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Original Article

Lesions found at routine meat inspection on finishing pigs are associated with production system

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ABSTRACT

Pigs raised under free-range conditions are expected to experience a higher level of animal welfare than conventionally raised pigs. However, free-range conditions may challenge prevention and treatment of diseases. In order to identify disease problems associated with raising conditions, this study compared slaughter lesions in pigs from conventional indoor, conventional free-range and organic free-range production systems. The study used data from 1,096,756 pigs slaughtered at one Danish abattoir from 1 January 2013 to 31 December 2015. Associations between production system and lesions at slaughter were tested in statistical models taking year, season and herd of origin into account.

Both conventional free-range and organic free-range production systems were associated with increased population averaged odd ratios (OR_{PA}) for several lesions compared with conventional indoor systems. Pigs raised in conventional free-range and organic free-range production systems had higher odds for white liver-spots (OR_{PA}, 5–7), tail lesions (OR_{PA}, 3–4), arthritis (OR_{PA}, 3), skin lesions (OR_{PA}, 3), bone fractures (OR_{PA}, 2), septicaemia (OR_{PA}, 1.1–1.5) and abscesses (OR_{PA}, 1.1–1.3) at slaughter. Pairwise comparisons of the two free-range production systems did not reveal statistically significant differences ($P > 0.05$). In all three production systems, airway infection was the most prevalent disease complex. In contrast to previous studies, this study did not find any association between airway infection and type of production ($P > 0.05$). Three lesions (leg swellings (OR_{PA}, 0.4–0.5), hernia (OR_{PA}, 0.7–0.8) and hoof abscess (OR_{PA}, 0.7–0.9)) had lower ORs in conventional free-range and organic free-range production compared with conventional indoor production. There was a marked herd effect (intraclass correlation coefficients 21–35%) on the occurrence of white liver-spots, tail lesions, skin lesions and airway infections. These results suggest possibilities for herd-level management interventions of the problems studied.

1 Introduction

The ability to express natural behaviour and to have access to outdoor areas is important to pig welfare (Bock and van Huik, 2007; Boogaard et al., 2011; Clark et al., 2016). Absence of disease obviously also plays an important role in animal welfare (Fraser, 1997). In Denmark, conventional free-range and organic free-range systems (together comprising approximately 1% of the total number of pigs slaughtered from Denmark) are the predominant welfare labels, both aiming to provide welfare-friendly and natural environments.

The ability to control disease may be compromised in systems which allow pigs to behave more naturally (Spoolder, 2007). A recent Danish study showed that some slaughter lesions, such as rib fractures, tail lesions and arthritis were more prevalent in pigs raised under free-range conditions than in conventional indoor-housed pigs (Alban et al., 2015). The latter study, which did not distinguish between conventional free-range and organic free-range pigs, underlined the dilemma of welfare-labelled pigs with health issues that compromise animal welfare. Other studies have specifically investigated slaughter lesions in organic vs. conventional indoor pigs (Hansson et al., 2000; Heldmer et al., 2006; Bonde et al., 2010). These studies found a higher prevalence of arthritis, arthrosis and white liver-spots, but a lower level of airway infections, in organically raised pigs.

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Table 1 provides a summary of regulatory conditions for housing and rearing of pigs in conventional indoor, conventional free-range and organic free-range production systems in Denmark. As the table shows, management factors such as weaning, age, pen area, access to roughage and regulations for antibiotic use differ between the systems. The lower consumption of antibiotics in organic systems (0.04 doses of tetracycline per slaughter pig vs. 1.3 doses in conventional free-range and 1.6 doses in conventional indoor production[1]) could pose a risk of under-treatment, resulting in a higher prevalence of lesions caused by infections at slaughter. Leaving tails undocked may pose a risk for tail biting behaviour, but providing straw and otherwise enriched environments are reported to be effective protective measures against tail biting (Zonderland et al., 2008).

This study compared lesions in slaughter pigs raised in conventional indoor, conventional free-range and organic free-range production systems, that were slaughtered from 1 January 2013 to 31 December 2015. The objective of the study was to evaluate the prevalence of lesions in the different types of production systems taking seasonal, yearly and herd effects into account.

2 Materials and methods

2.1 Study population and design

Data was extracted from the Danish slaughterhouse database and consisted of inspection details from pigs slaughtered at one Danish abattoir during from 1 January 2013 to 31 December 2015. During this period, all Danish welfare-labelled slaughter pigs were slaughtered at this abattoir. Data originated from a random sample of conventional indoor herds with a minimum of 200 pigs slaughtered in each year of the study period, and all conventional free-range and all organic free-range herds fulfilling the same criteria. Random sampling was carried out by selecting every fifth herd on a numerically sorted list of National Husbandry Register numbers[2] of relevant conventional indoor herds. In total, 1,096,756 pigs were included in the study. Table 2 presents detailed information on the origin of the pigs studied. From here on, the term 'Welfare label systems' will refer to both systems with outdoor access.

Pigs were inspected according to the Danish meat inspection circular and assigned up to six different abattoir codes.[3] Data were structured by aggregating the abattoir codes into a set of general findings and disease complexes. The aggregation of abattoir codes was based on knowledge on interrelated lesions and expected consistency in registration.

2.2 Statistical analyses

For descriptive purposes, within-herd prevalence of disease complexes (mean and range during the entire study period) was calculated. To visualise yearly and quarterly effects, descriptive plots of: (1) prevalence of disease complexes in 2013, 2014 and 2015 in each production system; (2) prevalence of disease complexes in quarter 1, 2, 3 and 4 in each production system; and (3) quarterly prevalence of disease complexes within each year for each production system, were constructed.

Potential associations between production system and disease complexes with prevalences of at least 0.1% were evaluated in generalised linear mixed models with pigs as the statistical unit. Co-variables in the initial models were year and season (quarter of year) of slaughter. Herd of origin was included as random effect to correct for clustering within herds. The models were fit in R[4] using the lme4 package (Bates et al., 2015). Model reduction was done by stepwise backwards elimination, removing variables with $P > 0.05$. Confounding was assessed by taking out and re-entering variables into the final models and checking for biologically important changes of estimates. As we were interested in results across herds, population average odds ratios (OR_{PA}) were calculated using the following formula:

$$OR_{PA} = \exp\left(\beta_{SS}/\mathrm{sqrt}\left[1 + 0.346^{*}\ \delta^2_{\ Herd}\right]\right)$$

where β_{SS} is the subject specific regression coefficient, $\delta^2_{\ Herd}$ is the herd variance, and 0.346 is an approximation of the residual variance (Dohoo et al., 2009).

Pairwise comparisons of the effects of production system, year and quarter of year (across an average of the co-variables) were performed using the lsmeans package in R (Russell, 2016). A significance level of $P < 0.05$ was used.

3 Results

Airway infection was the most prevalent disease complex in all three types of production, with an average within-herd prevalence of approximately 20%. Supplementary Table 1 shows the prevalence of abattoir codes in the three production systems and how codes were aggregated into disease complexes. Table 3 depicts the average herd prevalence of findings at slaughter during the entire study period within production systems. Head or trunk abscesses were observed in approximately 3% of the pigs in all three types of production. Leg swellings were observed in 3% of the pigs in conventional herds on average, whereas in Welfare label systems these lesions were apparent in around 1.5% pigs. Skin and tail lesions were observed in approximately 3% of the pigs in Welfare label systems and in 1% of the pigs in conventional indoor herds. As shown in Table 3, most averages covered notable herd variations.

The variation between years was low. Supplementary Fig. 1 provides detailed information on yearly prevalence of the disease complexes. In conventional indoor pigs, the variation between quarters was generally small. In the Welfare label systems, the prevalence of skin and tail lesions varied with season. Skin lesions were more prevalent in the 3rd quarter of the year, whereas the highest prevalence of tail lesions was in quarter 1 and 4 (data for quarterly prevalences not shown).

The statistical models showed a significant effect of production system on the occurrence of disease complexes at slaughter (Tables 4 and 5). Pigs from both Welfare label systems had higher odds for white liver-spots (OR_{PA}, 5–7; $P < 0.001$), tail lesions (OR_{PA}, 3–4; $P < 0.001$), arthritis (OR_{PA}, 3; $P < 0.001$), skin lesions (OR_{PA}, 3; $P < 0.001$), bone fractures (OR_{PA}, 2; $P < 0.001$), septicaemia (OR_{PA}, 1.1–1.5; $P < 0.001$) and abscesses (OR_{PA}, 1.1–1.3; $P = 0.04$) compared with indoor conventional pigs. Pigs from Welfare label systems had lower odds for leg swellings (OR_{PA}, 0.4–0.5; $P < 0.001$), herniae (OR_{PA}, 0.7–0.8; $P < 0.001$) and hoof abscesses (OR_{PA}, 0.7 to 0.9; $P = 0.04$) compared with conventionally indoor raised pigs. When compared pairwise, there was no significant difference between the effect of the two Welfare label systems on the occurrence of disease complexes ($P < 0.05$). We found no association between production type and airway infection ($P = 0.3$). The models showed a large influence of herd of origin in relation to white liver-spots,

[1] See: http://www.danmap.org/~/media/Projekt%20sites/Danmap/DANMAP%20reports/Danmap_2009.ashx (accessed 5 April 2017).

[2] See: https://www.foedevarestyrelsen.dk/english/Animal/AnimalHealth/Central_Husbandry_Register/Pages/default.aspx (accessed 5 April 2017).

[3] See: https://www.retsinformation.dk/Forms/R0710.aspx?id=139770 (accessed 5 April 2017).

[4] See: https://www.r-project.org/(accessed 5 April 2017).

Table 1
Regulations for rearing conditions applicable to Danish conventional indoor, conventional free-range and organic free-range production systems.

	Conventional indoor[5,6]	Conventional free-range[7]	Organic free-range[3,8,9,10]
Housing during suckling period	Indoors. Sow confined in farrowing crate.	Outdoors. Born in huts of min. 3.8 m^2 with straw bedding. Total area: Min 300 m^2 per litter.	Outdoors. Born in huts of min. 3.8 m^2 with straw bedding. Total area, at least 300 m^2 per litter.
Castration	With analgesics. Carried out 2nd-7th day of life.	With analgesics. Carried out 2nd-7th day of life.	With analgesics. Carried out 2nd-7th day of life.
Tail-docking	Allowed if needed. Carried out on 2nd −4th day of life.	Not allowed (dispensation possible for a 60-day period if massive problems).	Not allowed (dispensation possible for a 60-day period if massive problems).
Age at weaning	4 weeks (min 21 days)	5 weeks (min 30 days)	7 weeks
Housing during growing/ finishing period (at 100 kg live weight, requirements change with size)	0.65 m^2 per pig. Maximum 2/3 of floor can be slatted. Rooting material[a] required.	1.2 m^2 per pig (0.5 m^2 must be outdoor). Min. 50% with solid floor. Resting area with bedding material. Natural ventilation. Access to outdoor area (canopies allowed) with min. 50% solid floor.	2.3 m^2 per pig (1 m^2 must be outdoor). At least 50% with solid floor. Resting area with bedding material. Natural ventilation. Access to outdoor area (at least 50% solid floor and maximum 50% with roof) with rooting material[a].
Antibiotic- and antiparasitic treatment	Farmer can initiate treatment (almost all herds have a Health Agreement Contract, which allows them to).	Farmer can initiate treatment (herds must have a Health Agreement Contract, which allows them to). Withdrawal time for slaughter is twice the length in conventional herds.	A veterinarian has to initiate the treatment (coccidiostats excepted). Farmer is allowed to follow up on treatment. Withdrawal time for slaughter is twice the length in conventional herds. Maximum one treatment period (up to 14 days) per pig (antiparasitic treatment excepted).
Access to roughage[b]	No access	Access	Access

Min, minimum.
[a] Straw or other material.
[b] Grass, hay, silage, fruit, vegetables or foliage.

tail lesion, skin lesions and airway infection (intraclass correlation coefficients 21–35%).

Both year and season of slaughter were statistically significant ($P < 0.001$) in most of the models. The effects of year were generally minor, except that white liver-spots showed markedly lower odds in 2014 and 2015 compared with 2013. Generally, though not the case for all disease complexes, odds for disease were higher during the second, 3rd and 4th quarters compared to the 1st quarter (see Tables 4 and 5). Tail lesions had markedly lower odds during the summer period (2nd and 3rd quarter).

4 Discussion

This study evaluated data from pigs slaughtered at a single abattoir during a period of 3 years. Consequently, a large amount of data was available, and bias due to abattoir-related differences in registration, documented in previous studies, was not a study limitation (Enøe et al., 2003). We chose to evaluate disease complexes instead of specific abattoir codes, as this method would be less sensitive to inter-observer variability in registration. However, our approach did not allow direct comparisons with previous studies.

The study showed that the occurrence of lesions at slaughter was related to whether or not pigs were raised in Welfare label systems. However, we did not find significant differences between the two types of Welfare label systems evaluated. Thus, the differences in raising conditions offered to conventional free-range vs. organic free-range pigs were not reflected in the disease complexes present at slaughter. This finding is surprising, as conditions in the two systems differ quite markedly. As the antibiotic consumption in organic production is restricted (in 2009, the tetracycline consumption in organic free-range herds was 30 times lower than in conventional free-range systems[1]), we suspected that chronic inflammatory lesions would be more prevalent in organic slaughter pigs. However, a higher weaning age and larger space allowance in organic production could positively influence the prevalence of disease by increasing immunity and decreasing transmission of disease.

Seven disease complexes (white liver-spots, tail lesion, arthritis, skin lesions, bone fracture, septicaemia and abscesses) had higher odds in Welfare label systems than in conventional systems. Therefore, these results appear to support the hypothesis that the ability to control disease is compromised in systems allowing pigs to behave more naturally (Spoolder, 2007).

Previous studies have documented low sensitivity (16%) of routine meat inspection for the detection of white liver-spots (Bonde et al., 2010). Therefore, we assume that the true prevalence in Welfare label systems is 60–90 per thousand instead of 10–15 per thousand as reported in our study. Outdoor access and straw bedding predispose to infection with *Ascaris suum* (Roepstorff et al., 2011), and therefore, the higher prevalence of this infection in Welfare label systems is not surprising. Differences between organic and conventional systems (e.g. different regulations on the use of anthelmintic drugs) did not appear to affect the occurrence of these lesions.

Our study and a previous Danish study (Alban et al., 2015) indicate that extra space allowance, access to outdoor areas and the provision of straw are insufficient measures to prevent tail biting in pigs with entire tails. In both studies, pigs from Welfare label systems with undocked tails had approximately 3 times higher odds for tail lesions compared with conventionally indoor raised pigs with docked tails. In our study, odds for tail lesions were higher during winter (1st and 4th quarter of the year) than during summer, which probably reflects an association between cold, drafty conditions and tail biting. A large variation in the occurrence of lesions (especially tail and skin lesions) between years and seasons in Welfare-labelled pigs probably indicates that these pigs were more exposed to changes in climatic conditions than indoor raised pigs. Therefore, optimisation of the design of stables with outdoor access should be a key point of concern in the health management of these herds. Swedish and Swiss researchers reported a lower prevalence of tail lesions in pigs raised in 'animal

[5] https://www.retsinformation.dk/Forms/R0710.aspx?id=176045 (accessed 5 April 2017).
[6] https://www.retsinformation.dk/Forms/R0710.aspx?id=176842 (accessed 5 April 2017).
[7] http://www.friland.dk/leverandoerinfo/frilandsgris/produktionskoncept/ (accessed 5 April 2017).
[8] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32007R0834 (accessed 5 April 2017).
[9] http://www.friland.dk/leverandoerinfo/oekologisk-gris/(accessed 5 April 2017).
[10] http://naturerhverv.dk/tvaergaaende/oekologi/jordbrugsbedrifter/vejledning-om-oekologisk-jordbrugsproduktion/#c5462 (accessed 5 April 2017).

Table 2
Numbers of herds and pigs from conventional indoor, conventional free-range- and organic free-range production systems studied.

	Conventional indoor	Conventional free-range	Organic Free-range	Total
Herds (n)	78	25	37	140
Pigs slaughtered per herd (mean)	6843	10797	7920	7834
Minimum; maximum	1532; 26,943	1017; 23,299	1093; 28,811	1017; 28,811
Total pigs slaughtered (n)	533,765	269,933	293,058	1,096,756

Table 3
Herd prevalence of parameters registered at slaughter in conventional indoor, conventional free-range and organic free-range herds, with the average herd prevalence per thousand and herd range [minimum; maximum] for each parameter.

	Conventional indoor	Conventional free-range	Organic free-range
Herds (n)	78	25	37
General findings			
Dead[a]	0.1 [0; 0.6]	0.1 [0; 1.0]	0.1 [0; 0.6]
Unthrifty[b]	0.4 [0; 3]	0.7 [0; 6.9]	1.6 [0; 41]
Rejected postmortem	1.6 [0; 4.9]	2.4 [1.1; 6.9]	2.0 [0; 12]
Disease-complexes			
Airway infection[c]	225.2 [20.2; 588.7]	209.8 [47.8; 454.8]	177.7 [37.2; 417.9]
Leg swellings[d]	30.9 [9.7; 70.1]	15.8 [7.9; 34.4]	12.7 [5.8; 31]
Abscess[e]	30.2 [10.6; 85.2]	37.4 [15.7; 60.5]	33.6 [12.5; 76.9]
Septicemia[f]	21.4 [6.1; 55.2]	31.8 [8.9; 66.1]	24.5 [4.6; 82.3]
Hernia	12.1 [2.9; 79.8]	9.6 [5.4; 47]	7.2 [3.9; 12.3]
Skin lesions[g]	10.7 [0.5; 125.4]	23.2 [2.6; 68.2]	40.8 [5.3; 210.8]
Hoof abscess	7.8 [1.4; 18.6]	7.0 [3.2; 18.7]	5.9 [1.4; 17.7]
Tail lesion[h]	7.1 [0.6; 87.9]	29.3 [1; 75.6]	21.0 [0; 87.7]
Bone fractur[i]	5.1 [1.7; 11.6]	10.3 [6.6; 15.1]	11.7 [3.6; 22]
White liver-spots	4.6 [0; 37.7]	12.2 [3.4; 37.4]	15.8 [1.8; 29.5]
Arthritis[j]	2.6 [0; 8.4]	9.7 [3.4; 38.4]	9.0 [2.3; 17.2]
Enteritis[k]	0.8 [0; 2.8]	0.7 [0; 1.5]	0.6 [0; 2.7]
Kidney lesion[l]	0.4 [0; 1.8]	0.5 [0; 2]	0.5 [0; 1.4]

[a] Dead during transportation or at the abattoir or rejected antemortem.
[b] Thin or emaciated.
[c] Sinuitis/rhinitis, acute/chronic pneumonia or acute/chronic pleuritis.
[d] Callosities, scars or bursitis.
[e] Abscess in head or trunk.
[f] Pyaemia, endocarditis, acute/chronic pericarditis, acute/chronic peritonitis or osteomyelitis.
[g] Dermatitis, insect bites, sunburn, bite wounds etc.
[h] With or without signs of infection.
[i] Acute/chronic limb fracture, acute/chronic tail fracture, acute/chronic rib fracture or hip dislocation.
[j] Acute/chronic arthritis.
[k] Acute/chronic gastritis, acute/chronic enteritis, serosal adhesions, stomach ulcer or rectal stricture.
[l] Glomerulonephritis or mycotoxic lesions.

friendly' systems compared to conventionally raised pigs (Cagienard et al., 2005; Heldmer et al., 2006). These apparently contrasting results can be explained by the fact that in Sweden and Switzerland, tail docking of conventional pigs is not performed (European Food Safety Authority, 2007).

Our findings on the prevalence of arthritis confirm the findings of other studies that compared the occurrence of joint lesions in pigs with a large space allowance and outdoor access with that for conventionally raised pigs (Hansson et al., 2000; Heldmer et al., 2006; Etterlin et al., 2014; Alban et al., 2015). Thus, an association between increased exercise and joint lesions (in this study indicated by 3.5 increased odds for arthritis in Welfare label systems) seems evident. The term 'arthritis' used in our study should be interpreted with care, as only two joint-related abattoir codes were available. Pathological studies have shown that osteochondrotic lesions play a role in the majority of joint lesions in slaughter pigs (Etterlin et al., 2014), and this is also likely to be the case in our study. Etterlin et al. (2015) suggested that increased biomechanical stress might explain why pigs with outdoor access have a higher prevalence of osteochondrosis than indoor kept pigs. Interestingly, there is no clear link between joint lesions at slaughter and lameness, and some studies indicate that free-range pigs seem to be less clinically affected by osteochondrotic lesions than indoor raised pigs (Etterlin et al., 2015). Studies investigating clinical lameness rather than joint lesions report an equal or lower prevalence of lameness in outdoor systems vs. conventional systems (Cagienard et al., 2005; Scott et al., 2006; Etterlin et al., 2015).

Wounds, dermatitis, eczema and insect bites (abattoir code 603) constituted the major part of the disease complex 'skin lesions', which had approximately 3 times higher odds in pigs from Welfare label systems compared to conventional pigs. Unfortunately, it was not possible to separate lesions inflicted by trauma from lesions caused by insects or parasites. Sunburn, insect bites and sarcoptic mange are likely to be more prevalent in pigs with outdoor access due to higher exposure to sun and wildlife. In contrast, Guy et al. (2002) reported that injuries were less prevalent in outdoor and straw-bedded systems. As we observed a higher prevalence of skin lesions in the 3rd quarter of each year, it seems likely that most of the skin lesions in this study were caused by insect bites during summer.

Our results showed 2-fold increased odds for bone fractures (56% of which were healed rib fractures) in pigs raised in Welfare label systems. Unlike piglets born in outdoor huts, indoor raised

Table 4
Effects (standard error and population averaged odds ratios [OR_{PA}]) of production system, year of slaughter and quarter of slaughter on the occurrence of disease complexes with higher odds in conventional free-range (free-range) and organic free-range (organic) production systems compared to conventional production systems.

	White liver-spots		Tail lesion		Arthritis		Skin lesions*		Bone fracture**		Septicemia¤		Abscess	
	Coefficient$	OR_{PA}	Coefficient$	OR_{PA}	Coefficient$	OR_{PA}	Coefficient$	OR_{PA}	Coefficient$	OR_{PA}	Coefficient$	OR_{PA}	Coefficient$	OR_{PA}
Intercept	−6.16		−5.16		−6.09		−5.63		−5.26		−3.88		−3.38	
Prod type***														#
Conventional	0^{a}	1	0^{a}	1	0^{a}	1	0^{a}	1	0^{a}	1	0^{a}	1	0^{a}	1
Free-range	2.11 (0.29)^{b}	5.28	1.63 (0.23)^{b}	4.15	1.3 (0.12)^{b}	3.48	1.25 (0.25)^{b,c}	2.92	0.71 (0.06)^{b}	2.02	0.44 (0.1)^{b}	1.53	0.24 (0.09)^{b}	1.26
Organic	2.44 (0.27)^{b}	6.85	1.14 (0.16)^{b}	2.71	1.33 (0.1)^{b}	3.58	1.59 (0.16)^{c}	3.9	0.85 (0.06)^{b}	2.32	0.13 (0.08)^{a}	1.13	0.09 (0.08)^{a,b}	1.09
–														
Year														
2013	0^{a}	1	0^{a}	1	0^{a}	1	0^{a}	1	0^{a}	1	0^{a}	1	0^{a}	1
2014	−0.71 (0.03)^{b}	0.57	0.01 (0.02)^{a}	1.01	0.05 (0.03)^{a}	1.05	0.13 (0.02)^{b}	1.12	0.02 (0.03)^{a}	1.02	0.01 (0.02)^{a}	1.01	−0.08 (0.01)^{b}	0.93
2015	−0.72 (0.03)^{b}	0.57	−0.19 (0.02)^{b}	0.85	0.13 (0.03)^{b}	1.13	−0.19 (0.02)^{c}	0.85	−0.09 (0.03)^{b}	0.91	0.1 (0.02)^{b}	1.1	−0.16 (0.01)^{c}	0.86
–														
Quarter					-				N.S.					
1st	0^{a}	1	0^{a}	1	0^{a,c}	1	0^{a}	1			0^{a}	1	0^{a}	1
2nd	−0.26 (0.03)^{b}	0.81	−0.38 (0.02)^{b}	0.72	−0.15 (0.04)^{b}	0.87	0.36 (0.02)^{b}	1.36			−0.13 (0.02)^{b}	0.88	−0.1 (0.02)^{b}	0.91
3rd	−0.09 (0.03)^{c}	0.93	−0.44 (0.02)^{b}	0.69	−0.21 (0.04)^{b}	0.82	0.92 (0.02)^{c}	2.2			−0.08 (0.02)^{c}	0.93	−0.15 (0.02)^{c}	0.86
4th	−0.06 (0.03)^{c}	0.93	−0.07 (0.02)^{c}	0.94	0.02 (0.03)^{c}	1.02	0.01 (0.03)^{a,d}	1.01			−0.07 (0.02)^{c}	0.93	−0.08 (0.01)^{b}	0.93
ICC£	35%		21%		7%		24%		2%		5%		5%	

*: Dermatitis, insect bites, sunburn, bite wounds etc. **: Acute/ chronic limb fracture, acute/ chronic tail fracture, acute/ chronic rib fracture or hip dislocation. ***: Production type. ¤: Pyaemia, endocarditis, acute/ chronic pericarditis, acute/ chronic peritonitis or osteomyelitis. $: Within each variable, different letters as superscript indicate significant difference ($P < 0.05$) in pairwise comparison. When nothing else is stated, $P < 0.001$ counts for all significant variables. N.S., Non-significant variable ($P > 0.05$). #: $P = 0.04$. £: The random effect of herd is displayed as the Intraclass Correlation Coefficient (ICC), which is the percentage of total variation in data that is explained by the herd effect.

Table 5
The effects (standard error and population averaged odds ratios [OR_{PA}]) of production system, year of slaughter and quarter of slaughter on the occurrence of disease complexes with higher or equal odds in conventional production systems compared with free-range and organic production systems.

	Leg swellings* Coefficient$	OR_{PA}	Hernia Coefficient$	OR_{PA}	Hoof abscess Coefficient$	OR_{PA}	Airway infection** Coefficient$	OR_{PA}
Intercept	−3.55		−4.5		−4.71		−1.58	
Prod type***						#	N.S.	
Conv	0^{a}	1	0^{a}	1	0^{a}	1		
Free-range	−0.66 (0.09)^{b}	0.53	−0.2 (0.11)^{a,b}	0.82	−0.1 (0.11)^{a,c}	0.91		
Organic	−0.88 (0.08)^{b}	0.42	−0.4 (0.09)^{b}	0.68	−0.33 (0.09)^{b,c}	0.73		
–								
Year								
2013	0^{a}	1	0^{a}	1	0^{a}	1	0^{a}	1
2014	0.04 (0.02)^{b}	1.04	−0.07 (0.02)^{b}	0.93	−0.11 (0.03)^{b}	0.9	0.13 (0.01)^{b}	1.12
2015	−0.07 (0.02)^{c}	0.93	−0.14 (0.02)^{c}	0.87	−0.17 (0.03)^{b}	0.85	0.08 (0.01)^{c}	1.08
–								
Quarter			N.S.					
1st	0^{a}	1			0^{a}	1	0^{a}	1
2nd	0.08 (0.02)^{b}	1.08			−0.15 (0.03)^{b}	0.86	0.01 (0.01)^{a}	1.01
3rd	0.15 (0.02)^{c}	1.16			−0.22 (0.03)^{b}	0.81	−0.03 (0.01)^{b}	0.98
4th	−0.07 (0.02)^{d}	0.93			−0.17 (0.03)^{b}	0.85	−0.12 (0.01)^{c}	0.9
ICC£	4%		6%		6%		22%	

*: Callosities, scars or bursitis. **: Sinuitis/ rhinitis, acute/ chronic pneumonia or acute/ chronic pleuritis. ***: Production type. Unless stated otherwise, $P < 0.001$ counts for all significant variables. $: Within each variable, different letters as superscript indicate significant difference ($P < 0.05$) in pairwise comparison. N.S.: Non-significant variable ($P > 0.05$). #: $P = 0.004$. £: The random effect of herd is displayed as the Intraclass Correlation Coefficient (ICC), which is the percentage of total variation in data that is explained by the herd effect.

piglets are protected from the sow by farrowing crates. The finding probably points out a need to improve the design of outdoor huts for better protection of piglets from the sows.

From previously published reports, it seems reasonable to assume that tail lesions were the main cause of the slightly higher odds for septicaemia and abscesses in Welfare label systems (Huey, 1996). However, it is also worth considering whether the daily monitoring of animals kept in these systems constitutes a problem in relation to chronic infections. Identifying, monitoring and isolating pigs that require treatment is easier in conventional indoor pens than in systems with straw bedding and outdoor areas.

As in previous studies, we found that hoof abscesses and leg swellings were most prevalent in conventionally raised pigs (Cagienard et al., 2005; Alban et al., 2015). Hooves trapped in the slats of the pen floors and high density of heavyweight pigs in pens probably explain the occurrence of hoof abscesses. Previous studies have suggested that the higher prevalence of bursitis in conventionally raised pigs is due to heavyweight pigs resting on floors without bedding (Guy et al., 2002). The reasons for the higher prevalence of hernias in conventional pigs are unclear, but the same result has been reported in other studies (Cagienard et al., 2005; Scott et al., 2006; Alban et al., 2015).

A Danish study investigating Danish pigs slaughtered during 1 month in 2005 estimated the true prevalence of airway infections in organically raised pigs to be 16%, compared with 42% in conventionally raised pigs (Bonde et al., 2010). A recent study estimated OR for pleuritis in Welfare label vs. conventional production to be 0.8 (Alban et al., 2015; Sørensen, 2016). In the current study, approximately 20% of pigs in herds were affected by airway lesions and there were no differences between production systems. A Swedish study reported on an apparent trend towards a higher prevalence of enzootic pneumonia in organic production in the period 1997–2005 (Heldmer et al., 2006). During our limited study period, increasing prevalences were not observed.

Three of the disease complexes (white liver-spots, tail lesions and skin lesions) that were more prevalent in Welfare label systems exhibited large herd effects in the statistical models (ICC's of 21–35%). This suggests that there is scope for farmers to make management improvements to address these problems. In contrast, the occurrence of arthritis, bone fractures, septicaemia and abscesses (which were also more prevalent in Welfare label systems) showed a minor variability at herd level and may be more difficult to address using changes in herd management.

5 Conclusions

Airway infection was by far the most prevalent lesion visible at slaughter in this study. We found no association between production system and the occurrence of airway infections. Several health-related lesions in slaughter pigs were associated with the production system used. In particular, white liver-spots, tail lesions, arthritis and bone fractures were associated with being raised in a Welfare label system. These findings call for planned interventions customised for these systems. Differences in raising conditions and antibiotic use between conventional free-range and organic free-range systems were not reflected in the occurrence of lesions at slaughter. Therefore, free-range living in itself may be the main factor for the health issues identified in the study. Marked herd effects in our study indicated possibilities for implementing effective herd-level strategies to reduce the incident of white liver-spots, tail lesions, skin lesions and airway infections, regardless of production system.

Conflict of interest

None of the authors has any financial or personal relationships that could inappropriately influence or bias the content of the paper.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.tvjl.2017.04.016.

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