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Relationship between tail lesions and lung health in slaughter pigs

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ABSTRACT

Tail lesions are associated with poor health either because they serve as a point of entry for pathogens or because of shared risk factors. This study investigated the relationship between carcass tail lesion and lung lesion severity scores in slaughter pigs. Carcasses were scored after scalding/dehairing for tail lesion severity (0–4). Lungs were scored according to an adapted version of the BPEX pig health scheme. Severity of enzootic pneumonia (EP-like lesions) was recorded on a scale of 0–50. Severity of pleurisy was scored on a 0–2 scale with score 2 equating to severe pleurisy or those lungs that remained attached to the chest wall ('lungs in chest'). The database for assessing pleurisy lesions contained all pleurisy scores (n = 5628). Lungs with a score of 2 for pleurisy were excluded from the analysis of all other lung lesions as such lungs could not be assessed for other lesions (n = 4491). Associations between tail lesions and different lung lesion outcomes were analysed using generalized linear mixed models (PROC GLIMMIX) with random effect for batch.

Males were more affected by moderate (OR = 1.9, 95% CI 1.51–2.34) and severe (OR = 5.8, 95% CI 3.45–9.70) tail lesions than females. EP-like lesions and pleurisy were most commonly observed. Pigs with severe tail lesions tended to have more 'lungs in chest' than pigs with moderate tail lesions (P = 0.1). No other associations between tail lesions and lung lesions were found. Males had higher odds of having EP-like lesions (OR = 1.2, 95% CI 1.05–1.36) than females. Tail lesions on the carcass may not be an accurate predictor of lung health. However, tail lesions are important welfare indicators and respiratory disease is a significant infectious condition affecting pigs. Thus, recording of tail and lung lesions at meat inspection provides valuable information regarding on-farm health and welfare of pigs.

1. Introduction

The primary function of meat inspection conducted at slaughter is to protect public health by ensuring food safety. However the data collected also has potential to serve as a surveillance tool for pig health and welfare on farm (EFSA, 2011; Harley et al., 2012a; Stärk et al., 2014; Vial and Reist, 2014). Pig health schemes such as Wholesome Pigs Scotland (WPS) and BPEX Pig Health Scheme (BPHS) report on a variety of pathological lesions associated with reduced performance or animal welfare problems (Sanchez-Vazquez et al., 2011). Respiratory diseases cause substantial economic losses in intensive pig production (Holt et al., 2011; Merialdi et al., 2012). These diseases are multifactorial resulting from the interaction of infectious agents, host factors and environmental conditions (Merialdi et al., 2012) and their diagnosis, monitoring and control represent a major challenge for the pig industry. Another important challenge for the pig industry is tail biting which has important welfare and economic implications (EFSA, 2007). Tail biting lesions are often associated with carcass condemnations, trimmings and reduced carcass weight, especially when the lesions are severe (Valros et al., 2004; Walker and Bilkei, 2006; Kritas and Morrison, 2007; Marques et al., 2012; Harley et al., 2014). Thus, both tail biting and respiratory disease are among many factors associated with reduced performance. However, the relationship between general pig health and risk of tail biting is uncertain (EFSA, 2014). Clarity on the nature of this relationship is required to assist in resolving both health and behavioural problems on farms. Evaluation of the potential of tail lesions to act as an 'iceberg' indicator of health and welfare issues on farms is also necessary (Spoolder et al., 2011). Damage resulting from tail biting provides a route of entry

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Table 1
Tail lesion scoring system (adapted from Kritas and Morrison, 2007; Harley et al., 2012b).

Score	Description
0	No evidence of tail biting
1	Healed or mild lesions
2	Evidence of chewing or puncture wounds, but no evidence of swelling
3	Evidence of chewing or puncture wounds with swelling and signs of possible infection
4	Evidence of chewing or puncture wounds with severe swelling/infection or open, gaping wound in cases of complete tail amputation

Table 2
Description of lung lesions recorded at meat inspection modified from BPHS (BPEX, 2014; Sanchez-Vazquez et al., 2011; Smith et al., 2011; Ellerbroek et al., 2012).

Disease	Description	Scoring system
Enzootic pneumonia-like lesions (EP-like lesions)	• Red-tan-grey discolouration • Collapsed, firm, rubbery • Cranioventral lobes affected • Lobular pattern	Each pair of lungs is divided into a cranial lobe, middle lobe and caudal lobe. A score is assigned based on the area of the lobe affected. A score of 10 is assigned to the cranial and middle lobes if totally diseased, and a score of 5 to the caudal lobes[a]
Pleuropneumonia (APP)	• Focal bronchopneumonia with overlying pleurisy • Middle or caudal lung lobes affected	Binary: present or absent
Pleurisy	• Inflammation of the pleura • Fibrinous pleural adhesions • Mild or localised form describes discrete areas of inflammation of the pleura • Severe or extensive pleurisy involves whole lobes of the lung	Three categories: 0 absent, 1 mild, 2 severe (incl. lungs attached to chest wall; 'lungs in chest')
Abscess	• Abscesses in the lobes	Binary: present or absent
Pyaemia	• Multiple small abscesses in lung parenchyma	Binary: present or absent

[a] Accessory lobe not scored due to line speed.

for pathogens which can then be haematogenously disseminated to different organs including the lungs (Huey, 1996; Schrøder-Petersen and Simonsen, 2001; Heinonen et al., 2010). This results in an increased risk of carcass condemnation, mostly due to abscess formation (Huey, 1996; Valros et al., 2004; Marques et al., 2012). Pigs with moderate tail lesions had higher odds of having abscesses or pleurisy/embolic pneumonia and this risk increased with more severe tail lesions (Marques et al., 2012). Elbers et al. (1992) also found moderate correlations between tail inflammation and pneumonia, lung abscesses and severe pleurisy. A number of studies examined the occurrence of tail lesions of differing severity but pathological lesions were often scored as binary, i.e. presence or absence, or only when it was the cause of condemnation (Valros et al., 2004; Sanchez-Vazquez et al., 2011; Harley et al., 2012b, 2014). However, Teixeira et al. (2016) suggested that tail bitten pigs may have a higher rate of mild pathological lesions which do not necessarily lead to condemnation. Kritas and Morrison (2007) found no association between severity of tail biting and percentage of lung surface area that was affected by lesions of enzootic pneumonia. Munsterhjelm et al. (2013) reported that victims of tail biting had higher tail lesion scores than tail biting pigs and also had a higher severity score for respiratory organ inflammation.

Apart from providing an entry point for pathogens, tail biting could be associated with lung disease because both conditions share similar risk factors (Stärk, 2000; EFSA, 2007; Jäger et al., 2012). Tail biting also appears to be associated with gastric lesions (van den Berg et al., 2005) because both conditions are elicited by stress (EFSA, 2007; Swaby and Gregory, 2012). Stress suppresses the immune system and thus contributes to increased incidence and duration of disease (Dybkjær et al., 1998; Proudfoot and Habing, 2015). This may explain in part why tail biting is more common on farms where animals are more prone to disease (Moinard et al., 2003).

The objective of this study was to assess the relationship between tail and lung lesion severity scores in slaughtered pigs at one abattoir in the Republic of Ireland.

2. Material and methods

Visits to one abattoir (weekly throughput 15,000 pigs, which represents approx. 25% of pigs slaughtered in Ireland each week) were conducted on 5 days between January and March 2015. A team of three observers worked in 2 shifts of approximately 1.5–2 h each, during which every pig on the line was scored (line speed: 6 pigs/min). After scalding/dehairing, one observer scored carcasses for tail lesions according to severity (Table 1) and recorded sex, kill number and farm identification number. Lungs were removed from the carcass by abattoir personnel. Lungs were identified by attaching numbered pieces of paper which corresponded to the carcass kill/line number by a second observer.

A third observer recorded the number on the lungs and assessed lung lesions using an adapted version of the BPHS scale (Table 2). In brief, severity of enzootic pneumonia (EP)-like lesions was evaluated by assessing the percentage of lung lobe affected by lesions. The main adaptation related to exclusion of the accessory lobe for EP-like lesions due to the line speed. Pleurisy was recorded on a 0–2 severity scale (Table 2). Lungs that remained attached to the chest wall and were not removed from the carcass were automatically given a pleurisy score of 2 and recorded as 'lungs in chest'. Presence of other lung lesions (pleuropneumonia, abscess and pyaemia)

Table 3
The number of pigs, batches (including batch size measures) and farms observed. Data for all pigs (n = 5628) is used for analysis of pleurisy (Dataset 1). Pigs with pleurisy score 2 could not be assessed for other lung lesions and were excluded from analysis of enzootic pneumonia (EP)-like lesions, pleuropneumonia (APP), abscesses and pyaemia (Dataset 2).

	Dataset 1	Dataset 2
Pigs inspected (n)	5628	4491
Males	3114 (55.3%)	2477 (55.1%)
Females	2514 (44.7%)	2014 (44.9%)
Batches (n)	38	38
Median no. pigs	142	110
Min no. pigs	43	38
Max no. pigs	383	274
Farms (n)	26	26

was also recorded (Table 2). Lung number and lesion scores were recorded on a Dictaphone (Sony ICD—PX333D) to allow palpation of the lungs by the observer. Data were transcribed into Excel afterwards by the same observer.

2.1. Statistical analysis

Data from batches smaller than 30 pigs were omitted from analysis. A batch was defined as a group of pigs sent in by a farm on the same day. Some farms sent in multiple batches during the study however each batch was considered separately. Data from pigs for which either the lung and/or the tail lesion scores were missing were discarded.

Prevalence of tail and lung lesions were calculated at animal and within batch level. Tail lesion scores were collapsed into none/mild lesions (score $\leq$1), moderate lesions (score 2) and severe lesions (score $\geq$3). Lungs that had at least one lesion were considered diseased while lungs without any lesions were considered healthy. Lungs with severe pleurisy could not be assessed for the other lung lesions. Therefore, the database for assessing the pleurisy lesions contained all lungs scored (scores of 0–2; n = 5628) while the database for assessing the remaining lung lesions contained animals without pleurisy scores of 2 (n = 4491). EP-like lesion score could not be transformed to normality and therefore the following EP lesion categories were created: no lesions (score 0), mild (score 1–10), moderate (score 11–20), and severe EP (score 21–50) (adapted from BPEX, 2007). Due to the low prevalence of APP, abscesses and pyaemia these were excluded from further analyses.

All statistical procedures were conducted using SAS V9.3 (SAS Inst. Inc., Cary, NC). The dependent variables were the categories of different severity created for pleurisy and EP-like lesions. Binomial models were created for each category modelling the probability that a lesion of that category or higher was observed (e.g. EP score $\geq$11 vs EP score <11). Generalized linear mixed models (PROC GLIMMIX) were used to analyse associations of lung lesions with tail lesion severity and sex separately. Batch was included in the model as a random effect. Results are presented as odds ratio and 95% confidence intervals (95% CI). The prevalence of pleurisy and EP-like lesions was also analysed at batch level in order to examine if shared risk factors could create associations between lung lesions and tail lesion prevalence. Average EP score and tail lesion score was calculated for each batch. Data were transformed for normality where necessary. Analysis was done using linear mixed models (PROC MIXED) adjusted for average tail lesion score. Alpha level for determination of significance was 0.05 and trends are reported from 0.05 to 0.10.

3. Results

Descriptive data for the study population are included in Table 3. Six farms provided two batches and three farms provided three batches during the study.

Prevalence of tail lesions at animal and batch level is presented in Table 4. Male pigs had higher odds of having moderate (OR = 1.9, 95% CI 1.51–2.34) and severe (OR = 5.8, 95% CI 3.45–9.70) tail lesions than female pigs.

Lung lesions were observed in 77.9% of the observed pigs (n = 5628). Table 4 shows the prevalence of different lung lesions observed in the studied pigs. Mild and severe pleurisy were commonly observed although lungs attached to the chest wall were recorded less often. While the average EP-like lesion score was low (4.5 ± 0.11), it ranged from 0 to 44 between pigs. Most carcasses showed either no or mild EP-like lesions, but there was large variation between batches (Table 4). Abscesses were uncommon in the present study but there was some variation between batches. Both APP and pyaemia were rarely observed during the study.

Table 4
The prevalence of tail and lung lesions in observed pig carcasses, average and median batch level prevalence and range. Lungs in chest is a subcategory of severe pleurisy.

	No. of pigs	% of pigs	Average batch prevalence (%)	Median (range) batch prevalence (%)
Tail lesions	5628			
None/mild	5081	90.3	90.0	91.3 (71.1–100)
Moderate	412	7.3	7.2	5.7 (0–19.5)
Severe	135	2.4	2.9	1.6 (0–13.5)
Pleurisy	5628			
No pleurisy	3229	57.4	58.7	58.8 (19.8–95.6)
Mild pleurisy	1262	22.4	21.9	23.2 (1.0–38.8)
Severe pleurisy	1137	20.2	19.4	19.1 (3.1–44.0)
Lungs in chest	145	2.6	2.4	1.7 (0–9.5)
Enzootic pneumonia (EP)—like lesions	4491			
No EP	1879	41.8	41.9	41.9 (9.9–76.9)
Mild EP	2011	44.8	45.5	47.0 (19.8–71.1)
Moderate EP	387	8.6	8.2	6.7 (0–28.4)
Severe EP	214	4.8	4.4	1.6 (0–31.9)
Abscess	4491			
Abscess	35	0.8	0.8	0 (0–4.5)
Pleuropneumonia (APP)	4491			
APP	9	0.2	0.2	0 (0–2.4)
Pyaemia	4491			
Pyaemia	1	0.02	0.02	0 (0–1.1)

Table 5
The number and percentage of pig carcasses (n = 5628) affected by different categories of pleurisy within each tail lesion category: none/mild (score ≤1), moderate (score 2) and severe (score ≥3). Lungs in chest is a subcategory of severe pleurisy. Odds ratio and 95% confidence interval (95% CI) for binomial models of the different pleurisy outcomes and association with tail lesion severity are presented.

Prevalence	Tail lesions					
	None/mild		Moderate		Severe	
	n	%	n	%	n	%
No pleurisy	2896	57.0	252	61.2	81	60.0
Mild pleurisy	1155	22.7	85	20.6	22	16.3
Severe pleurisy	1030	20.3	75	18.2	32	23.7
Lungs in chest	133	2.6	5	1.2	7	5.2

Outcome binomial models	Tail lesions					
	None/mild		Moderate		Severe	
	OR	95%CI	OR	95%CI	OR	95%CI
≥Mild pleurisy (score ≥1)	ref.	ref.	0.8	0.48–1.41	0.8	0.33–2.01
Severe pleurisy (score 2)	ref.	ref.	0.8	0.38–1.88	1.3	0.41–4.43
Lungs in chest	ref.	ref.	0.5	0.20–1.36	2.1	0.82–5.50

Table 6
The number and percentage of pig carcasses (n = 4491) affected by enzootic pneumonia (EP) –like lesions within each tail lesion category: none/mild (score ≤1), moderate (score 2) and severe (score ≥3). Odds ratio and 95% confidence interval (95% CI) for binomial models of the different EP-like lesion outcomes and association with tail lesion severity are presented.

Prevalence	Tail lesions					
	None/mild		Moderate		Severe	
	n	%	n	%	n	%
No EP	1687	41.6	142	42.1	50	48.5
Mild EP	1825	45.1	147	43.6	39	37.9
Moderate EP	348	8.6	31	9.2	8	7.8
Severe EP	191	4.7	17	5.0	6	5.8

Outcome binomial models	Tail lesions					
	None/mild		Moderate		Severe	
	OR	95% CI	OR	95% CI	OR	95% CI
≥Mild EP (score ≥1)	ref.	ref.	0.9	0.46–1.96	1.0	0.28–3.58
≥Moderate EP (score ≥11)	ref.	ref.	1.0	0.61–1.79	1.0	0.36–2.54
Severe EP (score ≥21)	ref.	ref.	1.1	0.53–2.09	1.4	0.47–4.38

3.1. Pleurisy lesions

The association of tail lesion severity and sex was examined for pleurisy (Table 5). The presence of moderate or severe tail lesions did not significantly affect the odds of having pleurisy (P > 0.05, Table 5). However, tail lesion score tended to be associated with retention of lungs in the carcass due to severe pleurisy ('*lungs in chest*'; P = 0.109). This retention of lungs was observed more often in carcasses with severe tail lesions than in those with moderate tail lesions (OR = 4.1, 95% CI 1.10–15.1). No association was found between sex and any of the pleurisy outcomes (P > 0.05).

3.2. EP-like lesions

Average EP-like lesion score increased numerically with increasing severity of tail lesions (none/mild tail lesions: 4.5, moderate tail lesions: 4.7, and severe tail lesions: 5.4). However, no significant association was found between the severity of tail lesion and any of the EP-like lesion categories (Table 6). Sex was significantly associated with EP-like lesion categories. Males consistently had higher odds of having ≥mild EP (score ≥1; OR = 1.2, 95% CI 1.05–1.36), ≥moderate EP (score ≥11; OR = 1.4, 95% CI 1.14–1.66), and severe EP (score ≥21; OR = 1.6, 95% CI 1.16–2.11) than females.

3.3. Batch level

At a batch level, there was no significant association between either pleurisy prevalence or EP score and the average tail lesion score of a batch (P > 0.05).

4. Discussion

The aim of this study was to assess associations between tail lesion and lung lesion scores. In addition, indicative figures for the prevalence of respiratory diseases in Irish slaughter pigs were generated. Such data have not been reported previously; however it should be noted that this study was not designed as a prevalence study and results regarding lung lesion prevalence should be interpreted with caution. Both EP-like lesions and pleurisy were commonly observed during the study, in agreement with other reports (Holt et al., 2011; Merialdi et al., 2012; Eze et al., 2015). The use of different scoring methods makes direct comparisons between studies difficult. Both EP-like lesions (58.2%) and pleurisy (42.6%) prevalence are considerably higher than the 13% for EP-like lesions and 11% of pigs affected by pleurisy reported by Eze et al. (2015) for Northern Ireland. It should be noted that Eze et al. (2015) based their findings on reports of pig health and welfare schemes which only include farms on the scheme and may represent a biased sample. Moreover the study reported here took place during winter when prevalence of EP-like lesions and pleurisy is higher (Eze et al., 2015). Several different factors can impact lung health results, limiting comparisons and deductions between studies (Fablet et al., 2012). Further investigation is needed to assess accurately the lung health status of Irish pigs taking into account farm management and environmental conditions.

Male pigs were more affected by EP-like lesions than females as was previously reported for castrated males (Straw et al., 2006). It may be that males are more predisposed to disease due to sex differences in immune and stress responses (Williams et al., 2009; Proudfoot and Habing, 2015). Indeed it appears that male pigs are more susceptible to stress than females. For example, Ruis et al. (1997) reported higher basal levels of cortisol and an increased response following isolation in males compared to female pigs. Male pigs also showed a reduced response to vaccination after exposure to a stressor compared to control males, while this differences was not observed for female pigs (de Groot et al., 2001). Males are also more likely to be affected by tail lesions this and other studies e.g. (Kritas and Morrison, 2007; Keeling et al., 2012; Harley et al., 2014) but the reasons for this are less well elucidated.

Moderate tail lesions were found in 7.5% and severe tail lesions in 2.3% of the pigs, supporting previous findings (Harley et al., 2012b). The large variation between batches in tail lesion prevalence illustrates that some producers are more successful than others in keeping pigs under conditions which limit tail biting. This can be attributed to the multifactorial nature of the tail biting problem and the difficulty facing producers in identifying proper prevention strategies (EFSA, 2007). Tail damage is associated with other pathological lesions (Schrøder-Petersen and Simonsen, 2001; Heinonen et al., 2010); however conflicting findings are reported in the literature. Average EP-like lesion score increased with increased severity of tail lesions but this finding was not significant. Kritas and Morrison (2007) found a similar increase but no significant association between severity of tail lesions and the percentage of lungs affected by EP-like lesions, possibly because *Mycoplasma hyopneumoniae* does not spread to the lungs haematogenously (Kritas and

Morrison, 2007). Pigs with moderate and severe tail lesions have higher odds for the presence of pleurisy and/or embolic pneumonia (Kritas and Morrison, 2007; Marques et al., 2012). Although the current study reports a higher proportion of pigs with severe pleurisy in severely tail bitten pigs (score ≥3), this difference was not significant. There was a tendency for pigs with more severe tail lesions to have higher odds of lungs attached to the chest wall, compared to pigs with moderate tail lesions. This relationship could be further elucidated by looking at pigs that are euthanised on farm because of severe pleurisy and which would therefore be missed on the slaughterline. Similarly, pigs with severe tail lesions could be euthanised on the farm. Tails which differ from the uniform length observed in a batch (i.e. amputated or much shorter) can be considered to have been severely bitten tails which have healed. While the authors found that this occurrence was rarely observed on the slaughterline (<1%) we suggest that future research could benefit from adding an extra category which covers these cases to elucidate any associations between severe tail lesions and secondary infections (Huey, 1996).

We hypothesised that a relationship would exist between lung lesions and tail lesions as risk factors for tail biting such as mixing or moving of animals, stocking density, and ventilation also affect respiratory diseases (Stärk, 2000; EFSA, 2007; Jäger et al., 2012). Stress is one of the main risk factors for tail biting (EFSA, 2007) and also contributes to the occurence of disease by suppression of the immune system (Dybkjær et al., 1998; Proudfoot and Habing, 2015). Thus there is a plausible explanation for a possible relationship between general poor health and tail biting (EFSA, 2014). While it was suggested that tail biting was more common on farms where animals are more prone to disease (Moinard et al., 2003), we found no relationship between tail lesions and the presence of lung disease at batch level in this study. In contrast, Teixeira et al. (2016) found that average tail lesion score of a batch was associated with the prevalence of lung condemnations for pneumonia, pleuropneumonia and pleurisy based on the decision of the acting veterinary inspector. We found a similar relationship between tail lesion score and lungs being attached to the chest wall (e.g. likely to be condemned for pleurisy) at animal level but were unable to assess this relationship at a batch level due to the low occurrence of lungs attached to the chest wall. Possibly, the association between tail lesions and lung health due to shared risk factors only presents itself in extreme cases (i.e. condemnations).

This study was the first to examine different levels of severity of both tail lesions and lung lesions, however, due to the line speed the lung lesion scoring system was simplified and only scores or categories were recorded for EP-like lesions and pleurisy. Although Nielsen et al. (2015) found a moderate correlation between lung lesions recorded at routine meat inspection and lung lesions recorded at systematic health monitoring, it is suggested that careful assessment of viscera cannot be performed on the slaughterline and that organs should be transferred for a thorough examination (Straw et al., 2006). Differences could be caused by time and observer sensitivity and the differing objectives of public health versus animal health monitoring (Nielsen et al., 2015). This may explain in part why the results of our study are different from those of Teixeira et al. (2016) who found significant associations between tail lesion scores and lung condemnations for pleurisy, pneumonia and pleuropneumonia based on the decision of the veterinary inspector.

Our results suggest that severity of tail biting is not necessarily a predictor of respiratory disease at slaughter, which may reflect the complex aetiology of tail biting behaviour and the multifactorial nature of respiratory disease.

5. Conclusion

This study reports on preliminary findings of prevalence of lung lesions in Irish slaugher pigs. The prevalence of enzootic pneumonia and pleurisy in the investigated herds highlights the need for further investigation which should take into account farm management and environmental conditions. Data on tail and respiratory lesions suggest that measures to improve animal health, animal welfare and reduce economic losses are required on some farms. This study was the first to take into account different levels of severity for both tail lesions and lung lesions. Our results suggest that poor welfare as measured by tail lesions is not necessarily associated with poor lung health in pigs, except in the case of severe pleurisy whereby the lungs remain attached to the chest wall. Although tail lesions on the carcass may not be an accurate predictor of lung health, tail lesions are important welfare indicators and respiratory disease is among the most significant infectious conditions affecting pigs. Thus, recording tail and lung lesions at meat inspection provides valuable information regarding the on-farm health and welfare of pigs.

Conflict of interest

None of the authors of this paper have a financial or personal relationship with other people or organisations that could inappropriately influence or bias the content of the paper.

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