aims and/or to address specific limitations:

- The original scoring categories have been often collapsed, as certain classes are poorly represented and/or difficult to distinguish. Notably, the greatest challenges arise in identifying healthy tails, mild and chronic lesions (Haigh et al., 2019; van Staaveren et al., 2017a; van Staaveren et al., 2017b).

- Gomes et al. (2022) explicitly incorporated the evaluation of healed lesions, with or without tissue loss and/or tail shortening.

- Carroll et al. (2018), Gomes et al. (2022), and van Staaveren et al. (2016) considered tail length as an informative parameter for assessing fully healed stump amputations. As a matter of fact, tails shortened beyond the standard docking length (e.g., <5 cm) are interpreted as severe lesions (i.e., partial tail loss) on-farm. This is not without criticism, as docking length can vary widely and may lead to subjective evaluations in the absence of background information. In contrast, Brunger et al. (2019) and vom Brocke et al. (2019) observed that different degrees of tail loss could not be assessed because of tail-docking," while Keeling et al. (2012) stated that tail length cannot be considered to score lesions in docked tails. Finally, Harley et al. (2012) noted that tail-docking may result in the underestimation of biting–related amputations that occurred earlier in the production cycle.

The Kritas and Morrison method places considerable emphasis on swelling, a feature included in other scoring schemes (Amatucci et al., 2023; D'Alessio et al., 2023a; D'Alessio et al., 2024; Franco et al., 2021; Vitali et al., 2021a; Vitali et al., 2021b), even though this has been questioned by vom Brocke et al. (2019).

Among the most simplified systems are those established within national frameworks. A total of 13 studies employed a binary scoring approach (presence/absence of lesions), focusing on the detection of severe cases (see Table 1 for details).

Managing inter-rater agreement

As highlighted by Alban et al. (2013), *"meat inspection data have their inherent weakness such as some degree of variation in the meat inspectors' way of recording…and this variation is supposed to be larger between abattoirs compared to within an abattoir"*. In addition, the amount of work *per* person leads to a lack of repeatability and comparability of data, which can be partially managed through training programmes (Blömke et al., 2020). Therefore, training meat inspectors is a key factor for a reliable welfare assessment (van Staaveren et al., 2017b).

Tail lesion scoring shows a strong subjective component (Brünger et al., 2019). The inter-rater agreement issue has been tackled through a variety of approaches, thus influencing the robustness and comparability of data. Considering this, reviewed articles can be classified as follows.

Articles computing inter-rater agreement during the investigation

Brünger et al. (2019) and vom Brocke et al. (2019) estimated the agreement before and during data collection, on *ad hoc* sets of pictures, with the median PABAK ("prevalence-adjusted bias-adjusted" kappa) being 0.75 and 0.83, respectively. Notably, the agreement was higher for tail loss (i.e., for severe lesions; median PABAK = 0.87).

Keeling et al. (2012) observed no significant difference among raters after collapsing their scores (i.e., "no injury" vs. "injury"), while an overall significant difference was shown when applying the 6-point scale method. The inconsistency between observers was mainly due to lesions of lower severity (class 2) and possibly not caused by tail-biting. Moreover, a significant difference was also observed for the tail length scores, even when the 5-point scale was transformed into a 2-point scale (i.e., >50% vs. <50%).

Blömke et al. (2020) reported inter-observer reliability ranging between 0.53 and 0.66 (Krippendorff's alpha coefficient), using a binary scoring method (i.e., presence/absence of tail lesion). Moreover, they estimated the intra-observer agreement (i.e., score given at postmortem inspection vs. image analysis), yielding a value of 0.71 (Krippendorff's alpha coefficient).

Articles estimating the inter-rater agreement during the training period

Carroll et al. (2016), Teixeira et al. (2023; 2024), and Van Staaveren et al. (2017b) state that a suitable agreement was preliminary achieved, using different statistical methods.

Articles managing inter-rater agreement through shared assessment by multiple observers

Heinonen et al. (2021) and Valros et al. (2020) report that each tail was evaluated by at least two observers, who consulted each other in case of questionable findings and jointly agreed the final score.

Articles relying on a single observer's evaluations

Several articles fall into this group (Amatucci et al., 2023; Calderón Díaz et al., 2018; Carroll et al., 2018; Chou et al., 2018; Chou et al., 2020; D'Alessio et al., 2023a; D'Alessio et al., 2023b; Franco et al., 2021; Gerster et al., 2022; Gomes-Neves et al., 2024; Teixeira & Boyle, 2014; Teixeira et al., 2016; van Staaveren et al., 2015; van Staaveren et al., 2017b; Vitali et al., 2021a; Vitali et al., 2021b). This seems to be an oversimplified solution to the issue. As stated by Gerster et al. (2022), any examination performed by a single person introduces a substantial bias into the study results.

The relevance of slaughter-related artifacts

This point is closely related to the previous one, as it depends on the observer's skills, sensitivity and experience. There are conflicting opinions about the effect of carcass processing (i.e., scalding and dehairing) on the visibility of tail lesions. Worthy of note, Carroll et al. (2016) examined the tails at two different points of the slaughter chain, showing that lesions are more visible after scalding and dehairing rather than at exsanguination, regardless of their severity. Reasonably, this results from the removal of dirt and hair, which could hide some lesions (e.g., bruises).

Moreover, Heinonen et al. (2021) and Valros et al. (2020) observed a moderate correlation between scores given pre- and post-scalding, the latter being more accurate.

On the other hand, slaughter-related artifacts could make lesion detection more difficult and/or lead to interpretative mistakes, especially when "visual-only" methods are employed (Carroll et al., 2016; D'Alessio et al., 2023a; van Staaveren et al., 2015). Therefore, Gerster et al. (2022), Haigh et al. (2019), and Keeling et al. (2012) decided to score tail lesions before scalding, whereas Kongsted et al. (2020) carried out their investigation in a single abattoir to manage this variable.

Main challenges due to carcass processing are listed below and shown in Figure 5:

- discolouration at the base of the tail has been associated with carcass brushing, thus interfering with the assessment of low severity lesions (Brünger et al., 2019; Valros et al., 2020; vom Brocke et al., 2019);

- hair burns can be misclassified as minor injuries (Valros et al., 2020);

- tails can lose their tips after scalding, thus preventing the detailed assessment of lesions and length (Valros et al., 2020);

- the singeing process could result in red-brownish marks on the tail, thus mimicking inflammatory changes (Carroll et al., 2016; D'Alessio et al., 2023a);

- skin breakage and small bruises due to tail-biting could be misjudged as slaughter-related artifacts, and vice versa (D'Alessio et al., 2023a).

As noted by Brünger et al. (2019), this issue remains "*despite training, due to the great variation regarding colour and size along continuous gradients*".

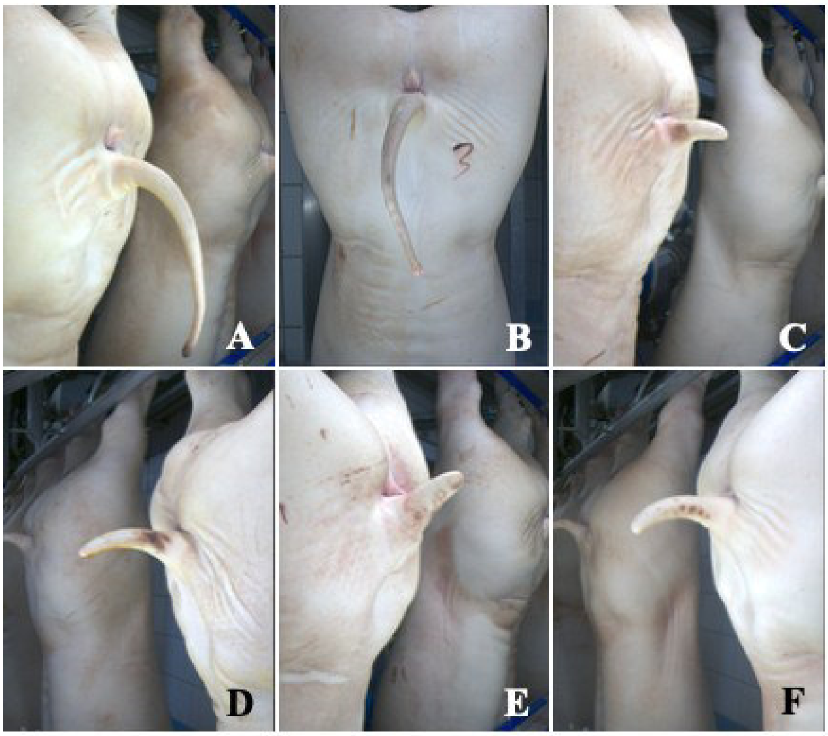

Figure 5. Common artifacts due to slaughtering process. (A) Browning of tip of an undocked tail. (B) The flat tip of the tail detached ("broken tail"), no signs of haemorrhage and/or inflammation being evident. Reddish discolorations of various shapes and sizes (C-F), mainly visible at the base of the tail (C, D). Similar changes are also visible on the rest of the carcass.

Slaughter vs. on-farm assessment of tail lesions

Slaughterhouse assessments are informative insofar as they accurately reflect on-farm welfare. Therefore, it is important to understand whether scores recorded at slaughter correlate with those observed on-farm. Such investigations are methodologically demanding, time-consuming, and often show a number of weaknesses and biases: a) assessments are conducted at a batch level (Keeling et al., 2012; Teixeira et al., 2024; Valros et al., 2020); b) different scoring systems are applied to alive and slaughtered pigs (D'Alessio et al., 2023b); c) pigs evaluated on-farm are not necessarily the same as those inspected at slaughter (Heinonen et al., 2021; van Staaveren et al., 2017b); d) a time gap often separates on-farm and post-mortem observations (Haigh et al., 2019; van Staaveren et al., 2017b); e) severely affected pigs may die or be euthanized before slaughter, thereby escaping inspection (Franco et al., 2021; Harley et al., 2012); f) chronic and healed lesions may go undetected at the abattoir (Franco et al., 2021; Harley et al., 2012); g) lesions resulting from transport, lairage, and antemortem handling are not representative of on-farm welfare (D'Alessio et al., 2023a; Valros et al., 2020; van Staaveren et al., 2017b).

Most of the few available studies indicate that a weak-to-moderate correlation exists between slaughter and on-farm tail-biting assessments, with scoring at slaughter being usually considered more detailed (D'Alessio et al., 2024; Grosse-Kleimann et al., 2021; Heinonen et al., 2021; van Staaveren et al., 2016; van Staaveren et al., 2017b). On the contrary, Gerster et al. (2022) observed no significant correlation between batch classification at the abattoir and on-farm, while Teixeira et al. (2024) reported a lower prevalence of tail lesions at slaughter than on farm.

Imaging analysis and automated scoring systems

According to D'Alessio et al. (2023a), visual-only assessment provides a valid alternative to handling-based evaluation of tail lesions, as the two scoring approaches exhibit a strong correlation. More in detail, the visual-only method is very effective at detect moderate-to-severe lesions, while its performances are lower for mild lesions. This encourages the development of automated scoring methods based on computer vision technologies (Brünger et al., 2019; vom Brocke et al., 2019), which could allow the collection of data on a large scale, even in high-capacity abattoirs. To date, two articles have been published about the assessment of tail lesions on pictures:

- Brünger et al. (2019) trained neural networks, their agreement with human observers ranging from 74% for tail lesions to 95% for tail loss.

- Blömke et al. (2020) developed an algorithm to detect tail lesions, which gained good values of sensitivity (77.8%), specificity (99.7%), and accuracy (99.5%) when compared with human observers, its agreement ranging between 0.42 and 0.75 (Krippendorff's alpha coefficient).

Conclusive remarks

Monitoring tail lesions ("iceberg indicator") at slaughter should be implemented to identify welfare problems on pig farms (EFSA, 2022). However, inconsistencies in recording methods limit the reliable use of meat inspection data for animal welfare surveillance. To address this issue, scoring systems should be harmonized, and tail lesions of different types and severities should be consistently recorded to provide meaningful feedback to farmers (Harley et al., 2012; Heinonen et al., 2021; Valros et al., 2020).

In our opinion, the key elements of the "ideal scoring method" can be summarized as follows:

- The scoring method should be simple, easily standardized, and at the same time informative. Using too complex methods affects inter-observer agreement, and it often makes necessary to collapse scores, as some of them are poorly represented or difficult to be reliably identified (Haigh et al., 2019; Harley et al., 2012; Keeling et al., 2012; Kritas & Morrison, 2007; van Staaveren et al., 2016; van Staaveren et al., 2017a; van Staaveren et al., 2017b; vom Brocke et al., 2019).

- Chronic/healed lesions should be carefully considered, as they are prevalent at slaughter (Bottacini et al., 2018; Gerster et al., 2020; Gomes et al., 2022; Kongsted et al., 2020).

- Although challenging, the definition of "healthy tail" is crucial for accurately collecting and interpreting data (Valros et al., 2020).

- Visual-only methods are preferable, as palpation is unfeasible as a routine under field conditions (D'Alessio et al., 2023a).

- Despite slaughter-related artifacts, tail lesions should be scored after scalding and dehairing, when they are much more evident (Carroll et al., 2016; D'Alessio et al., 2023a; Valros et al., 2020; vom Brocke et al., 2019).

- Mild lesions cause most of the inter-rater discrepancies, while being less relevant to assess welfare on-farm. For instance, bruises could result from antemortem handling, animal transport, or "tail in mouth" behaviour rather than from tail-biting. Likewise, superficial scratches are likely unrelated to tail-biting, being usually detectable throughout other portions of the carcass (D'Alessio et al., 2023a; Valros et al., 2020; van Staaveren et al., 2015; vom Brocke et al., 2019).

- The development of automated systems is desirable, as they would allow for the collection of objective measurements (e.g., tail length), managing the issue of inter-observer agreement (Blömke et al., 2020; Brünger et al., 2019; D'Alessio et al., 2023a).

- Measuring tail length is very useful to assess biting-related amputations, especially in undocked tails. However, tail length varies considerably within the pig population, likely due to genetic factors. It might be more informative to examine such data by batch, evaluating how values are dispersed around the mean (Keeling et al., 2012; Teixeira et al., 2024).

- Tail length assessment could be valid for docked tails, background information making this task easier and the results more reliable. In this regard, we point out that a few countries have established guidelines about the permitted length of tail-docking (van Staaveren et al., 2016). For instance, no more than half of the tail may be removed in Denmark, according to national legislation and welfare guidelines (Danish Agriculture & Food Council, 2023).

The features listed above could be the starting points for an effective and widely accepted scoring system.

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Ethical approval

Not applicable

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author Contributions

Conceptualization: GM, ACD; Methodology: GM, ACD; Formal analysis: GM, ACD; Writing original draft preparation: GM, AR; Writing, review and editing: GM, ACD, AR; Project administration: ACD; Funding acquisition: GM, ACD; All authors have read and agreed to the published version of the manuscript.

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Supplementary material

Authors	Country	Sample size	Scoring method	Evaluation of inter-rater agreement	Evaluation of slaughter artifacts	Prevalence values of tail-biting (%)	Tail length
Alban et al. (2013)	Denmark	1,760,535	Established at national level	n.d.	n.d.	0.16-0.29	n.d.
Alban et al. (2014)	Denmark	n.d.	Established at national level	n.d.	n.d.	0.1-0.18	n.d.
Alban et al. (2015)	Denmark	1,374,533	Established at national level	n.d.	n.d.	0.09-0.18	Docked and undocked
Amatucci et al. (2023)	Italy	17,256	Welfare Quality®	n.d.	n.d.	30.09-85.05	Docked and undocked
Blömke et al. (2020)	Germany	5,598	Binary system	Yes	Yes	n.d.	Docked
Bottacini et al. (2018)	Italy	73,200	Ad hoc developed	n.d.	Yes	<2	n.d.
Brünger et al. 2019	Germany	13,124	Ad hoc developed	Yes	Yes	n.d.	Docked
Calderón Díaz et al. (2017)	Republic of Ireland	796	Harley et al. (2012)	n.d.	n.d.	62.9	n.d.
Calderón Díaz et al. (2018)	Republic of Ireland	824	Harley et al. (2012)	n.d.	n.d.	n.d.	Docked
Carroll et al. (2016)	United Kingdom and Republic of Ireland	3,810	Harley et al. (2012)	Yes	n.d.	14.7-30.8	Docked
Carroll et al. (2018)	United Kingdom	532	Harley et al. (2012)	n.d.	n.d.	n.d.	Docked
Chou et al. (2018)	Republic of Ireland	800	Harley et al. (2012)	n.d.	n.d.	n.d.	Docked
Chou et al. (2020)	Republic of Ireland	576	Harley et al. (2012)	n.d.	n.d.	n.d.	Undocked
Ciui et al. (2025)	Germany	307,866	Binary system	n.d.	n.d.	<1.4	n.d.

Correia-Gomes et al. (2016)	United Kingdom	20,468,000	Binary system	n.d.	n.d.	<0.5	n.d.
Correia-Gomes et al. (2017)	United Kingdom	3,100,602	Binary system	n.d.	n.d.	0.2-1	n.d.
D’Alessio et al. (2023a)	Republic of Ireland	5,498	Ad hoc developed	n.d.	n.d.	30.1-36.45	Docked
D’Alessio et al. (2023b)	Republic of Ireland	288	Harley et al. (2012)	n.d.	n.d.	n.d.	Undocked
D’Alessio et al. (2024)	Republic of Ireland	7,197	Ad hoc developed	n.d.	n.d.	30.4	Docked
Fertner et al. (2017)	Denmark	2,906,626	Established at national level	n.d.	n.d.	0.5	n.d.
Flesja et al. (1979)	Norway	256,080	Binary system	n.d.	n.d.	2.29	n.d.
Franco et al. (2021)	Portugal	10,146	Established at national level	n.d.	n.d.	15.6	Docked
Gerster et al. (2022)	Switzerland	195,704	Ad hoc developed	n.d.	n.d.	36.8	Undocked
Gomes et al. (2022)	Spain	3,636	Harley et al. (2012)	n.d.	n.d.	n.d.	Docked and undocked
Gomes-Neves et al. (2024)	Portugal	15,863	Established at national level	n.d.	n.d.	11.5-24.4	Docked and undocked
Grosse-Kleimann et al. (2021)	Germany	24,715	Binary system	n.d.	n.d.	0.76	n.d.
Haigh et al. (2019)	Republic of Ireland	880	Harley et al. (2012)	n.d.	n.d.	n.d.	Docked and undocked
Harley et al. (2012)	United Kingdom and Republic of Ireland	35,288	Kritas et al. (2007)	n.d.	n.d.	58.1	Docked
Harley et al. (2014)	Republic of Ireland	3,422	Harley et al. (2012)	n.d.	n.d.	72.5	Docked

Heinonen et al. (2021)	Finland	10,517	Ad hoc developed	Yes	n.d.	51.9	Undocked
Keeling et al. (2012)	Sweden	15,068	Ad hoc developed	Yes	Yes	7-7.2	Undocked
Kongsted and Sørensen (2017)	Denmark	1,096,756	Established at national level	n.d.	n.d.	1-3	n.d.
Kongsted et al. (2020)	Denmark	2,449	Established at national level	n.d.	Yes	1	Undocked
Kritas and Morrison (2007)	United States of America	20,000	Ad hoc developed	n.d.	n.d.	n.d.	Docked
Lahrmann et al. (2017)	Denmark	1,786	Binary system	n.d.	n.d.	0.32-2	Docked and undocked
Lee et al. (2020)	United Kingdom	4,916,898	Binary system	n.d.	n.d.	0.24-1.36	n.d.
Martinez et al. (2007)	Spain	6,017	Binary system	n.d.	n.d.	2.9	n.d.
Menegon et al. (2025)	Italy	167,607	Binary system	n.d.	n.d.	1-41	Docked and undocked
Scollo et al. (2023)	Italy	52,500	Ad hoc developed	n.d.	n.d.	0.2-44	Docked and undocked
Teiga-Teixeira et al. (2024)	Portugal	318	vom Brocke et al. (2019)	n.d.	n.d.	43.97	n.d.
Teixeira and Boyle (2014)	Republic of Ireland	141	Harley et al. (2012)	n.d.	n.d.	n.d.	n.d.
Teixeira et al. (2016)	Republic of Ireland	3,143	Kritas et al. (2007)	n.d.	n.d.	71.9	Docked
Teixeira et al. (2023)	Chile	13,196	Binary system	Yes	n.d.	4.28	n.d.
Teixeira et al. (2024)	Spain	980	Heinonen et al. (2021)	Yes	n.d.	6-61%	Docked and undocked

Valros et al. (2020)	Finland	14,433	Ad hoc developed	Yes	Yes	41.3-50.8	Undocked
Van Staaveren et al. (2015)	Republic of Ireland	298	Kritas et al. (2007)	n.d.	n.d.	95.3	Docked
Van Staaveren et al. (2016)	Republic of Ireland	5,628	Kritas et al. (2007)	n.d.	n.d.	9.7	Docked
Van Staaveren et al. (2017a)	Republic of Ireland	13,133	Kritas et al. (2007)	Yes	n.d.	30.2	Docked
Van Staaveren et al. (2017b)	Republic of Ireland	6,335	Kritas et al. (2007)	n.d.	n.d.	73.3	n.d.
Vitali et al. (2021a)*	Italy	10,079	Welfare Quality®	n.d.	n.d.	34.08	Docked
Vitali et al. (2021b)*	Italy	10,079	Welfare Quality®	n.d.	n.d.	34.08	Docked
vom Brocke et al. (2019)	Germany	79,954	Ad hoc developed	Yes	Yes	25.4	Docked
Walker and Bilkei (2006)	Croatia	1,454	Kritas et al. (2007)	n.d.	n.d.	14-20	n.d.
Wallgren et al. (2024)	Sweden	27,898	Established at national level	n.d.	n.d.	2.3-11.8	Undocked

*Table I. Detail of reviewed articles. n.d. = not determined; *Articles report the same dataset.*

Reference(s)	Scores					
	0	1	2	3	4	5
Valros et al., 2020	The tail is fully intact. Long hairs grow out from the tail tip	The tail is clearly shortened. The tail end is scarred, of abnormal shape or too thick to be intact. There may still be hairs at the end, but they do not grow from the entire tail tip	There is fresh blood or a reddish scab on the tail, indicative of a lesion	There is a clear dry (brownish) scab/crust on the tail, usually at the end. No fresh (red) blood	A wound with fresh blood or a reddish scab is present, clearly distinguishable from dirt or dry scab. Part of the tail might be missing. Wound is > 0, but <2 cm in diameter or length	A wound with fresh blood or a reddish scab is present, clearly distinguishable from dirt or dry scab. Part of the tail might be missing. Wound is 2 cm or larger in diameter or length
Valros et al., 2020; Teixeira et al., 2024; Heinonen et al., 2021	The tail is fully intact, the end is rounded and slightly flattened	The tail is clearly shortened; the tail end is scarred, of abnormal shape or too thick to be intact. The skin is totally healed (no scab, wound or missing tissue).	There are either bite marks, bruises, or open wounds (missing skin tissue) on the tail	The tail has several small brown or red points, or long scratches, indicative of biting. These might be only bruises (no visible skin damage), or include minor skin damage, but with no tissue missing, and no visible wound; or the tail has a clear violet-colored bruising without tissue damage	The tail has missing tissue, which has not fully healed yet; uneven dents in the skin; or a part of the tail is missing. Wound is > 0, but < 2 cm in diameter or length.	The tail has missing tissue, which has not fully healed yet; uneven dents in the skin; or a part of the tail is missing. Wound is 2 cm or larger in diameter or length
Valros et al., 2020	>24 cm	17-24 cm	9-16 cm	<9 cm		
Gerster et al., 2022	100% of tail is remaining, the endplate is present	75-99% of tail remaining	50-74% of tail remaining	25-49% of tail remaining	1-24% of tail remaining	0% of tail remaining; the base of tail is convex
	No sign of injury, and the endplate is complete	Part of the tail tip is missing, complete cure through re-epithelization or scar tissue	Part of tail tip is missing, tissue damage with no signs of proliferation of granulation tissue	Chronic lesion, part of tail tip is missing, tissue damage with signs of proliferation, re-		

			and/or re-epithelization, bleeding or not bleeding	epithelization or necrosis, bleeding or not bleeding		
Keeling et al., 2012	No injury	Swollen	Small sore or wound	Small sore or wound and swollen	Major sore or wound	Major sore or wound and swollen
	Full length	Greater of 75% of tail length remaining	Between 50 and 75% of tail length remaining	Less than 25% of tail length remaining		

Table II. Scoring methods targeting undocked tails

Reference(s)	Scores					
	0	1	2	3	4	5
Alban et al., 2013, 2014, 2015; Fertner et al., 2017; 55. Kongsted and Sørensen, 2017; Kongsted et al., 2020; Lahrmann et al., 2017		Tail bite, local, limited	Tail bite/tail infection			
Teiga-Teixeira et al., 2024; vom Brocke et al., 2019	No visible lesion	Skin perforated with reddish discoloration, no loss of skin	Skin perforated with reddish discolouration and loss of skin	Skin perforated with brownish or blackish discolouration and loss of skin	Complete loss of tail up to tail base with perforated or healed skin surface	
Amatucci et al., 2023; Vitali et al., 2021a, 2021b	No injury	Superficial bite along the tail caudectomy but no evidence of swelling	Visible open lesion on the tail, presence of scarring, swelling or partial absence of the tail			
Scollo et al., 2023	Absence of tail lesion	Mild tail lesions, acute or chronic	Severe tail lesions, acute or chronic			
Carroll et al., 2016, 2018; Calderón Díaz et al., 2017, 2018; Chou et al., 2018,2020; D'Alessio et al., 2023b; Haigh et al., 2019; Harley et al., 2012, 2014; Kritas & Morrison, 2007; Teixeira & Boyle, 2014; Teixeira et al., 2016; van Staaveren et al., 2015, 2016, 2017a, 2017b; Walker & Bilkei, 2006	No evidence of tail biting	Healed or mild lesions	Evidence of chewing or puncture wounds, no swelling	Evidence of chewing or puncture wounds with swelling and signs of infection	Partial or total loss of the tail	
Franco et al., 2021; Gomes-Neves et al., 2024	No evidence of tail biting	Mild to moderate tail biting with no swelling	Severe tail biting with swelling, signs of possible infection, partial or total loss of the tail			
Brünger et al., 2019	No visible lesion or reddish/violet/ brownish discoloration	Lesion < tail diameter at respective location, with or without loss of tail substance	Lesion ≥ tail diameter at respective location, with or without loss of tail substance			

		No loss or partial loss with more than a stump left (> 3 cm)	Total loss: only a stump protruding from tail base (≤ 3 cm)			
D'Alessio et al., 2023a, 2024	No evidence of tail biting	Minor skin damage to the tail tip without teeth marks	Evidence of teeth marks, with breakage to the skin and redness	Breakage of the skin with redness and swelling	Fresh partial or complete tail loss, an open wound on the tail accompanied by pus or necrotic tissue	Severe tail loss with healing
	Absence of bruises	Presence of bruises				
Gomes et al., 2022	No evidence of tail biting	Superficial lesions only, without the presence of blood	Presence of puncturing wounds associated with tai bites, with possible presence of blood or inflammation	Extended lesion associated with chewing with partial loss of tail tissue but with no loss of tail length	Extended lesion associated with chewing with partial or total loss of tail length	
	No scar	Visible scar with no tissue lost or alteration of tail length (mild scarring)	Visible scar with presumable loss of tail length (severe scarring)			

Table III. Scoring methods developed regardless tail-docking.