Thomsen R, Edwards SA, Rousing T, Labouriau R, Sorensen JT. Influence of social mixing and group size on skin lesions and mounting in organic entire male pigs. *Animal* 2016, (ePub ahead of Print).

DOI link to article:

http://dx.doi.org/10.1017/S1751731116000069

Date deposited:

22/02/2016

Embargo release date:

07 July 2016

Influence of social mixing and group size on skin lesions and mounting in organic entire male pigs

R. Thomsen[1], S.A. Edwards[2], T. Rousing[1], R. Labouriau[3], J.T. Sørensen[1]

[1]*Department of Animal Science, Aarhus University, Blichers Allé 20, 8830 Tjele, Postbox 50, Denmark*

[2]*School of Agriculture, Food & Rural Development, Agriculture Building, Newcastle University, Newcastle upon Tyne NE1 7RU, UK.*

[3]*Applied Statistics Laboratory, Department of Mathematics, Aarhus University, Ny Munkegade 118, 8000 Aarhus, Denmark*

Corresponding author: Rikke Thomsen. E-mail: rikke.thomsen@anis.au.dk

Short title: Grouping strategies for organic entire male pigs

Abstract

Alternatives to surgical castration are needed, due to stress and pain caused by castration of male pigs. One alternative is production of entire male pigs. However, changed behaviour of entire males compared to castrated males might adversely affect the welfare of entire males and changes in management procedures and production system might be needed. Elements from the organic pig production system might be beneficial in this aspect. The aim of this article is to investigate the effect of grouping strategy including social mixing and group size on levels of mounting behaviour and skin lesions, hypothesising that procedures that disrupt the social stability (e.g. regrouping) will have a larger negative effect in small groups compared to large groups. Approximately 1600 organic entire male pigs of the breed (Landrace x Yorkshire) x Duroc were reared in parallel in five organic herds, distributed across four batches in a 2x2 factorial design in order to test the influence of social mixing (presence or absence of social mixing at relocation) and group size (15 and 30 animals). Animals were able to socialise with piglets from other litters during the lactation period, and were all mixed across litters at weaning. A second mixing occurred at insertion to fattening pens for pigs being regrouped. Counting of skin lesions (1348 or 1124 pigs) and registration of mounting behaviour (1434 or 1258 pigs) were done on two occasions during the experimental period. No interactive effects were found between social mixing and group size on either skin lesions or mounting frequency. Herd differences were found for both mounting frequency and number of skin lesions. No association between skin lesions and mounting were revealed. Social mixing and group size were shown as interacting effects with herds on mounting frequency ($P < 0.0001$), but with no consistent pattern across all herds. In addition, no effect of social mixing was found on mean number of skin lesions, but more lesions were observed in large groups ($P < 0.036$). This could indicate that keeping entire male pigs in groups of 30 animals as compared to smaller groups of 15 may marginally decrease the welfare of these animals.

Keywords

Entire male pigs, organic production, welfare, mounting, skin lesions

Implications

Production of entire male pigs corresponds well with the welfare principles of organic farming. Welfare of entire males might be influenced by management procedures in relation to grouping of animals, affecting the social organisation of pigs. The present study revealed no clear management recommendations on grouping strategy when rearing entire males in the organic farming system, as levels of skin lesions did not differ in different social mixing strategies and results showed inconsistent results on mounting behaviour across herds.

Introduction

Surgical castration of pigs is a routine procedure in many countries, not least in Denmark, where currently more than 10 million male pigs are surgically castrated each year. The castration procedure causes stress and pain (Prunier *et al.,* 2006) with decreased animal welfare as a result. As regards the organic production system, castration further conflicts with the ethical values concerning animal integrity (Verhoog *et al.,* 2004). In Denmark, legislation on the castration procedure prescribes the use of an analgesic prior to the surgical intervention (since 2009). However, even with the use of analgesia, welfare issues related to the procedure are still present (Prunier *et al.,* 2006; von Borell *et al.,* 2009). The castration procedure is also time consuming, not least within the organic farming system where sows farrow in outdoor paddocks. Based on these considerations, alternatives to surgical castration are needed. One alternative, which is in accordance with the values in organic farming, is production of entire male pigs. However, different welfare issues associated with this production method are reported, due to the behaviour of entire males caused by the hormonal changes during sexual maturation. The main effects reported are increased aggression of entire males compared to castrated males and females, as well as increased mounting behaviour (Rydhmer *et al.,* 2006; Boyle and Björklund, 2007; Fredriksen *et al.,* 2008). Elevated aggression levels can adversely affect the welfare of the animals by generating negative feelings such as fear, exhaustion or pain. As regards mounting behaviour, frequent mounting is suggested to increase the risk of leg problems and skin lesions (Rydhmer *et al.,* 2006). The behaviour induces high pitch vocalisations from the mounted pig (Hintze et al., 2013) indicative of feelings of discomfort. Furthermore, frequent mounting behaviour causes a high level of disturbance among all animals of a group (Rydhmer *et al.,* 2006), possibly reducing animal welfare.

The growing/finishing stage of slaughter pigs is normally from 30 kg until slaughter at around 110 kg (in Denmark). A gradual development of adverse behaviours over this period is expected as more animals reach the time of puberty. In this regard it is hypothesised that the amount of mounting behaviour will increase with increased weight and age of the animals as maturation occurs. As regards skin lesions, the amount should be high in newly mixed animals when formation of a hierarchy is ongoing and should decrease as the social stability of the group is attained. A second increase in lesions can then arise when the pigs reach puberty (Fredriksen *et al.,* 2008).

In order to be able to produce entire male pigs, without compromised animal welfare, changes in the production system and management strategies might be a necessity. The organic farming system offers more available space, access to rooting material and roughage as well as access to an outdoor run for pigs in the growing/finishing stage. This could contribute to a reduction of the unwanted behaviours of entire males. Still, the management procedures might be expected to have an impact. A normal management procedure within both conventional and organic pig production is regrouping, involving mixing of unfamiliar pigs, to optimise pen utilisation and minimise weight variation within groups. It is known from studies of conventionally raised pigs that mixing of unfamiliar pigs affects the social organisation of a group, causing increased aggression levels with detrimental effects on animal welfare (Giersing *et al.,* 2000; Li and Wang, 2011). For entire male pigs, such a procedure could have an even greater impact due to their increased aggression level. Rydhmer *et al.* (2013) found that entire males reared in stable groups showed less aggression and had fewer leisons compared to unfamiliar pigs in mixed groups. This is in agreement with Fabrega *et al.* (2013), who also found more skin lesions in mixed groups compared to stable wean-to-finish groups. In this study all pigs had been able to socialise with other litters prior to weaning, which was also the case for the un-mixed group in the study by Rydhmer et al. (2013).

In line with this, D'Eath (2005) reported that socialising piglets before weaning improved the social skills of the piglets with beneficial effects during future encounters with unfamiliar pigs, possible lowering the amount of fighting. As regards mounting behaviour, Rydhmer *et al.* (2013) found more mounting in the intact groups at start and end of the study, whereas Fabrega *et al.* (2013) found no effect on mounting behaviour in a stable wean-to-finish system compared to mixed groups.

It is hypothesised that regrouping of entire male pigs compared to simple relocation at transition into the finishing accommodation (approximately at 30 kg) will negatively affect animal welfare measured as skin lesions. Moreover regrouping is hypothesised to increase the level of mounting behaviour, due to advanced sexual maturation in mixed groups of pigs, as suggested by Fredriksen *et al.* (2008). Following formation of a new group, a dominance hierachy is established to give social stability and minimize costly aggressive interactions (Turner and Edwards, 2004). It is hypothesised that procedures that influence the social stability (e.g. regrouping) will have a larger negative effect in small groups compared to large groups (when comparing group sizes of 15 and 30 animals). The overall aim was to investigate management approaches in relation to welfare of organic entire male pigs, focusing on the effect of social mixing and group size on levels of mounting behaviour and skin lesions.

Material and methods

Animals

The target population, consisting of 1603 organic entire male pigs of the breed (Landrace x Yorkshire) x Duroc, constituted a hypothetical population representing entire males reared within the organic pig production system in DK. Entire male pigs are not produced on a regular basis within Danish organic pig production. The pigs were reared in parallel in five Danish commercial organic pig herds.
During the study, 248 pigs were excluded due to disease, death, deviations from study design, missing registrations and early slaughter.

Housing system

This study is part of a larger study on organic entire male pigs, with a thorough description of housing system and study design to be found in Thomsen *et al.* (2014a and 2014b). The pigs were reared according to the standard Danish organic production system, with an indoor area consisting of an activity area with solid and partially slatted floors and a resting area with straw bedding. Partitioning walls in the indoor area were present in three herds. All pens had access to an outdoor run with concrete floor and sprinkling system, either separated from the indoor area by solid walls or with no separation. The fixed facilities in the pens included automatic feeders or feeding troughs (2-7.5 animals per feeding place) including access to water by individual water nipples/stations. Concentrate feed was provided *ad libitum.* Roughage (clover/grass silage) was provided daily in the resting area.

Space allowance in the pens varied slightly between herds, but the stocking density was similar between small and large group sizes, with approximately 1.2 m^2 per pig on the indoor area and approximately 1 m^2 per pig on the outdoor area.

Study design

The experimental study was designed as a 2 x 2 factorial, stratified by social mixing (consisting of regrouping vs. simply relocation) and group size (approximately 15 vs. 30 animals), with parallel groups between and within 5 organic herds. Each herd produced 4 batches, each consisting of four experimental pens of entire male pigs. The study encompassed a two year period from 2011 to 2013, with two batches in the winter season and two in the summer season. The winter season encompassed birth of piglets in July to September and slaughter in January to March and the summer season birth in January to March and slaughter in June to August. All male pigs were born outdoors, with the possibility to familiarise with other litters in neighbouring paddocks. At weaning all pigs were mixed with different litters and located in pens resembling the rearing system normally used in the respective herds (in pens mixed with female pigs (herd 1(60 pigs/pen), herd 3 (one pen, 60 pigs/pen) and herd 5 (60 pigs/pen)) or in single-sex pens (herd 2 (25 pigs/pen), herd 3 (one pen, 60 pigs/pen) and herd 4 (30 pigs/pen)). At an average weight of 30 kg, approx. 5 weeks after weaning, the male pigs were allocated to the finishing pens according to the experimental design. The pigs stayed in the experimental pens until slaughter. The experimental design comprised two pens of regrouped pigs, with pigs being mixed from two different weaning pens, and two pens of relocated pigs, with pigs coming from only one weaning pen and simply being relocated into the experimental pens (social mixing treatment). Besides this, two different group sizes were applied, with each social mixing treatment having one pen of approximately 15 pigs and one pen of 30 pigs (group size treatment). Herd 2 had group sizes of 11/12 and 25 animals due to smaller pen sizes. Animals were removed from the pens in case of disease, death or early slaughter due to high weight, which gave smaller variations in the group sizes (Table 1). In addition 4 pens were excluded caused by deviations from the study design, e.g. animals not grouped according to experimental plan (Table 2). All measures (mounting, skin lesions and other clinical assessments) were performed at two registration points during the experimental period. The first registration round was performed a week after insertion into experimental pens, and the second within a week prior to first slaughter occasion.

Table 1 around here

Measurements

Mounting behaviour

Mounting events were registered at pen level, using continuous behaviour recording within a four hour registration period (Martin and Bateson, 1993). Mounting behaviour was defined as a mounting pig jumping on the back or front of another pig with one front leg on either side of the other pigs' back, with the recipient animal either standing or lying. (definition after Cronin *et al.,* 2003). Separation of two successive mounting events was defined by the front legs of the mounting pig touching the ground for more than 2 sec. Observations of mounting behaviour were made from simultaneous video recordings of each of the four pens in each batch in each of the five herds. Recordings only covered the indoor area of the pens. Registrations of behaviour were preferentially placed in a period covering the morning hours. Number of pens and pigs recorded for each registration round for each herd can be seen in Table 2. Pens not recorded were mainly due to problems with the video equipment (19 pens in total), and pens deviating from the study design (4 pens in total), Observations from video recordings were performed by one observer. Intra-observer reliability was calculated by a weighted Cohens kappa-coefficient (Cohen, 1960; Kundel and Polansky, 2003). To be able to perform a calculation of a kappa coefficient, data were reorganized. The four hour registration period were divided in series of time intervals of 3 min and the number of mountings performed within each of these intervals was counted, based on the specific time point for execution of the mounting event which was registered. For calculation of the coefficient the number of mountings within each time interval constituted a created scale ranging from zero to the maximum number of mountings observed, and based on this the number of agreements and disagreements between two repeated observations of the same time period were used for calculation of the weighted kappa coefficient for each of four pens. The calculated kappa coefficient showed a generally high agreement (ranging from 0.43-0.99 for four different pens) and should be seen in the context of the calculation method and a varying quality of the video recordings.

Skin lesions

Clinical assessments were performed by assessing each individual pig in each of the four pens per batch in each of the five herds. The assessments were performed by two observers. Skin lesions were assessed by direct observation of each animal. The animal was divided into 5 body areas (head incl. neck, shoulder incl. forelegs, back, abdomen and rear part incl. hind legs), and for both left and right side of the pig the number of lesions in each area was counted. A lesion was defined as being visible at a distance of 1 meter, being either surface penetration of the epidermis or actual wounds with penetration of muscle tissue, and including cuts, scratches and abrasions, both fresh (red) and old (black). When animals were very dirty (skin covered in a dense layer of manure), no counting of lesions was registered at the specific body area and the observation was set as missing. This was the case for 712 out of 13580 observations at 1st registration round and 1546 out of 13400 observations at 2nd registration round (for five body areas assessed on both left and right side), resulting in 4 pens with no lesion score in the 2nd round. The number of pens and animals with a total lesions score for the whole body can be seen in Table 2. Inter-observer reliability for assessment of skin lesions was determined as a high (>0.6) agreement (range of 0.87-0.94 for the five body areas) based on weighted kappa calculations (Cohen, 1960; Kundel and Polansky, 2003).

Table 2 around here

Lameness and general debility

Lameness was assessed by two observers by direct observation of each animal in each of the four pens per batch in each of the five herds. All animals were encouraged to walk around the pen and lying animals were forced to stand and walk. Degree of lameness was scored as; 0: normal gait, 1: impairment of walking, but still using all four legs, shortened stride, 2: severely lame, minimum or no weight-bearing on the affected limb, 3: not able to walk (Modified after Welfare Quality® 2009). General debility was assessed by direct observation of each animal based on both the vitality of the animal being 1: unaffected, 2: depressed, apathetic, hesitant to rise up, 3: languishing/dying, and the body condition assigned a score 1 for normal body condition, 2 for thin (with spine and hip bone just visible and able to feel with palm of hand) and 3 for very thin (with prominent and clearly visible spine, hip and pin bone).

Statistical analysis

Statistical analyses were performed using the statistical software R (R Core Team, 2014). Specifically the packages lme4 (implementing generalized linear mixed models) and multicomp (for performing inference with contrasts) were used. The number of mounts recorded per pen (in a four hour period) was modelled by a Poisson mixed model with a random component representing the pens and a number of fixed effects representing the herd (1-5), group size (small/large), social mixing (regrouping/relocation), season (summer/winter), registration round (1-2) and in some models higher order interactions. Since the number of animals per pen was not constant (varying from 7 to 32), the models included an offset defined by the logarithm of the number of animals per pen (N) and a logarithmic link was used so the models were multiplicative. That is, the model stated that,

$$\log\left(E\left(M_{hsgtapr}\right)\right) = \; log\left(N_{hsgtapr}\right) + X_{hsgtapr}\beta + \; \mathrm{e}_p \; ,$$

where $M_{hsgtapr}$ is a random variable representing the number of mounts for a pen at the hth herd, under the grouping size s, subject to the gth grouping system, at the season t, at the registration round (corresponding age group) a. $N_{hsgtapr}$ represents the number of animals in the given pen. The fixed effects are represented by the vector of parameters $\beta \;\; where \; X_{hsgtapr}$ is the associated set of discrete explanatory variables and the Gaussian random component is denoted by e_p. This model is mathematically equivalent to

$$E\left(M_{hsgtapr}/N_{hsgtapr}\right) = \; \exp(X_{hsgtapr}\beta + \; \mathrm{e}_p),$$

which is a multiplicative mixed model for the number of mounts per animal in each pen (i.e. $M_{hsgtapr}/N_{hsgtapr}$). The fixed effects (and interactions) were tested using likelihood ratio tests (LRT) applied to suitably defined nested models. The p-values of the likelihood ratio tests (LRT) were obtained using parametric bootstrap with 1,000 bootstrap simulations (see Jørgensen *et al.,* 2012).

The mean number of lesions (mean per pen) was analysed using Gaussian linear mixed models, where the response was the logarithmic transformed sum of the total number of lesions per animal and including the logarithm of the number of animals with a registered lesion score per pen as an offset, in such a way that the response was the mean number of lesions per animal with a registered lesion score. The model included a random component representing the pens and a number of fixed effects representing the herd, group size, social mixing, season and registration round, and in some models higher order interactions. The fixed effects (and interactions) were tested using likelihood ratio tests (LRT) applied to suitably defined nested models. The p-values of the likelihood ratio tests (LRT) were obtained using parametric bootstrap with 1,000 bootstrap simulations. The p-values reported are adjusted for multiple comparisons by the method of false discovery rates (see Benjamini and Yekutieli, 2001). Initially a model containing the main effects of factors representing the herd, group size, social mixing, season, registration round and all the possible third order interactions was adjusted and compared via LRT to an additive model containing only the main effects. This test yielded a p-value of 0.87. Subsequently the removal of each of the fixed effects was tested. To analyse for association between skin lesions for each of the five body areas and amount of mounting per number of animals in each pen, Spearman correlation coefficients were calculated, with the statistical unit being the pen. These calculations were done separately for each of the two registration rounds.

Results

Average weight and age for each of the two registration rounds were as follows: 1^{st}: 37.5±13 kg and 92±9 days, 2^{nd}: 94±19 kg and 150±8 days,. Levels of mounting behaviour for the different treatments in the 2x2 factorial design can be seen in Figure 1. Analysis of mounting showed no interaction of social mixing and group size (the p-value for reduction of a model with all the second order interactions to this model was 0.64) and in addition, no main effect of group size or regrouping was detected. The analysis, however, revealed the presence of significant interactions between herd and social mixing, herd and registration round, as well as a tendency for herd and group size, with no consistent pattern between herds (Table 3). In addition, a direct significant effect of season was found on level of mounting, with more mountings during winter. All significant effects in the model had p-values smaller than 0.001 (adjusted for multiple comparisons by the method of the false discovery rate).

Figure 1 around here

Table 3 around here

The total number of skin lesions (sum of all body parts) for the different treatments in the 2x2 factorial design can be seen in Figure 2. Neither the effects of an interaction of grouping and group size nor the main effects of social mixing and season on the mean number of lesions were found to be statistically significant. Group size significantly affected the mean number of lesions ($P < 0.036$), with more lesions in large groups compared to small groups. In addition, the mean number of lesions significantly differed between registration rounds, with more lesions in the first registration round compared to 2nd round ($P < 0.0001$). Herd significantly affected the mean number of lesions ($P < 0.0001$). Results are summarized in Table 4.

The distribution of animals according to number of lesions on the front area showed a different pattern between registration rounds, with more animals with 0 lesions in the second round compared to the first round and most animals with at least 11 lesions in the first round compared to the second round. The majority of animals in the second round had 1-5 lesions, in contrast to a spread between 1-20 lesions for the first round (Fig. 3). The number of skin lesions on the different body areas did not correlate with number of mountings performed in the pens in either of the two registration rounds.

Figure 2 around here

Figure 3 around here

Table 4 around here

The number of animals being lame, having a low body condition or being apathetic was very low and statistical comparison between groups could not be performed. Descriptive analysis showed no major difference between herds or grouping treatments. Differences between registration rounds were only seen for body condition score, with more animals being thin (score 1) at 1st round compared to 2nd round (Table 5). From the farmers own registrations only 4 animals were removed due to lameness and 31 animals were registered with too low a weight to be included in the planned slaughter rounds and were therefore excluded from the study.

Table 5 around here

Discussion

In the present study two different social mixing strategies were investigated, regrouping and relocation, with the hypothesis that social mixing would have a different effect in small versus large group size. This was not confirmed, as an interaction of social mixing and group size did not show a significant effect on the mean number of lesions or on frequency of mountings within pens. In the present study all pigs were mixed at weaning and, for the group exposed to regrouping, a second mixing was performed at insertion into the finishing accommodation. It was hypothesized that a second mixing, compared to being only relocated, would increase the mounting level. This could, however, only partly be confirmed, as no consistent effect of social mixing on mounting level were found, with more mounting in groups of relocation compared to regrouping in some herds and the opposite in other herds. In the present study, the level of skin lesions was assumed to reflect the aggression level among pigs, as described by Turner *et al.* (2006). It was hypothesized that mixing would affect the level of skin lesions one week after, but this was not confirmed, as the mean number of lesions surprisingly did not differ between the two social mixing strategies. Results from previous studies have also reported different effects of group management on behaviour and welfare of entire males. Fàbrega *et al.* (2013) found no significant effect of previous mixing on behaviour (both aggressive and mounting behaviour), but did find a difference in skin lesions between groups which were mixed at weaning and at insertion into fattening pens and groups being socialised prior to weaning and then reared without mixing from weaning to finish, when these were measured in the days just after mixing. Rydhmer *et al.* (2013) found that entire males reared in intact groups and being socialised prior to weaning showed less aggression, had fewer skin leisons, but higher levels of mounting (at start and end of the study) compared to unfamiliar pigs in groups mixed at insertion into fattening pens. Fredriksen *et al.* (2008) found a difference in aggression level and skin lesion score between groups of entire males and female pigs submitted to one social mixing (mixed one time at approximately 25 kg at weaning) compared to those in farrow-to-finish pens. They found no effect on mounting behaviour. In the present study all pigs were able to socialise with piglets from other litters in the period before weaning, which could account for the absence of effect of the different social mixing strategies on skin lesions. Socialising piglets has been found to modify the behavioural responses of piglets by improving their social skills with beneficial effects in later stages of the production as for instance during regrouping (D’Eath, 2005). Weight variation between animals within a group has been found to decrease the aggression level post regrouping, probably due to an improved ability to assess the relative strength of opponent pigs (Andersen *et al.,* 2000). In the present study there was a large variation in body weight within pens that, on some occasions, spanned more than a 20 kg difference. This could also have contributed to the absence of an effect of social mixing on mean number of skin lesions within pens. In addition, when removing animals from a group of pigs, as done in the relocation groups of the present study, the remaining animals may need to establish a new dominance hierarchy, which will increase the aggression level (Coutellier *et al.,* 2007), in the relocation groups equalizing the effects of the social mixing strategy.

The overall mean level of lesions was higher in large groups compared to small groups, independent of the social mixing strategy. This is in accordance with findings by Spoolder *et al.,* (1999), who found more agonistic behaviour in large groups of entire male pigs. Contrary results have also been reported, with less aggression in large groups compared to small groups (Turner *et al.,* 2001). An increased level of fighting could be assumed with more animals in a group, due to more relationships to be established (Spoolder *et al.,* 1999) and with increasing number of unfamiliar pigs

(Arey and Franklin, 1995). On the other hand, larger groups have a larger total area available, increasing the space for social interactions and avoidance of aggressors (Turner and Edwards, 2004). In large groups (> 50 animals) compared to smaller ones, it seems that the establishment of a new hierarchy depends less on aggression during the immediate post-mixing phase eventhough the reason for that phenomenon are not clear (Turner and Edwards, 2004), and more lesions in a large group is not necessarily to be expected. A difference in social organisation might, however, require a larger group size than 30 animals, as this number still might enable the pigs to recognize each other, and to establish an ordinary dominance hierarchy in both group sizes. A confounding factor in the present study is a possible effect of number of feeding places, with this being equal between group sizes in four out of five herds, ranging from 2-4 pigs per feeder space in small groups and 4-7.5 in large groups. This could have caused more aggression in pens with more pigs sharing each feeding place, as was the case with the large size groupes. Feed being a limited resource is often the cause of aggressive behaviour (Hagelsø Giersing and Studnitz, 1996), although with feed being available *ad libitum* in the present study, and with this number of feeding places not being considered inadequate (Spoolder *et al.,* 1999), the effect of feeding places on mean number of skin lesions observed is likely to have been minimal.

Social mixing and group size affected mounting levels as an interaction effect with herd (group size only as a tendency), showing contradictory patterns for the different herds. The lack of unequivocal results on mounting could indicate that performance of this behaviour is rather sensitive to the environment in which the animals are held with different environmental factors on the different herds affecting the mounting level, e.g. farm personnel entering the pens which increase the general activity of the animals and might affect the mounting level. Mounting behaviour has been suggested to cause skin lesions. The number of skin lesions on the different body areas did, however, not correlate with number of mountings performed in the pens. In agreement with this, Hintze e*t al.* (2013) did not find mounting to be associated with the occurrence of scratches. Rydhmer *et al.* (2006) found no significant association between mounting and aggressive behaviour, but found a relationship between sexual behaviour and skin lesions, with mounting males having more scratches than pigs not involved in mounting. They even suggested that mounting rather than fighting caused the scratches observed, as no relationship was found between received aggression and frequency of scratches. However, the lack of correlation in the present study suggests that lesions cannot reliably be used as a proxy measure for the prevalence of mounting behaviour on a group level.

It was hypothesised that number of skin lesions would be high in newly mixed animals when formation of a hierarchy was ongoing and would then decrease as the social stability of the group was attained. This was confirmed, as the results showed more skin lesions in the first registration round compared to the 2nd round. This was supported by results showing a higher percentage of animals with more than 11 lesions on the front part in the first round compared to the second round, where most animals had only 1-5 lesions. Formation of new groups (relocation and regrouping), and therefore the establishment of a dominance hierarchy, occurred shortly prior to the 1st registration round, resulting in increased levels of aggression and, in consequence, increased levels of skin lesions. The decreasing number of lesions with increasing age and weight in the present study could also be indicative of a general decrease in activity level with increasing age as found in other studies (Cronin *et al.,* 2003). It was hypothesised that the amount of mounting behaviour would increase with increased weight and age of the animals as maturation occurred. This could only partly be confirmed as the level of mounting differed between 1st and 2nd registration round, however, with this being equivocal for different herds. This difference between herds could be attributed to a different time course of sexual maturation as discussed later.

Mean number of lesions did not differ between seasons. Prunier *et al.* (2013) found fewer skin lesions in the spring than in autumn and attributed this to earlier puberty in the autumn. A seasonal effect was found on mounting level, with more mounting during the winter periods as compared to summer periods. This is in accordance with Prunier *et al.* (2013), who reported a tendency for more mountings during autumn compared to spring, in line with the suggested accelerated pubertal development of the animals during autumn. This effect may be caused by differences in photoperiod between seasons, which have been found to affect sexual maturation in this species which has evolved from a seasonal breeder (Andersson *et al.,* 1998).

A significant difference in mean number of lesions as well as mounting frequency was found between herds. This could be ascribed to differences in pen design as regards skin lesions. Partitioning walls have, in previous studies, been shown to reduce aggression levels (Barnett *et al.,* 1992), as this provides an opportunity to escape an aggressor. Partitioning walls were present in herd 4 and 5, where the mean number of lesions was also smallest. Stocking density was adjusted to the different group sizes, and differences between herds were very small, leaving this as an unlikely cause of differences in skin lesions between herds. With mounting behaviour mostly being related to sexual behaviour, different rates of sexual maturation between animals in each herd could be postulated to affect the contradictory results between herds.

Conclusion

No interactive effects were found between social mixing and group size on either skin lesions or mounting frequency in entire male pigs produced under organic standards. Effects of social mixing and group size on mounting frequency were shown as interacting effects with herds, however, with no consistent pattern across all herds. Whilst no effect of social mixing was found on mean number of skin lesions, this measure differed between group sizes, with more lesions in large groups. This could indicate that keeping entire male pigs in groups of 30 animals as compared to smaller groups of 15 may marginally decrease the welfare of these animals. Herd differences were found for both mounting and skin lesions, suggesting effects of environmental factors on these behaviours. No association between skin lesions and mounting were revealed, showing that skin lesions cannot be reliably used as an indirect measure of riding behaviour.

Acknowledgements

The work was carried out under the project “Organic pig production without castration”, which is part of the Organic RDD program. This is coordinated by International Centre for Research in Organic Food Systems, ICROFS and was funded by the Danish AgriFish Agency, Ministry of Food, Agriculture and Fisheries. The authors thank the participating farmers for their cooperation and technician Pia

Haun Poulsen for help on data recording.

References

Andersen IL, Andenæs H, Bøe KE, Jensen P and Bakken M 2000. The effects of weight asymmetry and resource distribution on aggression in groups of unacquainted pigs. Applied Animal Behaviour Science 68, 107-120.

Andersson H, Rydhmer L, Lundstrom K, Wallgren M, Andersson K and Forsberg M 1998. Influence of artificial light regimens on sexual maturation and boar taint in entire male pigs. Animal Reproduction Science 51, 31-43.

Arey DS and Franklin MF 1995. Effects of straw and unfamiliarity on fighting between newly mixed growing pigs. Applied Animal Behaviour Science 45, 23-30.

Barnett JL, Hemsworth PH, Cronin GM, Newman EA, McCallum TH and Chilton D 1992. Effects of pen size, partial stalls and method of feeding on welfare-related behavioural and physiological responses of group-housed pigs. Applied Animal behaviour Science 34, 207-220.

Benjamini Y and Yekutieli D 2001. The control of the false discovery rate in multiple testing under dependency. Annals of statistics 29, 1165-1188.

Boyle LA and Björklund L 2007. Effects of fattening boars in mixed or single sex groups and split marketing on pig welfare. Animal Welfare 16, 259-262.

Cohen J 1960. A coefficient of agreement for nominal scales. Educational and Physiological Measurements 20, 37–46.

Coutellier L, Arnould C, Boissy A, Orgeur P, Prunier A, Veissier I and Meunier-Salaün MC 2007. Pig's responses to repeated social regrouping and relocation during the growing-finishing period. Applied Animal Behaviour Science 105, 102-114.

Cronin GM, Dunshea FR, Butler KL, McCauley I, Barnett JL, and Hemsworth PH 2003. The Effects of immuno- and surgical-castration on the behaviour and consequently growth of group-housed, male finisher pigs. Applied Animal behaviour Science 81, 111-126.

D'Eath RB 2005. Socialising piglets before weaning improves social hierarchy formation when pigs are mixed post-weaning. Applied Animal Behaviour Science 93, 199-211.

Fabrega E, Puigvert X, Soler J, Tibau J and Dalmau A 2013. Effect of on farm mixing and slaughter strategy on behaviour, welfare and productivity in Duroc finished entire male pigs. Applied Animal Behaviur Science 143, 31-39.

Fredriksen B, Lium BRM, Marka CH, Mosveen B and Nafstad O 2008. Entire male pigs in farrow-to-finish pens - Effects on animal welfare. Applied Animal Behaviour Science 110, 258-268.

Giersing M, Lundstrom K and Andersson A 2000. Social effects and boar taint: significance for production of slaughter boars (Sus scrofa). Journal of Animal Science 78**,** 296-305.

Hagelsø Giersing M and Studnitz M 1996. Characterization and investigation of aggressive behaviour in the pig. Acta Agriculturae Scandinavica, Section A Animal Science (Supplement) 27, 56-60.

Hintze S, Desiree S, Turner S and Meddle SL 2013. Mounting behaviour in finishing pigs: Stable individual differences are not due to dominance or stage of sexual development. Applied Animal Behaviour Science 147, 69-80.

Kundel HL and Polansky M 2003. Measurement of observer agreement. Radiology 228, 303-308.

Jørgensen B and Labouriau R 2012, Exponential families and theoretical inference, 2nd edition volume 52. Monografías de Matemática, Springer, Rio de Janeiro, Brazil.

Li Y and Wang L 2011. Effects of previous housing system on agonistic behaviours of growing pigs at mixing. Applied Animal Behaviour Science 132, 20-26.

Martin P and Bateson P 1993. Recording methods. In Measuring behaviour, an introductory guide. (ed. P Martin and P Bateson), pp. 84-100. Cambridge University Press, Cambridge, United Kingdom.

Prunier A, Bonneau M, von Borell EH, Cinotti S, Gunn M, Fredriksen B, Giersing M, Morton DB, Tuyttens FAM and Velarde A 2006. A review of the welfare consequences of surgical castration in piglets and the evaluation of non-surgical methods. Animal Welfare 15, 277-289.

Prunier A, Brillouët A, Merlot E, Meunier-Salaün MC and Tallet C 2013. Influence of housing and season on pubertal development and skin lesions of male pigs. Animal 7, 2035-2043.

R Core Team 2013. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Retrieved on 13 March, from URL http://www.R-project.org/

Rydhmer L, Zamaratskaia G, Andersson HK, Algers B, Guillemet R and Lundström K 2006. Aggressive and sexual behaviour of growing and finishing pigs reared in groups, without castration. Acta Agriculturae Scandinavica, Section A Animal Science 56, 109-119.

Rydhmer L, Hansson M, Lundström K. Brunius C and Andersson K 2013. Welfare of entire male pigs is improved by socialising piglets and keeping intact groups until slaughter. Animal 7, 1532-1541.

Spoolder HAM, Edwards SA and Corning S 1999. Effects of group size and feeder space allowance on welfare in finishing pigs. Animal Science 69, 481–489.

Thomsen R, Edwards SA, Jensen BB, Rousing T and Sørensen JT 2014a. Weight and season affects androstenone and skatole occurrence in entire male pigs in organic pig production. Submitted to Animal, November 2014.

Thomsen R, Edwards SA, Jensen BB, Rousing T and Sørensen JT 2014b. Effect of faecal soiling on skatole and androstenone occurrence in organic entire male pigs. Submitted to Animal, November 2014.

Turner SP, Horgan GW and Edwards SA 2001. Effect of social group size on aggressive behaviour between unacquainted domestic pigs. Applied Animal Behaviour Science, 74, 203-215.

Turner SP and Edwards SA 2004. Housing immature domestic pigs in large social groups: implications for social organisation in a hierarchical society. Applied Animal Behaviour Science 87, 239-253.

Turner SP, Farnworth MJ, White IMS, Brotherstone S, Mendl M, Knap P, Penny P and Lawrence AB 2006. The accumulation of skin lesions and their use as a predictor of individual aggressiveness in pigs. Applied Animal Behaviour Science 96, 245-259.

Verhoog H, Lund V and Alrøe HF 2004. Animal welfare, ethics and organic farming. In Animal health and welfare in organic agriculture (eds M Vaarst, S Roderick, V Lund, W Lockeretz), pp. 73-94, CABI Publishing, Wallingford, UK.

von Borell E, Baumgartner J, Giersing M, Jäggin N, Prunier A, Tuyttens FAM and Edwards SA 2009. Animal welfare implications of surgical castration and its alternatives in pigs. Animal 11, 1488-1496.

Welfare Quality® 2009. Welfare Quality® assessment protocol for pigs (sows and piglets, growing and finishing pigs). Welfare Quality® Consortium, Lelystad, Netherlands.

Table 1. *Mean, standard deviation (sd), min and max number of animals in the two group sizes 'small' and 'large' for each of the two registration rounds.*

	Mean	Sd	Min	Max
1st round				
Small	14	1.5	11	17
Large	28	2.7	22	32
2nd round				
Small	13	1.8	7	15
Large	26	3.4	17	32

Table 2. *Number of pens and number of pigs for each treatment (grouping strategy and group size) and each measurement (skin lesions and mounting) stratified for registration round 1 and 2 and each of five herds (herds 1-5).*

	Herd 1		Herd 2		Herd 3		Herd 4		Herd 5	
	No. of pens	No. of pigs	No. of pens	No. of pigs	No. of pens	No. of pigs	No. of pens	No. of pigs	No. of pens	No. of pigs
1st round										
Regrouping	8	173	7	122	7	164	8	173	8	175
Relocation	8	173	8	139	7	163	8	174	7	147
Small[1]	8	15	7	12	7	14	8	15	8	15
Large[1]	8	29	8	24	7	30	8	29	7	28
Skin lesions	16	318	15	247	14	269	16	239	15	275
Mounting	16	346	15	261	14	327	16	347	7	153
2nd round										
Regrouping	8	170	7	116	7	157	8	164	8	164
Relocation	8	164	8	133	6	123	8	155	7	130
Small[1]	8	14	7	12	7	13	8	13	8	14
Large[1]	8	28	8	22	6	27	8	27	7	26
Skin lesions	16	314	15	203	13	220	15	221	13	166
Mounting	12	245	10	180	13	280	13	259	15	294

[1]Mean number of pigs for small and large group size.

Table 3. *Estimated number of mounts per animal in each of five herds for the reference category summer period, group size large, regrouping and 1^{st} registration round for significant variables and, in addition, ratio between the expected number of mounts in each category of the variables group size, grouping strategy and registration round, stratified for each herd. The lower and upper limits of an asymptotic confidence interval (with 95% coverage) and p-values of asymptotic Wald tests for equality of the respective variables are given.*

	Estimated number of mounts/ animal/4 hours (reference)	Ratio of expected number of mounts relative to respective reference	Lower confidence level	Upper confidence level	P-value
Season (winter)		1.773[1]	1.359	2.313	<0.0001
Herd 1 (reference)	0.900		0.557	1.453	0.6658
Herd1:group size (small)		0.637	0.367	1.106	0.1094
Herd1:grouping (relocation)		0.498	0.287	0.863	0.0129
Herd1:2nd registration round		0.814	0.664	0.863	0.0476
Herd 2 (reference)	0.302		0.146	0.623	0.0012
Herd2:group size (small)		1.800	0.791	4.096	0.1610
Herd2:grouping (relocation)		2.784	1.223	6.341	0.0148
Herd2:2nd registration round		0.648	0.447	0.938	0.0217
Herd 3 (reference)	0.269		0.136	0.532	0.0002
Herd3:group size (small)		0.972	0.420	2.253	0.9479
Herd3:grouping (relocation)		3.929	1.732	8.911	0.0011
Herd3:2nd registration round		1.430	1.053	1.942	0.0222
Herd 4 (reference)	0.379		0.193	0.742	0.0047
Herd4:group size (small)		1.971	0.891	4.364	0.0941
Herd4:grouping (relocation)		1.635	0.741	3.609	0.2233
Herd4:2nd registration round		0.869	0.638	1.183	0.3725
Herd 5 (reference)	0.607		0.305	1.209	0.1557
Herd5:group size (small)		1.623	0.720	3.656	0.2426
Herd5:grouping (relocation)		1.357	0.599	3.074	0.4642
Herd5:2nd registration round		1.505	1.073	2.109	0.0178

[1]Numbers below 1 indicate a higher level in the reference category (e.g. summer, group size large, regrouping and 1^{st} registration round) and the opposite for numbers above 1.

Table 4. *Estimated mean number of lesions per animal in each herd for the reference category group size large and 1st registration round for tested variables and the ratio between the expected number of lesions relative to the number in the reference category for each significant variable in the log normal model. The lower and upper limits of an asymptotic confidence interval (with 95% coverage) and the p-values of asymptotic Wald tests for equality of the respective variables are given.*

	Estimated mean number of lesions per animal	Ratio of expected number of lesions relative to the number in the reference category[1]	Lower	Upper	P-value
Herd 1	17.307		13.949	21.474	<0.0001
Herd 2	19.253		15.401	24.068	<0.0001
Herd 3	21.399		8.520	13.122	<0.0001
Herd 4	10.574		17.123	26.743	<0.0001
Herd 5	9.627		7.679	12.069	<0.0001
Group size (small)		0.816	0.687	0.969	0.0103
2nd registration round		0.511	0.444	0.588	<0.0001

[1]Numbers below 1 indicate a higher level in the reference category (e.g. group size large and 1st registration round).

Table 5. *Percentage of animals for each score of lameness, body condition, apathy and died/removed animals for each of two registration rounds (1st and 2nd).*

	1st	2nd
Lameness		
0	98,9%	98,5%
1	1,0%	1,2%
2	0,1%	0,3%
3	0,0%	0,0%
Body condition		
1	96,7%	99,9%
2	3,3%	0,1%
3	0,1%	0,0%
Apathy		
1	99,5%	99,9%
2	0,5%	0,1%
3	0,0%	0,0%
Died/removed	2,2%	4,9%

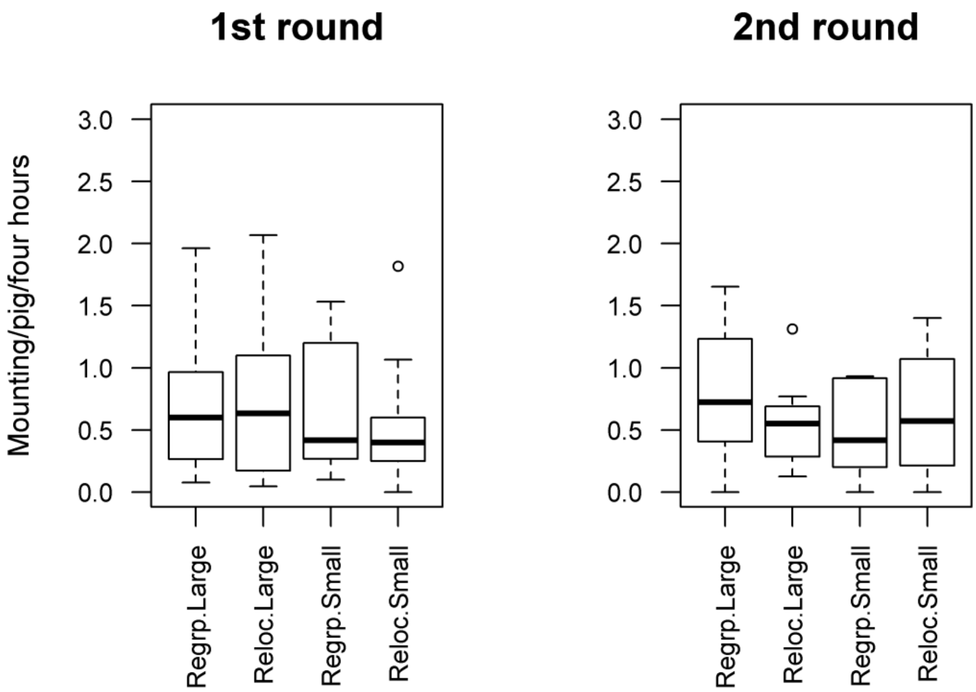
Figure captions

Figure 1. Level of mounting per pig per four hours for grouping strategy (Regrouping, Relocation) x group size (Large, Small) for each of two registration rounds. The length of the box represents the interquartile range, the horizontal line in the box interior represents the median and the vertical lines issuing from the box extend to the minimum and maximum values of the mounting variable on pen level. The small circles represent outliers (extreme values).

Figure 2. Total number of skin lesions per pig for grouping strategy (Regrouping, Relocation) x group size (Large, Small) for each of two registration rounds. The length of the box represents the interquartile range, the horizontal line in the box interior represents the median and the vertical lines issuing from the box extend to the minimum and maximum values of the skin lesion variable on pig level. The small circles represent outliers (extreme values).

Figure 3. Percentage of animals according to number of lesions on the front part of the body (head and shoulder) for 1st and 2nd registration round. Number of lesions are divided into 5 categories; 0, 1-5, 6-10, 11-20, >20.

Figure 1



1st round
2nd round
Mounting/pig/four hours
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Regrp.Large
Reloc.Large
Regrp.Small
Reloc.Small

Figure 2

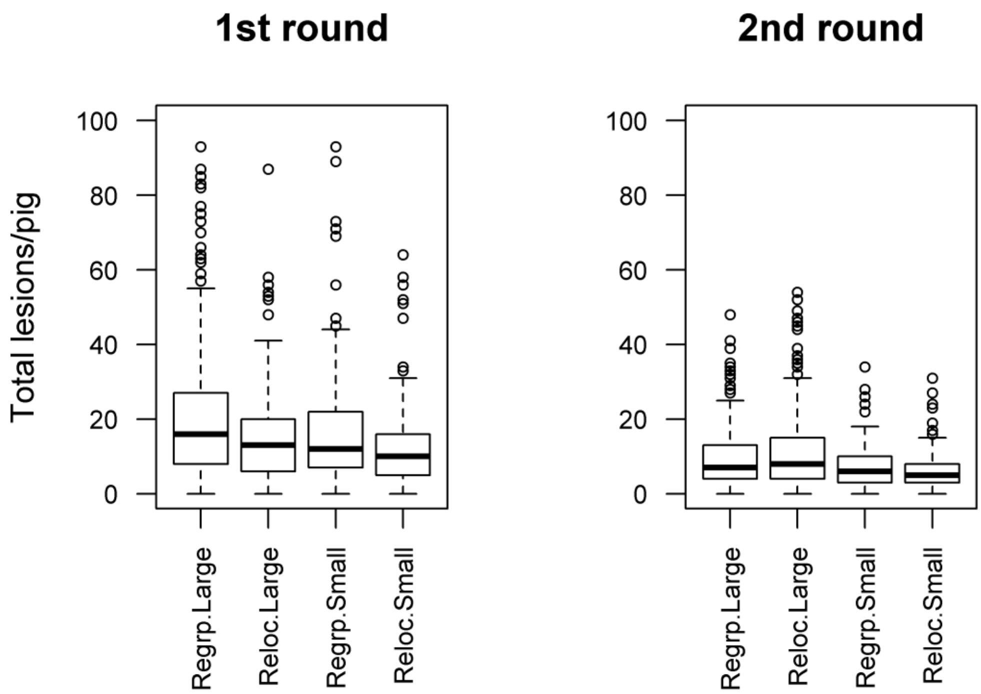
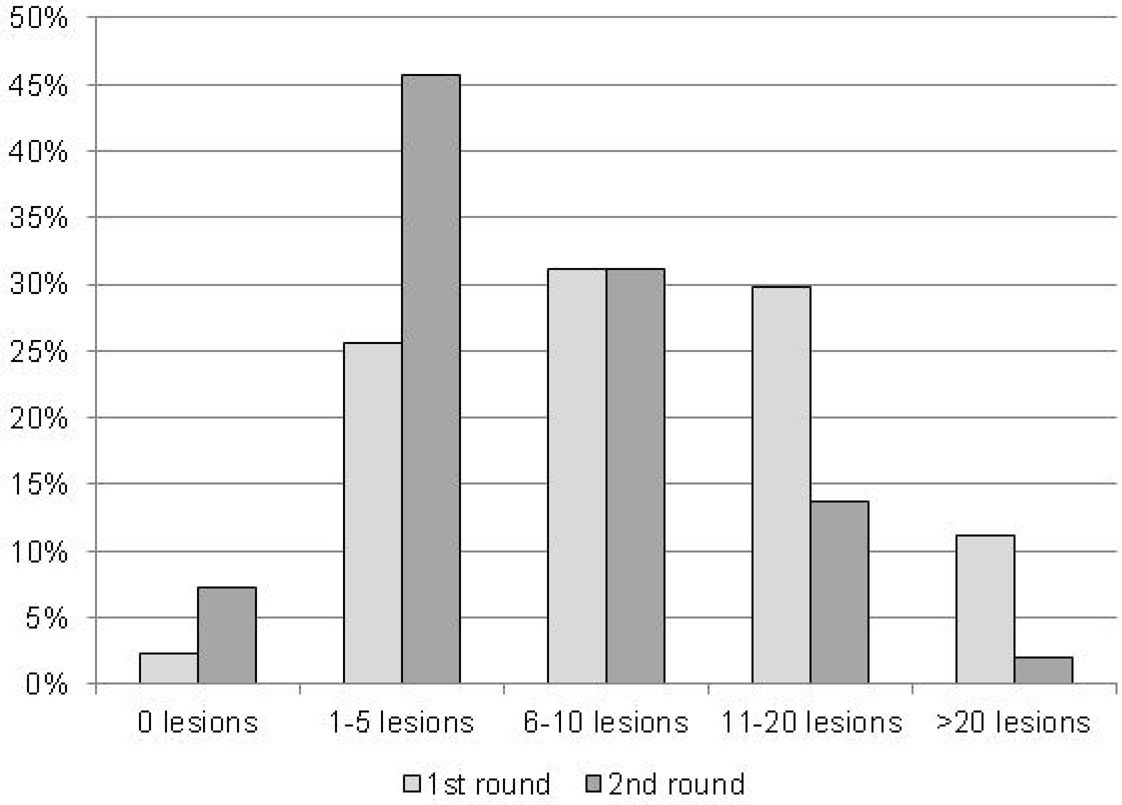

1st round
2nd round
Total lesions/pig
100
80
60
40
20
0
Regrp.Large
Reloc.Large
Regrp.Small
Reloc.Small

Figure 3


50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
0 lesions
1-5 lesions
6-10 lesions
11-20 lesions
>20 lesions
1st round
2nd round