Damaging biting behaviors in intensively kept rearing gilts: The effect of jute sacks and relations with production characteristics

W. W. Ursinus*,†, H. J. Wijnen,*, A. C. Bartels*,‡, N. Dijvesteijn‡,§, C. G. van Reenen†,#, and J. E. Bolhuis*

*Wageningen University, Department of Animal Sciences, Adaptation Physiology Group, PO Box 338, 6700 AH Wageningen, The Netherlands; †Wageningen UR Livestock Research, Animal Behaviour & Welfare, PO Box 338, 8200 AH Wageningen, The Netherlands; ‡Wageningen University, Department of Animal Sciences, Animal Breeding and Genomics Centre, PO Box 338, 6700 AH Wageningen, The Netherlands; §TOPIGS Research Center IPG B.V., PO Box 43, 6640 AA Beuningen, The Netherlands; and #Wageningen University, Department of Animal Sciences, Animal Production Systems Group, PO Box 338, 6700 AH Wageningen, The Netherlands

ABSTRACT: Pigs may display biting behavior directed at pen mates, resulting in body damage such as tail wounds. We assessed the suitability of jute sacks (hung vertically at wall) to reduce biting behaviors and tail wounds in rearing gilts. Additionally, we assessed several characteristics of different types of tail biters. Tail docked rearing gilts originated from 72 litters, which were kept in partly slatted pens with jute sacks (J) or barren control pens (CON; 36 litters per treatment). Tail and ear damage were observed at weaning (4 wk) and during the weaner and rearing phase (17 J and 19 CON pens). Sow (dam) damage was also considered. Biting behaviors (tail, ear, and other) were observed during the weaner and rearing phase. Weight was recorded at birth, weaning, and end of the weaner phase and ADG was calculated from birth till weaning and from weaning till 9 wk. Furthermore, estimated breeding values for litter size, litter birth weight, growth, and lower back fat seemed associated with higher levels of ear or tail-biting behavior (P = 0.002 to 0.09), albeit dependent on treatment and phase. Higher phenotypic litter sizes were associated with higher levels of biting behaviors (P = 0.004–0.08). High-tail-biters and Medium-tail-biters (the latter less pronounced) stemmed from larger litters (P = 0.01 to 0.05), were heavier (P = 0.03 to 0.04), grew faster (P = 0.05 to 0.08), and displayed higher levels of all kinds of biting behavior directed to pen mates and the jute sack (P < 0.001 to 0.10) compared with non-tail-biters, the effect size dependent on treatment and phase of life. To conclude, jute sacks may profoundly reduce damaging behaviors and tail wounds in rearing gilts, probably because they partly meet the behavioral need of pigs for rooting and chewing. Furthermore, (tail) biting is associated with production level of the gilts (phenotypically and genetically), which suggests a role for breeding programs and additional research focusing on metabolic demands of (tail) biting pigs.

Key words: ear biting, enrichment, estimated breeding values, growth, pigs, tail biting

INTRODUCTION

Tail biting is a common problem in the pig sector (EFSA, 2007) and the behavior is known for its multifactorial background (Van Putten, 1969; Taylor et al., 2010). The effectiveness of enrichment to fulfill the need to explore and forage (EFSA, 2007) and to reduce tail biting has been demonstrated (e.g., Beattie et al., 1996; Zonderland et al., 2008). Organic materials such as straw or compost
are most promising to improve pig welfare (Beattie et al., 2001; Bracke et al., 2006) as they meet all pigs’ requirements of proper enrichment (i.e., complex, changeable, destructible, manipulable, and with edible parts; Van de Weerd et al., 2005; Studnitz et al., 2007). Nevertheless, the majority of pig producers do not use these materials due to their labor requirements, hygienic consequences, and costs (Tuyttens, 2005) and, therefore, other, preferably long-lasting, materials are used (mainly metal chains; Bracke et al., 2013) to meet legislation. These materials may reduce tail biting on a short-term but not on a long-term basis (Bracke et al., 2006; Zonderland et al., 2008) due to loss of attractiveness. Therefore, the search for other suitable enrichment is still ongoing. Jute sacks (also called burlap, hessian, or gunny bags) may provide suitable enrichment as they are made of firm plant material, chewable, easy to handle, and not too expensive. The main aim of our study was to assess the suitability of jute sacks to reduce tail biting and other damaging behaviors. We chose rearing gilts as subject of study as tail biting is common in these pigs. Moreover, rearing gilts have longer tails than fattening pigs, which may increase the risk of wounds (Valros et al., 2012). Additionally, we studied different types of tail biters (Non, Medium, High; Brunberg et al., 2011) and assessed relationships between tail biting, other damaging behaviors, and production characteristics. Knowledge about characteristics of these pig types may help in understanding the development of tail biting.

MATERIALS AND METHODS

The experiment was approved by the Animal Care and Use Committee of Wageningen University.

Animals and Housing

Preweaning. Piglets (Landrace × Topigs 20 [synthetic line of Great Yorkshire and Large White and Landrace] 1,033 in total) born in 2 rounds from 72 sows at commercial farm Van Beek SPF Varkens B.V. Lelystad, the Netherlands. No tooth resection was performed, but tails were docked ~1/2 in gilts (509 in total) and ~3/4 (i.e., 1/4 tail remaining) in males (524 in total). Males were not castrated. Piglets were further subjected to standard procedures on farm. Piglets were kept in commercial farrowing pens (2.5 × 1.65 m, 54.7% slats) with sow crate and either in pens with jute sack (J; also called burlap, hessian or gunny bags/sacks) or in control pens without a jute sack (CON) from birth onward (Fig. 1). Distribution of litters over J (36 litters) and CON (36 litters) treatment was balanced for sow parity and round. In total, 226 gilts and 241 boars were kept in J pens and 283 gilts and 283 boars were kept in CON pens. Jute sacks (57 × 95 cm, ~140 gr jute; Van Heusden, Waardenburg, the Netherlands) were attached to the pen wall (height: 55 cm) using a metal strip and with the open side downward. The sow could not reach the jute sack. In the preweaning phase, 1 sack was used for 2 pens and therefore always 2 neighboring farrowing pens had a jute sack available (Fig. 1). Control piglets could not see the jute sack. Temperature was set at 20°C and a solid floor (1.2 × 0.45 m) with heating lamp above it was available for the piglets. Commercial piglet pellets were fed ad libitum from 10 d of age until weaning and water was available through 1 nipple drinker. Daylight entered the farrowing pens and artificial lighting was usually on from 1000 h until 1600 h.

Postweaning. After weaning, at 4 wk of age, male and female piglets were separated and only females were further studied until the age of 13 wk. Gilts (346 in total) were first housed in weaner pens (2.95 × 1.45, ~50% slats) in groups of 8 to 10 (36 pens) depending on piglet size. The pens had partly barred pen walls and consequently gilts were able to make snout contact with neighboring gilts. All pens had a chain with a plastic toy. Treatment (J/CON) remained for gilts the same throughout life. Jute sacks were from now on attached to the front side of the pen to prevent neighboring pens from reaching the enrichment material (Fig. 2). Jute sacks were replaced when the groups were relocated and when necessary (20 times in total), which was mainly when the sack came off the pen wall and occasionally when <30 cm of the sack was left (height of pen walls was 75 cm or 1 m for weaner and rearing pens, respectively). A commercial pellet was provided ad libitum in a feeder containing 2 feeding places, and water was available through 1 nipple drinker. Ambient temperature was first set at 26°C and gradually decreased to 21°C. At approximately 9 wk of age, gilts (309 in total) were, by group (36 pens), transferred to rearing pens (3.95 × 2.08 m, 40% slats or 3.9 × 2.2, ~50% slats, equally divided over treatments), which were separated by partly barred walls.
Rearing pens consisted of a maximum of 9 gilts; surplus gilts (usually the lightest ones) were removed from the experiment. Feed was provided ad libitum in a feeder with 2 feeding places and 1 nipple drinker was available. Temperature started at 25°C and was gradually decreased to 20°C. Daylight entered the pens and artificial lighting was usually on from 1000 h until 1600 h.

**Damage Scores**

**Tail Damage Scores.** Tail damage scores (1. no tail damage, 2. bite marks, 3. small wound, 4. medium wound, part of tail missing, 5. severe wound, no tail is left) were based on procedures of Kritas and Morrison (2007) and Zonderland et al. (2008). Wounds referred to any skin damage involving (clotted) blood. Tail damage was recorded for the first time the day before weaning when piglets were lifted and the tail was kept between 2 fingers. Thereafter, tail damage was recorded when gilts were 9, 11, and 13 wk of age. The observer entered the pen and kept the tail again between 2 fingers, but without lifting the gilts.

**Ear Damage Scores.** Ear damage was recorded together with tail damage scoring. At weaning, ears were kept between 2 fingers, but thereafter, no physical contact was necessary to record the damage. Only damage to the backside of the ears (both left and right) was recorded and damage was divided in top half (near the tip of the ear) and bottom half (near the base of the ear; 1. no ear damage, 2. top or bottom lesions, 3. top and bottom lesions, 4. severe damage, part of ear is missing). Damage scores of both ears were recorded, but only maximum damage (either left or right ear) was used for further analysis.

**Sow Damage.** The day before weaning, sow (i.e., the dam) damage—likely caused by the piglets—was recorded for the tail, udder, and vulva. Tail damage scoring was identical to the previously described tail damage scoring system for gilts. The procedure of Anonymous (2010) was used to record damage to the udder (consisting of multiple mammary glands; 1. no damage, 2. little damage [i.e., ≤2 individual glands damaged; lesions are present], 3. medium damage [i.e., >2 individual glands damaged or 1 deep wound; looks like a scissor cut], 4. severe damage [i.e., >2 individual glands damaged and >1 deep wounds]). Vulva damage was adapted from Welfare Quality (2009) and assessed the presence and size of lesions (1. no damage, 2. small lesions [≤2 cm], 3. large lesions [>2 cm]).

**Behavioral Observations**

Behavioral observations were performed postweaning in both weaner (6, 7, and 8 wk of age) and rearing pens (11 wk of age). Observations were done from 0800 to 1130 h and 1400 to 1730 h. Each pen was observed 2 × 10-min during the morning and 2 × 10-min during the afternoon at 2 consecutive days, resulting in 80 min observations per gilt per week of observation. All occurrences of tail biting (chewing or forcefully biting the tail of a pen mate), ear biting (chewing the ear of a pen mate), and other types of biting pen mates (chewing other parts of the body than the tail or ears, excluding aggressive bites) were recorded. Both biter and victim were documented. Furthermore, in pens with jute sacks, all occurrences of nosing (snout contact) and biting (chewing) the jute sack were recorded as well. A number was sprayed on the back of each gilt for proper identification using stock marker spray.

**Production Characteristics**

Total (T) litter size, litter size excluding stillborn piglets (CS), and litter size excluding stillborn piglets and corrected for added or removed cross-fostered piglets (CSC; 173 piglets were cross-fostered of which 73 were gilts, 29 in J pens, and 44 in CON pens) were determined. Weight was recorded at birth, at weaning (4 wk of age), and at 9 wk of age. The ADG in grams per day was determined from birth until weaning, from weaning until 9 wk of age, and from birth until 9 wk of age. The estimated breeding values (EBV) of all piglets were obtained via routine genetic evaluation using MIXBLUP in a multitrait model (Mulder et al., 2010) and they provide the deviation from the population average. The EBV for litter size, litter birth weight, test daily gain (TDG) between ~25 to 105 kg and life daily gain (LDG) between birth and ~105 kg, and back fat were obtained.

**Statistical Analysis**

SAS version 9.2 (SAS Inst. Inc., Cary, NC) was used for all statistical analyses.
Gilt Damage Scores. To be able to test the effect of treatment (J/CON) on tail and ear damage, first pen averages were calculated for damage scores of gilts only and for all piglets present (i.e., gilts and boars) at time of weaning (week 4). Thereafter, a general linear model was run with fixed effects of treatment and round (1/2). A similar model was used to test the effect of treatment on tail and ear damage scores when gilts were 9 wk of age. Tail and ear damage scores of gilts during the rearing phase (week 11 and 13) were first averaged per animal and then per pen and thereafter subjected to the same procedure as described for week 9.

A generalized linear mixed model with a binary scale (0/1) and logit link function was used to test the effect of jute sack presence, per observation day (week 4, 9, 11, and 13), on number of pigs with a tail wound or mild (i.e., top and bottom lesions) to severe ear damage (i.e., part of ear is missing). At weaning, fixed effects of treatment, sex, their interaction and round, and a random effect of pen (nested in treatment and round) were included in the model. Postweaning, only gilts were studied and, therefore, sex and the interaction between sex and treatment were excluded from the model.

Sow Damage. The effect of the presence of jute sacks on sow damage scores was tested with a generalized linear mixed model with a multinomial distribution and cumulative logit link function. Fixed effects of treatment (J/CON) and round (1/2) were tested. A generalized linear mixed model with a binary scale and logit link function was used to test the effect of jute sacks on the presence of a tail wound or not, the presence of at least tail bite marks or not, medium damage to the mammary glands (severe damage was not observed), and small to large vulva damage (only 4 sows had large lesions). Again, fixed effects of treatment (J/CON) and round (1/2) were included in the model.

Behavioral Observations. To test the effect of treatment on behavioral data obtained in the weaner phase (week 6, 7, and 8), a mixed model was used with fixed effects of treatment (J/CON) and round (1/2) and random effects of pig (nested in pen, round, and treatment) and pen (nested in round and treatment). A similar model was run to test the effect of treatment on behavioral data obtained in the rearing phase (week 11), but without the random effect of pig as only 1 wk was considered. Variables for which the residuals did not approach normality were square root transformed.

Estimated Breeding Values and Litter Size. To assess relationships between EBV and damaging behaviors of gilts, all damaging behaviors were averaged over gilts born in the same litter because they have the same EBV. Only litters of ≥5 gilts were included in the model; boars were excluded. A general linear model, by treatment, was conducted with damaging behaviors as dependent variables, and EBV (1 per model) was included as covariate together with the fixed effect of round (1/2). The same approach was used to assess relationships between T and CS and damaging behaviors. Damaging behaviors were again considered as dependent variables, whereas litter size (T and CS, 1 per model) was considered as covariate. Here, litter size CSC was not considered as this variable was not based on original litters but on actual number of piglets present. If residuals of damaging behaviors (as averages from gilts of the same litter) did not approach normality, logarithmic transformation was applied.

Tail Biters and Non-Tail-Biters and Their Characteristics. To assess relationships between type of tail biter (other damaging behaviors) and production (weight and growth) variables, first a distinction was made between Non-tail-biters, Medium-tail-biters, and High-tail-biters in both treatments (J/CON) and in both phases in which damaging behaviors were observed (weaner and rearing phase). Considering the weaner phase, animal averages of damaging behaviors observed during week 6, 7, and 8 were used. The distinction between types of tail biter was based on tailbiting performance in the particular phase and treatment group. Pigs that never displayed tailbiting behavior were classified as Non-tail-biters, pigs with tailbiting levels between zero and the median of values (i.e., median of observed tailbiting occurrences instead of average value or true median, as the presence of many non-tail-biters and low performers resulted in a low average and true median) were classified as Medium-tail-biters (J weaner: 0 to 2, J rearing: 0 to 3, CON weaner: 0 to 2.67, CON rearing: 0 to 5 tailbiting occurrences during 80 min of observations) and pigs performing tail biting as much as the median of observed values or more were classified as High-tail-biters (J weaner: 2 to 6.3, J rearing: 3 to 5, CON weaner: 2.67 to 7, CON rearing: 5 to 16 tailbiting occurrences during 80 min of observations). We chose different classifications for each treatment because many types of enrichment reduce (more or less) tailbiting behavior (e.g., Van de Weerd et al., 2006; Zonderland et al., 2008; Van de Perre et al., 2011) and likely also the level of tail biting of different types of tail biters. A different classification per phase was used because tailbiting behavior in the weaner phase was averaged over multiple observation weeks and tailbiting behavior in the rearing phase was not. Furthermore, tailbiting behavior may increase over time in all individuals (Ursinus et al., 2014a) and therefore an update of classifications was considered necessary. To test the effect of tail-biter category on displaying damaging behaviors and weight and growth variables, mixed models were used with fixed effects of type of tail biter (Non-tail biter, Medium-tail biter, and High-tail-biter) and round (1/2) and a random effect of pen (nested in round). Variables for which the residuals did not approach normality were square root transformed.
Table 1. Pen averages (mean) of tail and ear damage scores of pigs kept in pens with or without jute sacks, recorded at time of weaning and during the weaner and rearing phase.

<table>
<thead>
<tr>
<th>Phase/damage</th>
<th>Damage score</th>
<th>Jute sack</th>
<th>Control</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weaning (wk 4) 36 pens 36 pens</td>
<td>Tail (gilts) 1.4 ± 0.05 1.5 ± 0.04 0.38</td>
<td>Ear (gilts) 1.7 ± 0.06 1.8 ± 0.05 0.36</td>
<td>Tail (all piglets) 1.4 ± 0.03 1.5 ± 0.03 0.01</td>
<td>Ear (all piglets) 1.7 ± 0.04 1.8 ± 0.04 0.01</td>
</tr>
<tr>
<td>Weaning (wk 9) 17 pens 19 pens</td>
<td>Tail 1.6 ± 0.05 1.8 ± 0.04 0.03</td>
<td>Ear 1.7 ± 0.08 1.9 ± 0.09 0.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rearing (wk 11, 13) 17 pens 19 pens</td>
<td>Tail 1.5 ± 0.04 1.8 ± 0.06 &lt;0.001</td>
<td>Ear 1.7 ± 0.04 1.7 ± 0.05 0.96</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Tail damage scores: 1 (no damage) to 5 (severe damage).
2 Ear damage scores: 1 (no damage) to 4 (severe damage).

RESULTS

Effect of Jute Sacks

Gilt Damage Scores. Jute sack provision significantly reduced both tail and ear damage at weaning (i.e., 4 wk of age) when considering all piglets present (gilts and boars; Table 1). However, provision of a jute sack did not significantly affect tail or ear damage at weaning when considering gilts only. Postweaning, jute sacks reduced tail and ear damage of gilts in the weaner phase (9 wk of age). Furthermore, jute sacks reduced tail damage during the rearing phase (11 and 13 wk of age), but not ear damage (Table 1). The provision of a jute sack did not reduce the proportion of pigs (gilts and boars) with a tail wound (mild, medium, or severe) in week 4 (\(P = 0.50\)), 9 (\(P = 0.42\)), and 11 (\(P = 0.20\)) but profoundly decreased the proportion of gilts with a tail wound in week 13 (\(OR = 0.2, P = 0.01\); Fig. 3). Furthermore, gilts were less likely to have a tail wound (\(OR = 0.3, P = 0.02\)) but more likely to have an ear wound (\(OR = 1.9, P = 0.02\)) at time of weaning compared to boars. Provision of a jute sack did not reduce the proportion of pigs with damage at the ear top and bottom or severe ear damage (score > 2) in week 4 (\(P = 0.14\)) and 13 (\(P = 0.37\)), but it tended to do so in week 9 (\(OR = 0.4, P = 0.05\)) and it was the opposite in week 11 (\(OR = 2.5, P = 0.04\)).

Sow Damage Scores. A jute sack provided to the piglets tended to reduce tail damage scores of sows (58 sows were used) measured at time of weaning as compared to sows kept in CON pens (mean score J: 2.0 ± 0.14, CON: 2.3 ± 0.09, with score 1 = 12%, 2 = 62%, 3 = 26%, 4 = 0%, 5 = 0% of total sows, \(P = 0.09\)). Treatment (J/CON) did not affect proportion of sows with a tail wound (mild, medium, or severe; \(P = 0.44\); Fig. 4), but J treatment reduced the proportion of sows with tail damage (score ≥2; \(J: 76\%, CON: 97\%, P ≤ 0.05\)). Treatment did also not affect proportion of sows with medium damage to the mammary glands (\(P = 0.90\)) or small to large vulva damage (\(P = 0.26\); Fig. 4).

Damaging Behaviors. Jute sacks always substantially reduced (36 to 50%) frequencies of all types of biting behavior directed at pen mates as compared to CON pens (Table 2). Furthermore, jute sacks were bitten approximately 10 times per pig during 80 min of observations in both the weaner and rearing phase (Table 2).
Estimated Breeding Values

The EBV (64 litters) for litter size, litter birth weight, TDG (~25 to 105 kg), and LDG (birth till ~105 kg) and back fat per treatment (J/CON) are presented in Table 3. In gilts kept in CON pens, EBV for TDG ($\beta = 0.002$, $P = 0.04$) and EBV for litter birth weight ($\beta = 0.001$, $P = 0.002$) were positively associated with ear biting during the weaner phase. A similar tendency was found between EBV for LDG and ear biting in gilts kept in CON pens during the weaner phase ($\beta = 0.003$, $P = 0.09$). Moreover, in gilts kept in J pens, a negative relation was found between EBV for back fat and ear biting expressed during the rearing phase ($\beta = -0.83$, $P = 0.05$). In gilts kept in CON pens, a positive relation tended to be present between EBV for TDG and tail-biting behavior displayed during the rearing phase ($\beta = 0.01$, $P = 0.09$). In gilts kept in J pens, a positive association tended to be present between EBV for litter size and tail-biting behavior displayed during the rearing phase ($\beta = 0.51$, $P = 0.06$). Moreover, in gilts kept in J pens, EBV for litter birth weight tended to be positively related to ear-biting behavior displayed during the rearing phase ($\beta = 0.004$, $P = 0.07$).

Total Litter Size and Litter Size Excluding Stillborn Piglets

Litter size CS ($\beta = 0.15$, $P = 0.01$) was, in J pens, higher in gilts that had a higher incidence of tail-biting behavior during the rearing phase. T litter size ($\beta = 0.31$, $P = 0.01$) and litter size CS ($\beta = 0.25$, $P = 0.004$) were, in CON pens, higher in gilts that displayed more other (than tail or ear) biting behavior directed at pen mates during the rearing phase. T litter size ($\beta = 0.12$, $P = 0.08$) tended, in CON pens, to be higher in gilts that displayed more tail-biting behavior during the rearing phase.

Tail-Biters and Non-Tail-Biters and Their Characteristics

Pens with jute sacks. Tail biters were not consistent in their tail-biting behavior because no effect was present of type of tail biter as identified during the weaner period on tail biting observed during the rearing phase, nor was type of tail biter as identified during the rearing phase related to tail biting as observed during the weaner phase (Table 4).

Type of tail biter (Non-, Medium-, or High-tail-biter) identified in J pens during the weaner phase was associated with weight at weaning and weight measured in week 9 (but not at birth), where High-tail-biters (16 gilts) were heavier than Non-tail-biters (52 gilts; Table 4), and Medium-tail-biters (95 gilts) tended to be heavier at time of weaning compared to Non-tail-biters. Accordingly, High-tail-biters grew faster from birth till weaning compared to Non-tail-biters and from weaning till 9 wk of age they tended to grow faster compared to both Non-tail-biters and Medium-tail-biters. Furthermore, High-tail-biters tended to ear bite more, tended to bite more in other parts of the body during the weaner phase, and also tended to bite more in jute sacks during the weaner and the rearing phase compared to Non-tail-biters. High-tail-biters also tended to bite more in jute sacks during the weaner phase compared to Medium-tail-biters. High-tail-biters were, furthermore, more likely to stem from larger litters CSC; ($P \leq 0.05$, OR = 1.2). Similar results were observed when combining Medium- and High-tail-biters, where Medium/High-tail-biters had a higher likelihood of stemming from a larger litter CSC; ($P = 0.04$, OR = 1.2) than Non-tail-biters.

Type of tail biter identified in J pens during the rearing phase was not significantly associated with tail-biting behavior in the weaner phase, any of the other damaging behaviors observed, nor with weight or growth (Table 4). However, Non-tail-biters (106 gilts) tended to nose the jute sack less during the rearing phase compared to Medium-tail-biters (33 gilts) and High-tail-biters (9 gilts). Additionally, High-tail-biters ($P = 0.01$, OR = 1.5), but not Medium/High-tail-biters ($P = 0.40$), again had a high likelihood of stemming from a large litter CSC.

### Table 2. Pen averages (mean) of damaging behaviors performed by pigs in pens with jute sacks or control pens and jute sack usage in pens with jute sacks

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Jute sack</th>
<th>Control</th>
<th>$P$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weaner (wk 6, 7, 8)</td>
<td>17 pens</td>
<td>19 pens</td>
<td></td>
</tr>
<tr>
<td>Tail biting</td>
<td>0.7 ± 0.08</td>
<td>1.1 ± 0.07</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Ear biting</td>
<td>1.8 ± 0.11</td>
<td>3.4 ± 0.22</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Other biting</td>
<td>1.6 ± 0.11</td>
<td>3.0 ± 0.24</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Jute sack biting</td>
<td>9.6 ± 0.79</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Jute sack snout contact</td>
<td>2.4 ± 0.11</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Rearing (wk 11)</td>
<td>17 pens</td>
<td>19 pens</td>
<td></td>
</tr>
<tr>
<td>Tail biting</td>
<td>0.5 ± 0.09</td>
<td>1.0 ± 0.19</td>
<td>0.04</td>
</tr>
<tr>
<td>Ear biting</td>
<td>1.7 ± 0.15</td>
<td>2.9 ± 0.22</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Other biting</td>
<td>1.8 ± 0.17</td>
<td>3.5 ± 0.28</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Jute sack biting</td>
<td>9.8 ± 1.46</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Jute sack snout contact</td>
<td>1.2 ± 0.13</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

1Behaviors are given in frequencies per 80-min observations.
Table 3. Litter average of estimated breeding values (EBV) for gilts kept in pens with or without a jute sack available. The EBV provide the deviation from the population average and can be either ‘−’ or ‘+’

<table>
<thead>
<tr>
<th>EBV</th>
<th>Jute sack Mean</th>
<th>Range</th>
<th>Control Mean</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>EBV litter birth weight, g</td>
<td>−22.3 ± 15.77</td>
<td>−156.6 to 152.0</td>
<td>−24.8 ± 12.66</td>
<td>−170.3 to 151.9</td>
</tr>
<tr>
<td>EBV litter size, n</td>
<td>0.6 ± 0.13</td>
<td>−0.8 to 2.1</td>
<td>0.3 ± 0.11</td>
<td>−1.0 to 1.6</td>
</tr>
<tr>
<td>EBV TDG(^1), g</td>
<td>8.7 ± 4.57</td>
<td>−62.6 to 52.4</td>
<td>10.2 ± 4.05</td>
<td>−52.0 to 52.4</td>
</tr>
<tr>
<td>EBV LDG(^2), g</td>
<td>3.0 ± 3.22</td>
<td>−50.7 to 24.6</td>
<td>3.9 ± 2.54</td>
<td>−35.4 to 26.8</td>
</tr>
<tr>
<td>EBV back fat, mm</td>
<td>−0.6 ± 0.08</td>
<td>−1.4 to 0.1</td>
<td>−0.6 ± 0.09</td>
<td>−1.6 to 0.6</td>
</tr>
</tbody>
</table>

\(^1\)TDG = test daily gain between ~25 to 105 kg.
\(^2\)LDG = life daily gain between birth and ~105 kg.

**Control pens.** Consistency of tail-biting behavior over time depended on phase of life and type of tail biter. There was no effect of type of tail biter as identified during the weaner period on tail biting observed during the rearing phase (Table 5). However, type of tail biter as identified during the rearing phase was significantly related to tail biting as observed during the weaner phase, where High-tail-biters displayed the most tail-biting behavior compared to Non- and Medium-tail-biters also during the weaner phase.

Type of tail biter (Non-, Medium-, or High-tail-biter) identified in CON pens during the weaner phase was not significantly associated with weight or growth of the animals (Table 4). However, Non-tail-biters (32 gilts) displayed less ear biting and other biting behaviors during the weaner phase compared to Medium-tail-biters (132 gilts) and High-tail-biters (19 gilts). High-tail-biters, furthermore, displayed more ear biting and tended to display more other biting behavior compared to Medium-tail-biters. Litter size CSC did not affect the likelihood of being a High-tail-biter \((P = 0.59)\) or a Medium/High tail biter \((P = 0.66)\).

Type of tail biter identified in CON pens during the rearing phase was also not significantly associated with weight or growth of the animals (Table 5). However, High-tail-biters (9 gilts) displayed more tail-biting and ear-biting behavior during the weaner phase as compared to Non-tail-biters (95 gilts) and Medium-tail-biters (57 gilts). Furthermore, Medium-tail-biters displayed more biting in other parts of the body than in ears or tails during the rearing phase compared to Non-tail-biters. Litter size CSC did not affect the likelihood of being a High-tail-biter \((P = 0.57)\) or a Medium/High tail biter \((P = 0.48)\) as identified in the rearing phase.

**DISCUSSION**

**Jute Sack Usage**

The provision of a jute sack significantly reduced all types of damaging biting behaviors of breeding gilts directed at their pen mates, with levels of biting behaviors being reduced in J pens up to 50% compared to CON pens. Consequently, tail damage was at all times lower in pigs from J pens compared to CON pens, with the proportion of 13-wk-old gilts having a (mild) tail wound being decreased from ~15% in CON pens to ~2% in J pens. The jute sacks provided remained attractive throughout the experiment, as illustrated by the similar number of interactions (~10 times per 80 min) of gilts with the jute sack in both the weaner and rearing phase. The relatively high and sustaining level of interest in the jute sack by the pigs gives the jute sack a head start compared to many other enrichment materials that seem not attractive at all such as a chain or plastic pipe attached to a chain (Van de Weerd et al., 2003; Bracke et al., 2007). However, it must be noted that in the current experiment jute sacks were replaced by new sacks at time of relocating the gilts to new pens and also occasionally when the sack was, for example, torn from the wall, which may have led to a renewed interest (Trickett et al., 2009) in the jute sack. However, behavioral observations were conducted 2, 3, and 4 wk after weaning, and 2 wk after relocating the gilts to the rearing pens. Thus, jute sacks were most likely not novel anymore during behavioral observations when considering that habituation to enrichment material can occur rapidly (Van de Weerd et al., 2003). Previously, a decreased interest in a jute sack was observed over time, but the pigs studied were kept in straw-bedded pens before onset of the study (Van de Weerd et al., 2003), which may have affected their interest in other ‘simpler’ objects. Biting pen mates was not fully eliminated in J pens and provision of a jute sack may reduce biting behavior not as much as straw bedding can (~4 times lower, Camerlink et al., 2014) as straw can be used for digging and rooting and is (more) edible. Nevertheless, some biting in pen mates also occurs in pens with straw (Camerlink et al., 2014) and tail damage is also observed in straw-housed pigs (Ursinus et al., 2014a). Moreover, absolute differences in tail-damage scores between both treatments (J/CON) would probably have been more pronounced when studying pigs with long instead of half-long tails as was the case in the current study. Early ear damage was also reduced by the presence of a jute sack, but later in life treatment did not affect ear damage scores. This may implicate that although ear-biting behavior was much
lower in J pens compared to CON pens, ear damage as scored in our study may also have stemmed from aggressive encounters as pigs may target the ears during fights (McGlone, 1985; D’Eath, 2002).

Sow damage scores at time of weaning were not affected by treatment (J/CON) except for a tendency for a higher tail damage in the pens without a jute sack available for the piglets. As a limited number of sows were considered for analysis, a lack of power may have resulted in an underestimation of differences in sow damage in J and CON pens (specifically tail and vulva damage). It may be worthwhile to consider sow damage in future studies regarding biting behavior of piglets as, seemingly, not all biting behavior is directed to litter mates or pen fixtures, but also to the dam.

### Table 4. Individual pig production levels and behaviors displayed by different types of tail biters (Non-, Medium-, and High-tail-biter) as identified during the weaner and rearing phase in pens with a jute sack available

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Non-tail-biter</th>
<th>Medium-tail-biter</th>
<th>High-tail-biter</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tail biting rearing</td>
<td>1.0 ± 0.11</td>
<td>1.0 ± 0.11</td>
<td>1.0 ± 0.11</td>
<td>0.25</td>
</tr>
<tr>
<td>Ear biting rearing</td>
<td>1.2 ± 0.20</td>
<td>1.2 ± 0.20</td>
<td>1.2 ± 0.20</td>
<td>0.39</td>
</tr>
<tr>
<td>Jute sack nosing rearing</td>
<td>1.1 ± 0.12</td>
<td>1.1 ± 0.12</td>
<td>1.1 ± 0.12</td>
<td>0.17</td>
</tr>
</tbody>
</table>

### Table 5. Individual pig production levels and behaviors displayed by different types of tail biters (Non-, Medium-, and High-tail-biter) as identified during the weaner and rearing phase in control pens

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Non-tail-biter</th>
<th>Medium-tail-biter</th>
<th>High-tail-biter</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tail biting rearing</td>
<td>1.0 ± 0.11</td>
<td>1.0 ± 0.11</td>
<td>1.0 ± 0.11</td>
<td>0.25</td>
</tr>
<tr>
<td>Ear biting rearing</td>
<td>1.2 ± 0.20</td>
<td>1.2 ± 0.20</td>
<td>1.2 ± 0.20</td>
<td>0.39</td>
</tr>
<tr>
<td>Jute sack nosing rearing</td>
<td>1.1 ± 0.12</td>
<td>1.1 ± 0.12</td>
<td>1.1 ± 0.12</td>
<td>0.17</td>
</tr>
</tbody>
</table>

### Different Types of Pigs and Their Characteristics

Most gilts were not likely to be consistent in their tail-biting behavior over time. Also, in a previous study (Ursinus et al., 2014a), we observed inconsistency in tail-biting behavior, which suggests that intrinsic motivations to bite may fluctuate over time. However, in the current study, High-tail-biters kept in CON pens during the rearing phase were likely to have also bitten more on tails during the weaner phase. This suggests that some
pig types may be more consistent in displaying biting behavior than others.

Generally, High-tail-biters and, to a lesser extent, Medium-tail-biters, also performed relatively high levels of ear and other biting behavior directed at pen mates. However, these findings were less pronounced in J pens, which is likely related to the relatively high levels of interacting with the jute sack by the tail-biters, especially the High-tail-biters. It has been suggested in previous studies that pigs displaying high levels of tail-biting behavior may be most specialized in biting pen mates, whereas pigs that display medium levels of tail biting may display all kinds of aberrant behaviors (e.g., belly nosing) directed at pen mates and pen fixtures (Brunberg et al., 2011). Our results do not support this, as Medium-tail-biters also displayed relatively high levels of biting behaviors and High-tail-biters also seemed highly interested in the jute sack. It has been suggested that tail-biting pigs can be divided into ‘two stage’ (gradually developing), ‘sudden-forceful’ (related to resources), and ‘obsessive’ (fanatical) tail biters (Taylor et al., 2010, p. 139-141) and that the tail-biting behavior of these distinct types of tail biters may have different motivational backgrounds. However, reliably distinguishing between such differences in tail biters is difficult (Brunberg et al., 2011) when starting observations postweaning, as tail biting already occurs preweaning and, moreover, the number of obsessive tail biters is likely low (Ursinus et al., 2014a).

Nevertheless, the current study also points to the existence of different motivational backgrounds of tail biting (as pointed out by Taylor et al., 2010) because especially high levels of tail biting were related to several of the EBV and phenotypic weight, growth, and litter size. However, it should be noted that the current study was not designed as a genetic study (i.e., EBV effects may be partly confounded with maternal effects for litter birth weight). Therefore, results should be considered with caution but may give us valuable insight into the genetic background of damaging biting behaviors. A high EBV for litter birth weight and a low EBV for back fat were associated with higher levels of ear-biting behavior but not tail-biting behavior. A high EBV for growth (test daily gain between ~25 to 105 kg or life daily gain between birth and ~105 kg) was also associated with relatively high levels of ear-biting behavior and, to a lesser extent, with tail-biting behavior. Also, phenotypic weight and growth was highest in gilts identified as High-tail-biters but only early in life and only in J pens. Additionally, original litter size (total or excluding stillborn piglets) seemed higher in (mainly CON-housed) gilts that displayed relatively high levels of biting behaviors. Also, litter size corrected for cross-fostering was found to be highest in gilts identified as High-tail-biters. Collectively, these results may suggest that selection for heavier litter birth weight, higher growth, less back fat, and larger litters may result in higher levels of aberrant behavior, albeit partly dependent on treatment (J/CON) and phase of life. Our results seem, therefore, in line with previously proposed associations between biting behavior and genetics (Breuer et al., 2003, 2005) and tail biting and weight (Breuer et al., 2005). Alternatively, a relationship between biting behavior and a large litter size may also reflect overcrowding in the farrowing pen. Tail biting was, in Landrace but not Large White pigs, found to be genetically correlated with lean tissue growth rate (positive) and back fat thickness (negative), and tail biters may be the larger pigs (Breuer et al., 2005) instead of the smaller pigs, which was suggested by others (Wallgren and Lindahl, 1996; Beattie et al., 2005). Although the EBV for back fat was not associated with tail-biting behavior in our pigs as was expected based on the study of Breuer et al. (2005), back fat was associated with ear biting in gilts kept in J pens. Because the genetic makeup of the pigs used in the present study was not entirely the same as that of the Landrace pigs of Breuer et al. (2005), this may suggest that the relationship between EBV for back fat and (manipulative) behavior depended on breed. Possibly, experimental setup and housing conditions may also affect this relationship. The associations found in our study between biting behavior and a higher weight, growth, and larger litters may be related to metabolic demands of these pigs. Differences in metabolic demands may affect foraging behavior (Day et al., 1995) and thereby may also affect the level of tail-biting behavior (Fraser, 1987). High-tail-biters may, thus, have a higher (unfulfilled) nutritional demand compared to pigs expressing less or no tail-biting behavior. For instance, tail biting increased when pigs were fed a diet with low levels of tryptophan (i.e., precursor of serotonin; Martínez-Trejo et al., 2009; Azmitia, 2010), and recently, tail biting has been associated with low blood serotonin levels (Ursinus et al., 2014b). Altogether, it seems plausible that a mismatch between the high level of production and metabolic demand of pigs can result in (temporary) high levels of tail-biting behavior. It must be noted, however, that especially tail biting in J pens showed a relationship with growth, which may suggest that these tail biters have a specific metabolic motivation to start tail biting, whereas tail biters from CON pens likely have a broader motivation and are driven more by boredom.

Conclusions

The provision of a jute sack can reduce tail, ear, and other biting behavior of gilts directed to pen mates by up to half as much compared to gilts kept in barren pens. Consequently, in pens with a jute sack available, tail damage was also lower and a 5-fold reduction was observed in the proportion of 13-wk-old gilts having a tail wound. Furthermore, displaying high levels of tail-biting behavior was generally related to displaying higher levels of all
kinds of biting behavior, a relatively high (phenotypic and possibly genotypic) growth, and originating from a large litter. However, relationships between tail biting and other measured variables varied between pigs kept in pens with or without jute sacks, which suggests that boredom rather than a metabolic motivation plays the largest role in pigs kept in barren pens. Nonetheless, our results may imply a role for future breeding programs and, additionally, more research seems essential with respect to the metabolic demands of highly tail-biting pigs.

LITERATURE CITED


