Mounting behaviour in finishing pigs: Stable individual differences are not due to dominance or stage of sexual development

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Abstract

Every year around 100 million male piglets are castrated in the EU, usually without anaesthesia or post-operative analgesia. This surgical intervention is painful and stressful. Several main players within the pig industry have voluntarily agreed to end the practice of surgical pig castration in the EU by 2018. One alternative to castration is entire male pig production. However, entire males behave differently than castrates, for example, by performing more mounting behaviour, which is suggested to be a welfare problem.

The aim of our study was to develop a comprehensive ethogram of different types of mounting and to investigate properties, causes and consequences of mounting behaviour in finishing pigs.

The study included 80 entire male and 80 female pigs from two farrowing batches born six weeks apart. Mixed sex and single-sex housing of pigs are both common in pig farming, so to ensure our study was representative, the 160 pigs were assigned to social groups of 20 in three treatments: entire male pigs only (MM, 2 groups, n=40), entire females only (FF, 2 groups, n=40) and entire males and females mixed together (MF, 4 groups, n=80). Measurements took place during the final six weeks before slaughter (between 63.5 and 105.5kg). Observations of mounting behaviour on 12 days per batch suggested that: i) males mounted more than females, ii) within sex, there was no effect of treatment on the amount of mounting (although the statistical power of the study to detect these effects was low), iii) there were individual differences in mounting that were stable over time (within sex).

Classification of mounting into different categories revealed that sexual mounting was most common overall and in males but only rare in females. Compared to other types of mounting (e.g. caused by crowding or during a fight), sexual mounts lasted longer and provoked more screaming by the recipient. There were no relationships between mounting behaviour on the one hand and dominance rank in food competition tests, the circulating levels of sex hormones (oestradiol, testosterone and progesterone) at the end of the study, the health scores (lameness and scratches) or weight gain on the other hand.

The stable individual differences of mounting over time suggest that mounting behaviour is a trait of the individual rather than the appearance of random outbreaks. However, these differences in

mounting cannot be explained by dominance behaviour or by differences in sex hormone concentrations that could indicate the onset of puberty.

Mounting behaviour and in particular sexual mounting provoked high pitched screaming of the recipients indicating that mounting is a welfare problem. For the welfare assessment of entire male pig production the performance of mounting behaviour should be considered.

Keywords: mounting behaviour, sexual behaviour, dominance, puberty, welfare

1. Introduction

Every year approximately 100 million male piglets are castrated in the EU (EFSA, 2004), usually without anaesthesia or post-operative analgesia (Prunier et al., 2006). This surgical intervention itself is stressful and painful (Marx et al., 2003; Prunier et al., 2005), and differences in behaviour indicate that pain can persist for up to five days after castration (Hay et al., 2003). Norway banned the castration of male piglets entirely in 2009 and Switzerland only permits this intervention under anaesthesia. Several of the main industrial pig producers voluntarily agreed in 2010 to end the practice of surgical pig castration in the EU by 2018 (EuropeanCommission, 2010).

One alternative to surgical castration is the rearing of entire males as it is common in the UK and for the majority of producers across Spain and Portugal. However, entire male pigs show more aggressive and mounting behaviour compared to castrates (Fredriksen et al., 2008; Rydhmer et al., 2010). Consequently, the consequences of rearing entire males should to be assessed so that adapted management and husbandry strategies can be adopted to improve welfare.

The objectives of this experiment were to develop and apply a comprehensive ethogram describing the variety of types of mounting behaviour and to investigate properties, causes and consequences of this behaviour in entire male and female finishing pigs kept in single and mixed-sex groups.

It was hypothesised that most mounting would occur in single-sex groups with males, followed by mixed-sex groups and that least mounting is seen in single-sex groups with females (H1). Clark reported that the amount of individual mounting behaviour observed in a behavioural test of pig aggression (resident-intruder test) was consistent between test sessions (Clark, 2007). Our previous pilot data (Scott et al., unpublished) suggest that the level of mounting shows considerable variability

within a population. The hypothesis was that mounting in the home pen shows stable individual differences over time (H2).

Two main causes underlying mounting behaviour have been discussed in the literature. Firstly, mounting has been described as sexual behaviour (Rydhmer et al., 2006; Fredriksen et al., 2008). As the number of pigs reaching puberty should increase with the age of the pigs, it was hypothesised that the amount of mounting would also increase over time (H3). Moreover, individual differences in mounting behaviour should be related to the rise in circulating sex steroids as a marker for the puberty onset (H4). A second explanation for the performance of mounting is that it might be a form of dominance behaviour (Fredriksen et al., 2008). We hypothesised that mounting behaviour is positively correlated with dominance (H5). Finally, as mounting has been reported to have negative economic and welfare consequences (Rydhmer et al., 2006), we quantified the effects of mounting on weight gain, lameness and scratches.

The experiment included two batches of 80 finishing pigs each allocated to three treatment groups (single males, single females, mixed-sex), in order to represent the typical diversity of finisher housing in the pig industry, where mixed sex or single-sex housing from weaning are both commonly used by different pig producers. Measurements comprised observations of mounting behaviour over six weeks per batch, quantification of sex steroids, dominance tests, pig weight and scoring of lameness and scratches.

2. Materials and methods

2.1. Animals and housing

The study included 80 entire male and 80 female crossbred pigs (Synthetic white × (Large white x Landrace)) from two farrowing batches born six weeks apart. The 80 pigs of each batch were kept in four pens of 20 pigs each. In each batch one pen only contained males (MM), one only females (FF) and two of the pens comprised ten males and ten females each (FM1 and FM2). This low level of replication at the group level meant that the power of the study to detect treatment differences was low, so non-significant results for treatment differences should be treated with caution.

Allocation to the four groups was balanced by weight (Table 1). When weaned and weighed at the age of four weeks the 40 heaviest males and the 40 heaviest females out of 105 piglets in batch 1 and 91

106 piglets in batch 2 were selected for the study. All pigs were given individual coloured ear tag
107 combinations to make them easily identifiable. Five pigs of batch 1 and eight pigs of batch 2 died
108 before the start of the experiment, had to be euthanised, or were separated from their groups due to
109 bitten tails during the course of the study.

110 The study took place from day 74 until day 111 after weaning, covering the last six weeks before pigs
111 were slaughtered at an average weight of 105.5 ± 9.8 kg. This period was chosen as most mounting is
112 seen in finishing pigs (Scott et al., unpublished). Pigs were moved from the grower to the finisher
113 accommodation at least six days prior to the beginning of the study. Experimental animals were kept
114 in a block of four adjacent pens with pairs opposite on either side of the central passage. The
115 arrangement of treatment groups in the pens was randomised between the two batches to control for
116 effects based on pen location.

117 All pens measured 2.30m × 5.95m containing an area in which straw was provided (60%) and a solid
118 floor dung area (40%). They were cleaned daily. The side walls of the pens were 1.00m high and were
119 solid except for the fence in the dung area in which animals could have contact with pigs from
120 neighbouring pens through a metal rod fence. Pigs were fed a commercial pelleted diet *ad libitum* in a
121 three-space feeder and water was accessible *ad libitum* through two nipple drinkers per pen. Pigs were
122 housed alongside other pens of pigs in an unheated building in which temperature was regulated by
123 means of automatically controlled natural ventilation. Daily mean (±s.d.) temperature was 16.9 (±1.0)
124 °C, with daily mean max and min temperatures of 18.1 (±1.8)°C and 15.6 (±1.2)°C respectively.

125 *2.2. Mounting behaviour*

126 Mounting behaviour was recorded by direct observation for each batch for two hours between 13:15
127 and 15:15 h on 12 days distributed over the six weeks of the study period. The time period was chosen
128 based on the results of our recent pilot study demonstrating a peak of mounting activity in the early
129 afternoon. This pilot study comprised three full-day observations of four groups of mixed-sex finisher
130 pigs weighing between 70 and 100kg.
131 All pigs could be observed simultaneously as they were kept in a block of four adjacent pens.
132 Observations were carried out by the same observer who was standing in the middle of the central

passage while observing. Daily habituation time was not necessary as pigs were used to the presence of the observer. Every mounting event during the observational periods was recorded and, if possible, the identities of the initiator and the recipient, the kind of mounting, the incidence of the recipient´s screams and the duration of the mounting behaviour subdivided into four categories: `short´ (<1s), `medium´ (1s- 10s), `long´ (>10s- 60s) and ´very long`(>60s), Table 2). Moreover, all mounting attempts were recorded. Occasionally mounting was taking place with more than one pig or more than one pen. It is possible that some mounting events were missed, although we estimate that this occurred on fewer than 1% of occasions. In cases of more than one mount at the same time priority was given to the identification of the mounters (5.1% missing data), compared to the recording of the other aspects of mounting behaviour such as the identity of the recipients (22.7% missing data) duration (5.0% missing data) and the occurrence of vocalizations (4.7% missing data).

2.3. Selection of focal animals

After four days of observation, eight focal animals per pen (32 per batch and 64 in total) were determined. From each pen the four animals demonstrating the most and the four animals performing the least mounting were selected (high and low mounters). For the mixed-sex pens selection of focal animals was balanced for sex by choosing the two animals showing the most and the two animals showing the least amount of mounting for each sex. For selection of the `least mounting pigs´, when several animals per pen had not performed any mounting so far, the animals which had been the most common mounting recipients were selected (batch 1: n=11, batch 2: n=11).

Focal animals were used in a group feeding competition test and for physiological measurements based on blood samples to determine the onset of puberty.

2.4. Blood sampling

To determine which of the pigs had already reached puberty, blood from the focal animals was collected in the fifth week of both study periods. Pigs were restrained by a snitch (a wire noose around the upper jaw, used to raise the head) and five to eight millilitre of blood were taken from the jugular vein with heparinised 10ml vacuum syringes (Vacutainer ®). The blood was immediately centrifuged and the plasma harvested and stored at -20 °C.

160 Plasma testosterone, oestradiol and progesterone concentrations were determined by
161 radioimmunoassay using `Coat-A-Count´kits (Siemens Healthcare Diagnostics Inc. Los Angeles CA
162 USA) according to the manufacturer's instructions and as previously described for pig plasma
163 (Andersson et al., 1998; Brandt et al., 2007; Langendijk et al., 2009). All plasma samples for each
164 hormone assay were run in duplicate in a single assay and serially diluted pig plasma samples gave
165 results parallel to the standard curve. For testosterone the minimum detection limit was 0.04 ng/ml;
166 for oestradiol this was 8pg/ml and for progesterone it was 0.02ng/ml (the intra-assay coefficients of
167 variation were less than 7 % for all three assays).

168 *2.5. Group feeding competition test*

169 Food competition tests were performed to determine the dominance rank of the focal animals. Each
170 group was tested once in week four and then again in week five of the study period and two groups of
171 eight pigs were tested per day. In previous pilot work (Scott et al., unpublished) these tests had worked
172 well for groups of less than 10 pigs, so we tested only the 8 focal animals rather than the whole group.
173 All tests were carried out in the morning after focal pigs had been separated from their group the
174 previous afternoon and had been food-deprived overnight. The separation and test pens were identical
175 to the home pens but without access to food.
176 Before starting the test all pigs were encouraged to stand, to ensure equal conditions for every
177 individual. The pig´s usual pelleted food (one full jug ≙ 424 g) was placed on the floor in the middle
178 of the cleaned pen. Two observers recorded the identities of initiator and recipient of all attacks until
179 all food was consumed. Attacks included ´bite or head-knock´ (delivering a blow by a rapid sideways
180 or upwards movements of the head), `push´ (leaning the body against another pig and shoving it
181 away) and `chase´ (running after another pig that runs away; modified after D´Eath, 2002). The pig
182 initiating the greatest number of attacks was then removed and brought back into its home pen. The
183 criterion for removal was that at least three attacks from the same pig were recorded. If several pigs
184 achieved the criterion all of these animals were removed and given the same rank score. After
185 separation of the pigs the test was repeated with the adjusted amount of food for the remaining number
186 of pigs (food was reduced by 50g for each pig removed). When no pig attacked more than twice, the

187 test was rerun two more times and ceased when the criterion was not reached during the second
188 repetition.
189 Based on the order of removal, a rank score was assigned to each pig with pigs being removed first
190 getting a score of 1 and so on. All remaining pigs at the end of the test were scored with the same rank
191 (10) to make the groups with different numbers of remaining animals comparable to each other.

192 *2.6. Performance and health*

193 Each pig was weighed at the beginning and at the end of the study period. The total weight gain was
194 calculated in order to assess the performance of the pigs.
195 Health scoring was carried out for all pigs on a weekly basis and included lameness and scratches that
196 were always scored by the same person. Locomotion scoring was based on four categories modified
197 after D´Eath (2012): Score 0 (`normal´): Even strides, rear end sways slightly while walking, pig is
198 able to accelerate and change direction rapidly. Stands normally. Score 1 (`stiff´): Abnormal stride
199 length, movements no longer fluent, pig appears stiff. Pig still able to accelerate and change direction.
200 Stands normally. Score 2 (`lame/ limping´): Pig slow or reluctant to get up (may dog sit), shortened
201 stride, pig minimises weight-bearing on affected limb (stands on toes) or avoids placing affected limb
202 on the floor while moving (holds limb off floor while standing). Score 3 (`downer´): Pig does not
203 move and struggles to stand when encouraged to do so.
204 The person scoring the pigs walked around in the pen and looked at each pig individually after
205 encouraging it to walk. The number of scratches was recorded for each individual animal. Only
206 scratch marks which seemed likely to be caused by mounting behaviours were included. Considering
207 the experience from the pilot study scratches had to be at least five millimeters wide and without
208 visible lesions from the teeth. Moreover, `real mounting scratches´ that were two wide scratches
209 parallel to each other in the distance of two claws were recorded separately.

210 *2.7. Ethical considerations*

211 The experiment was carried out in accordance with the ethical policy of the International Society for
212 Applied Ethology. The SRUC´s Animal Experiments Committee and the UK Government´s Home
213 Office approved the procedures. Blood sampling was the only Home Office licensed procedure and so
214 was covered by a project license and carried out by personal licensees. In the study mounting

behaviour was not provoked, it was only observed. Tail-bitten animals were separated from the group to avoid stress and pain for the victim animals. For the group feeding competition tests and the physiological data only selected focal animals were used to reduce the number of pigs involved. By testing pigs only twice, a minimum of tests was carried out to achieve a dominance rank score. To minimise the adverse effects of hunger, pigs were food deprived overnight when they typically eat little or no food (Stolba and Wood-Gush, 1989; de Haer and Merks, 1992).

2.8. Statistical analyses

Data were analysed with Minitab (v. 16) except for general ANOVAs that were run with GenStat (v. 14, Lawes Agricultural Trust, Rothamsted, UK). The 13 pigs that were removed from the experiment during the course of the study were excluded from the tests leading to a general sample size of n=147. For parametric tests, the distribution and homogeneity of variance was checked by inspecting data histograms, or for ANOVAs by inspecting a histogram of residuals and a plot showing the residuals versus the fitted values. If appropriate, transformations were used to improve normality: log 10 transformations of the mounting data, the testosterone and progesterone values and square root transformation of the oestradiol values. All analyses considering the effect of treatment were also run separately for both sexes to avoid confounding with sex. Consequently, differences between the males in MM and FM groups and between the females in FF and FM groups were investigated. The effects of sex and treatment on mounting behaviour, the level of sex hormones and weight gain were tested by general ANOVAs. Since treatments were applied at the group level, group was fitted to the model as a blocking factor, which in Genstat ANOVA means that treatment effects are worked out at the appropriate level, using the correct error degrees of freedom- in this case this is the between group level. It should be noted that the level of replication was so low that the experiment was under-powered for detection of more subtle treatment effects. As such non-significant effects of treatment should be viewed with a degree of caution. Sex and treatment effects on lameness and scratches were analysed by Kruskal-Wallis tests. Moreover, the health parameter data and the average mounting/ being mounted frequencies per pig per week were converted to 1/0 and Fisher´s exact tests were run separately for every week and every health parameter. A Bonferroni correction was applied ($p<0.01$ instead of $p<0.05$ used as significant level, as there were five weeks). Fisher´s exact tests were also run

to analyse the associations between two of the three recorded properties of mounting behaviour (type, duration, screaming) at a time. For these tests the parameters of mounting type and duration were combined to form two categories of each (type: sexual and non-sexual mounting, duration: short/ medium and long/very long). To minimise the effect of pseudoreplication only the first mounting event of each individual in each session was considered. Moreover, proportions for each individual and each category were calculated. Differences in sex and treatment were analysed for each category of each parameter using Mann-Whitney U tests.

Spearman´s rank correlations were used to test for associations between dominance rank (average of the ranks of the two food competition tests) and mounting/ being mounted, dominance rank and weight gain and for associations between mounting/ being mounted and the different weight parameters (weight gain, starting weight, end weight). Moreover, Spearman's rank correlations were also used to explore the development of mounting over time (by correlating each pig´s number of mounts per session with the order of the 12 sessions) and the consistency of mounting behaviour/ being mounting (by correlating data from single sessions (1,6, and 12) with each other and triplets of sessions (1-3, 4-6, 7-9, 10-12)). Spearman's rank correlations were also used to investigate associations between the plasma concentrations of sex hormones. The individual consistency of mounting and being mounted was also checked by the application of Kendall´s coefficient of concordance.

3. Results

3.1. Properties of mounting behaviour, effects of sex and treatment

The frequency distribution of performed and received mounting behaviour is shown in Fig. 1. Most pigs did not perform any or only sporadic mounts while certain individuals displayed a lot of mounting (Fig. 1A). Recipients of mounting had a less skewed distribution, although there was still considerable individual variation in the amount of mounting received (Fig. 1B).

Treatment had a significant effect on the overall level of mounting (total mounting mean ± s.e.: FF=5.3±1.3, FM=11.7±1.5, MM=19.7±3.1; $F_{(2,5)}$ =9.10, p=0.022; H1). However, it was evident that this was predominantly due to differences between the sexes: Sex had a significant effect on mounting with males mounting around three times as much as females overall (total mounting mean ± s.e.:

males=18.8±2.0, females= 5.7±0.9; between group $F_{(1,6)}$=15.2, p=0.008, within groups $F_{(1,138)}$=22.2, p<0.001) and within mixed sex (FM) groups (total mounting mean ± s.e.: males=18.8±2.1, females=5.7±0.; $F_{(1,69)}$=25.6, p<0.001). When males and females were analysed separately, there was no effect of treatment on mounting (males: total mounting mean ± s.e.: males in FM=17.9±2.6, males in MM=19.7 ±3.2, $F_{(1,4)}$=0.00, p=0.982; females: females in FM=6.2 ±1.2, females in FF=5.3±1.3, $F_{(1,4)}$=0.61, p=0.478; H1), although this result should be treated with caution because of the low number of groups of each treatment in this study. However, there was no significant difference in the amount of mounting received by males and females in the mixed-sex groups (males=8.4±0.8, females=10.0±1.1; $F_{(1,69)}$=0.98, p=0.326).

29.6% of all mounts were classified according to the different types of mounting described in table 2, while the remainder were 'unclassified'. Among these classified mounts, sexual mounting was observed most frequently (51.6%), followed by fence mounting (36.6%), crowding mounting (9.1%), mounting while playing with straw (2.2%) and mounting during a fight (0.6%). Most mounting events were between one and 10 seconds long (medium; 71.1%) and very long mounts (longer than one minute) were only seen rarely (7.7%).

There were highly significant effects of sex of the mounter on the type of mounting (Median proportion of mounts identified as sexual: males=0.04, females=0.00; W= 3169.0.0, p<0.001), the duration of mounting (Median proportion of mounts which were long or very long: males=0.14, females=0.00; W= 3313.0, p<0.001) and the occurrence of screaming (Median proportion of mounts in which recipient screamed, males=0.04, females=0.00; W= 3291.0, p<0.001). Males displayed more sexual mounting, longer mounts and provoking more screaming by the recipients than females. The effects of treatment split by sex on mounting type were not significant.

Sexual mounts lasted longer than non-sexual mounts (p<0.001; Fig. 2 A. Moreover, sexual mounting provoked more screaming by the recipients than non-sexual mounting (p<0.001, Fig. 2 B).

3.1.1. The effect of treatment on mounting

296 Fig. 3 shows the mean number of mounts per pig in the different treatment groups (H1). There was no
297 significant effect of treatment split by sex on the amount of mounting behaviour (males: $F_{(1,67)}=0.02$,
298 p=0.89; females: $F_{(1,70)}=1.33$, p=0.366).

299 *3.1.2. Consistency of mounting behaviour in individuals over time*

300 The analysis of Kendall's coefficient of concordance showed that the numbers of mounts per
301 individual across the different observation sessions were positively and weakly but highly significantly
302 associated with each other (W=0.33, p<0.001; H2). A similar result but with a weaker relationship was
303 found for individual consistency of mounting receipt (W=0.18, p<0.001).
304 These results were supported by Spearman´s rank correlations looking for associations between
305 different single sessions and combinations of sessions (session 1-3, 4-6, 7-9 and 10-12 combined
306 together). For mounting, correlations of the combined sessions ranged between $r_s=0.202$ and $r_s=0.275$
307 with all correlations being highly significant at p<0.001. Correlations of the combined sessions for
308 received mounts were all significant at p<0.05 or lower ranging from $r_s=0.086$ and $r_s=0.184$.

309 *3.2. Causes underlying mounting behaviour*

310 *3.2.1. Mounting behaviour and puberty*

311 *3.2.1.1. Development of mounting over time*

312 Fig. 4 presents the development of mounting in general and sexual mounting in particular over time
313 for both sexes (H3). The 12 observation sessions per batch were spread over six weeks. There was a
314 significant negative correlation between the order of the observation sessions and the ranked number
315 of all mounts (respectively sexual mounts) performed indicating that mounting behaviour decreased
316 over time ($r_s=-0.59$, p=0.045, respectively $r_s=-0.58$, p=0.048). However, this effect was only
317 significant for males ($r_s=-0.78$, p=0.003, respectively $r_s=-0.585$, p=0,046) but not for females
318 ($r_s=0.196$, p=0.542, respectively $r_s=0.218$, p=0.495).

319 *3.2.1.2. Sex steroids*

320 Values of the testosterone, oestradiol and progesterone for female and male focal animals are
321 presented in Table 3. Plasma concentrations of oestradiol and testosterone in female pigs were so low
322 as to be undetectable by our assay for all but one individual, so were not analysed further. For males

levels of oestradiol and testosterone did not significantly differ between treatment groups (oestradiol: $F_{(1,25)}$=1.68, p=0.324; testosterone: $F_{(1,25)}$=0.90, p=0.444). For progesterone, 13 males and 24 females had undetectably low levels. Including these in the analysis as zeroes, males had significantly higher values of progesterone than females (medians: males=0.13, females=0.00; H=4.09, p=0.043) and the levels of this hormone were higher in MM males than in FM males ($F_{(1,25)}$=43.35, p=0.022). When assessed as covariates, the total frequency of mounting performed or the amount of sexual mounting in particular were not significantly related to hormone concentrations (Total mounting, male oestradiol $F_{(1,25)}$=0.53, p=0.475; male testosterone $F_{(1,25)}$=0.0, p=0.99; male progesterone $F_{(1,25)}$=0.31, p=0.584; H4).

Hormone levels of pigs classified as high or low mounters when selected as focal animals were analysed by Mann-Whitney U tests and did not differ significantly (oestradiol: W=1088.5, p=0.4908; testosterone: W=1052.0, p=0.8689; progesterone: W=982.5, p=0.3894).

Finally, for males, hormone concentrations were highly correlated (all p<0.001) at the individual level (oestradiol and testosterone r_s=0.72, oestradiol and progesterone r_s=0.66, testosterone and progesterone r_s=0.72).

3.2.2. Mounting behaviour and dominance

Dominance rank and the number of recorded mounts were not associated (r_s=0.115, p=0.364). Furthermore, weight gain was not affected by dominance rank (r_s=0.144, p=0.261).

3.3. *Consequences of mounting behaviour*

3.3.1. Performance

There was a significant effect of sex on weight gain ($F_{(1, 137)}$=9.89, p=0.002) with males weighing more than females at the end of the study (males: 107.5kg ±9.6; females: 103.4kg ±9.4). Treatment split by sex did not have a significant effect on weight gain (males only: $F_{(1,65)}$=1.76, p=0.316; females only: $F_{(1,67)}$=0.24, p=0.675).

For both sexes mounting performance was not associated with weight gain, starting weight or end weight. However, there was a significant positive correlation between the frequency of mounting receipt and weight gain in males (r_s=0.262, p=0.026) and mounting receipt and starting weight in

females (r_s= 0.394, p<0.001). End weight and mounting receipt were positively associated in both sexes (males: r_s=0.316, p=0.007; females: r_s=0.342, p=0.003) showing that the effect of heavier pigs being mounted more was not only caused by the sex differences in weight.

3.3.2. Scratches and lameness

Sex and treatment split by sex had no significant effect on the occurrence of scratches (86.4% of the animals affected), `real mounting scratches´ (12.93% affected) or lameness (2.72% affected, Table 4). The performance of mounting behaviour or being mounted was not associated with any of the three health parameters (Mounting: scratches: X^2=0.000, p=0.983, real mounting scratches: X^2=2.055, p=0.154, lameness (Fisher´s exact test) p=0.347; being mounted: scratches: X^2=1.325, p=0.250, real mounting scratches: X^2=1.362, p=0.243, lameness (Fisher´s exact test) p=0.386).

4. Discussion

The aims of this study were to develop and apply a comprehensive ethogram of different types of mounting behaviour and to investigate properties, causes and consequences of mounting in entire male and female finishing pigs. The results of the experiment confirm that entire male pigs perform more mounting behaviour than females and that the number of mounts received by males and females does not differ significantly (Rydhmer et al., 2006). The individual rank-order with respect to the frequency of mounting performed was consistent over time. Mounting was neither associated with dominance rank nor with the level of sex steroids. Moreover, health and weight gain were not related to the amount of mounting performed or received.

To investigate the consequences of two different rearing strategies on mounting behaviour, single-sex and mixed-sex treatment groups were chosen (H1). Males mounted considerably more than females, and apparent differences in the level of mounting between the different sex-composition treatment groups could be explained by the different sexes present: Analysing each sex separately, there were no differences between treatments in the amount of mounting performed (i.e. no difference between the amount of mounting by males in MM or FM groups, and no differences between females in FF or FM groups). However, it should be considered that the study only included two (FF, MM) or four (FM) pens per treatment group. A larger (more powerful) study would be required to investigate whether

single or mixed sex grouping resulted in differences in behaviour over and above the effects of sex identified here. Moreover, males from MM had direct contact with females through the fence. Males kept in single-sex sections within a building perform more mounting than males in single-sex pens kept in the same section with females (Salmon and Edwards, 2006). Consequently, the contact with females in neighbouring pens may have decreased the amount of mounting shown by males in MM pens.

It has been argued that at least the females are spared from being mounted when rearing pigs in single-sex pens (Rydhmer et al., 2006). It is difficult to assess whether we should regard most of the mounts being received by fewer pigs (i.e. males in single-sex groups) or the same amount of mounting distributed over more pigs (i.e. males and females in mixed-sex groups) as being the preferable scenario for the welfare of *all* pigs. To better understand the impacts on welfare it would be important to further investigate what it means for a pig to be mounted in the longer term. Furthermore, the disturbance for all pigs within a pen provoked by mounting should be considered.

The investigation of mounting properties included different types of mounting, their duration and the screaming they provoke as well as the individual consistency of mounting over time. In the literature mounting is discussed as sexual behaviour (Cronin et al., 2003; Rydhmer et al., 2006; Fredriksen et al., 2008) and the behaviour belongs to the pig´s sexual behaviour repertoire (Hemsworth and Tilbrook, 2007). Moreover, surgically and immuno-castrated males show less mounting than entire males indicating that sex hormones are relevant for the performance of mounting behaviour (Cronin et al., 2003; Rydhmer et al., 2010).

However, in the present study mounting behaviour was divided into different categories. This distinction may be important as different types of mounting may have different origins and welfare consequences. For example, mounting another pig to get into contact with animals from a neighbouring pen or to manipulate the fence or wall, the so-called fence mounting, gave the impression of being more exploratory than sexual behaviour. As a consequence, the strategies used to reduce them might also be different- for example we could speculate that ‘crowding’ and ‘fence’ mounting could be altered with stocking density or pen design, whereas sexual mounting might be less affected by those factors. The mounting behaviour that we observed involving pelvic thrusts and/or a

protruded penis was more obviously a sexual behaviour. Accounting for approximately half of all mounts that could be categorised, sexual mounting was the most common type of mounting. However, it was almost exclusively seen in males. Sexual mounts were longer than non-sexual mounts and provoked more screaming by the recipients being mounted. It remains unclear whether the screaming was evoked by the sexual movements per se or by the longer duration of these mounts as type and duration were confounded. However, loud and high pitched screaming in pigs is an indicator of stress and reduced welfare (van Putten, 2000; Manteuffel et al., 2004). Consequently, we conclude that sexual mounting has a greater impact on welfare than non-sexual mounting. We recommend that in future studies, mounting behaviour should be divided into different categories to include these distinctions.

Individual differences in mounting in the home pen were consistent over time (H2). However, the correlations between the rank of mounts performed and session number were quite weak. The high variability between the different observation sessions might have masked the effect of consistency in individual mounting behaviour.

The amount of mounting was stable between different test sessions in a resident-intruder test (Clark, 2007). Based on the consistency across situations and over time, we suggest that mounting is a behavioural trait rather than a less consistent state (Kooij et al., 2002). The existence of a consistent stable mounting trait raises the possibility that genetic selection against mounting behaviour could possibly be included in breeding programmes to improve welfare in entire male pig production. However, as mounting is an important trait for breeding boars, such a selection strategy might lead to fertility and sexual behaviour problems. Moreover, ethical issues should be considered before changing animal behaviour through selection (D'Eath et al., 2010).

As possible causes underlying mounting behaviour we investigated the relationship between mounting on the one hand and the onset of puberty and dominance rank on the other hand. If mounting increased with puberty, then an increase over time would be expected (H3). However, the amount of mounting shown by females stayed stable while males performed significantly less mounting over time indicating that the behaviour is not necessarily related with sexual maturity. Mounting behaviour peaks when pigs are around two months old (Berry and Signoret, 1984; Ford, 1990). At this age

mounting is described as `sex play´ rather than sexual behaviour (Berry and Signoret, 1984). The findings of this experiment confirm the results of another study describing a decline in mounting following this peak (Ford, 1990).

In addition to the increase in mounting over time, a relationship between the levels of sex hormones and the performance of mounting behaviour was hypothesised (H4). However, levels of the sex steroids were in the typical range for immature male and female pigs (Shearer et al., 1972; Zamaratskaia et al., 2004). Moreover, they were not related with the amount of mounting in general or sexual mounting specifically. These results appear to suggest that mounting behaviour does not have to be associated with the onset of puberty which is initiated by the production of sex hormones (Andersson et al., 1999). Pigs normally attain puberty at the age of between six and seven months in males (Lagerlöf and Carlquist, 1961) and five and seven months in females (Eliasson-Selling and Andersson, 1992). Animals in this study were slaughtered at approximately 4.5 months of age. Consequently, the analyses of sex steroids levels confirm that pigs had not yet attained puberty and that the observed mounting behaviour can therefore not be explained by the attainment of puberty, and that stable differences between individuals in the amount of mounting cannot be explained by differences in the age of puberty onset.

The second potential cause underlying mounting that was investigated was dominance behaviour. Mounting was not associated with the dominance rank determined in a food competition test (H5). One explanation for this result may be that dominance is resource-relative (Lindberg, 2001). This means that dominance relationships within a group may differ for different resources. Consequently, the dominance order determined in a food competition test may not be the same as the one underlying mounting behaviour. However, we did not observe any mounting to displace a pig from another resource, such as a preferred lying area, suggesting that mounting was not correlated with prioritized access to any resource.

For reasons of practicability, rank order was only determined for the focal animals which were separated from the remaining pen mates the night before testing. This change in group composition might have influenced the dominance relationships (Rushen, 1987; Krauss and Hoy, 2011).

460 Moreover, groups of pigs show considerable fluctuations in the level of aggression at feeding periods
461 (Meese and Ewbank, 1972). Even though each group of pigs was tested twice in the food competition
462 test, spontaneous changes in the dominance rank order might have affected the results.

463 Taken together, the high amount of mounting can neither be explained by the onset of puberty nor by
464 dominance behaviour. Mounting may be affected by a general arousal mechanism (Price, 1985). Even
465 though the effect of arousal on mounting behaviour was not formally investigated, informal
466 observations during the study gave the impression that mounting was provoked by excitement. When
467 walking through the pens for the health scoring, for example, mounting behaviour appeared to
468 increase. The same effect could be observed when a new person entered the building. Further studies
469 quantifying the effect of disturbance and arousal on mounting behaviour would be valuable.
470 Another possible explanation for the high level of mounting in intensively kept finishing pigs is that
471 mounting is a behavioural change caused by the rearing conditions and potentially reflecting impaired
472 welfare of the mounting pig.
473 The cause of individual differences in mounting behaviour remains an open but important question for
474 animal welfare research.

475 In this study the consequences of mounting behaviour on the performance and health of the pigs were
476 investigated. No relationship between mounting and weight gain was found. As expected, males were
477 heavier than females when sent to slaughter (Andersson et al., 1997). In contrast to this, pigs in a
478 different study had approximately the same end weight regardless of sex (Rydhmer et al., 2006).
479 Higher requirements of energy and possibly a lower feed intake in pigs performing lots of mounting
480 (which are mainly males) were given as explanations for this finding.
481 Pigs with a higher end weight were mounted more often than lighter individuals independent of sex.
482 Why might heavier pigs be the targets of mounting? It seems unlikely that sexual stimuli such as
483 pheromones are being produced more by larger animals since our hormonal analysis suggests that
484 early puberty onset is not a likely explanation for differences in mounting. Another suggestion might
485 be that mounting is a behaviour that relatively large, dominant animals use on each other to
486 communicate their dominance. However, our other results suggest that mounting is not associated with

dominance measured in a food –competition test. It may simply be that larger pigs were less agile in moving away from mounting pigs.

Considering the effects of mounting on health, neither mounting nor being mounted was associated with scratches or `real mounting scratches´. This finding is in contrast to the results of Rydhmer and colleagues who describe a relationship between scratches and mounting behaviour (Rydhmer et al., 2006). In accordance with Rydhmer a relationship between mounting and leg problems could not be demonstrated. One possible explanation for this lack of associations is that scores for scratches and lameness were very low. Moreover, as mounting in the different sessions varied a lot, our average values per week might not have reflected well the weekly amount of mounting behaviour.

In summary, neither performance nor health was affected by mounting. However, the effects of mounting behaviour should gain further research with emphasis on the subjective experience of both the mounting and the mounted pig.

5. Conclusion

In entire pig production, mounting behaviour is increased compared to that found in castrates. The results of this study indicate that mounting behaviour is a trait of the individual rather than the appearance of random outbreaks. Mounting cannot be explained by dominance behaviour or the onset of puberty and evidence from our physiological data suggests that pigs in our study were still immature.

Further studies are necessary to investigate the causes underlying mounting behaviour in intensively kept pigs. We suggest that the effect of arousal on mounting may be a promising approach and that mounting behaviour should be divided into different categories when performing further studies. Mounting behaviour and in particular sexual mounting provokes high pitched screaming of the recipients indicating that mounting behaviour is a welfare problem. For the welfare assessment of entire male pigs the performance of mounting behaviour should be taken into account.

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517 **References**

518 Andersson, H.K., Schaub, A., Lundström, K., Thomke, S., Hansson, I., 1997. The effects of feeding
519 system, lysine level and gilt contact on performance, skatole levels and economy of entire
520 male pigs. Livestock Production Science 51, 131-140.
521 Andersson, H.K., Rydhmer, L., Lundström, K., Wallgren, M., Andersson, K., Forsberg, M., 1998.
522 Influence of artificial light regimens on sexual maturation and boar taint in entire male pigs.
523 Anim. Reprod. Sci. 51, 31-43.
524 Andersson, H.K., Hullberg, A., Malmgren, L., Lundström, K., Rydhmer, L., Squires, J., 1999. Sexual
525 Maturity in Entire Male Pigs: Environmental Effects, Relations to Skatole Level and Female
526 Puberty. Acta Agriculturae Scandinavica: Section A, Animal Science 49, 103-112.
527 Berry, M., Signoret, J.-P., 1984. Sex play and behavioural sexualization in the pig. Reprod. Nutr. Dev.
528 24, 507-513.
529 Bosi, P., Russo, V., 2004. The production of the heavy pig for high quality processed products. Italian
530 Journal of Animal Science 3, 309-321.
531 Brandt, Y., Lundeheim, N., Madej, A., Rodriguez-Martinez, H., Einarsson, S., 2007. Effects of ACTH
532 injections during estrus on concentrations and patterns of progesterone, estradiol, LH, and
533 inhibin alpha and time of ovulation in the sow. Domest. Anim. Endocrinol. 32, 122-137.
534 Clark, C.C.A., 2007. Understanding the phenotype of aggressiveness The University of Edinburgh.
535 Cronin, G.M., Dunshea, F.R., Butler, K.L., McCauley, I., Barnett, J.L., Hemsworth, P.H., 2003. The
536 effects of immuno- and surgical castration on the behaviour and consequently growth of
537 group-housed, male finisher pigs. Appl. Anim. Behav. Sci. 81, 111-126.
538 D´Eath, R.B., Turner, S., 2009. The natural behaviour of the pig in: Marchant-Forde, J.N. (Ed.), The
539 welfare of pigs Springer, pp. 13-45.

D'Eath, R.B., Conington, J., Lawrence, A.B., Olsson, I.A.S., Sandøe, P., 2010. Breeding for behavioural change in farm animals: practical, economic and ethical considerations. Anim. Welfare 19, 17-27.

D´Eath, R.B., 2012. Repeated locomotion scoring of a sow herd to measure lameness: consistency over time, the effect of sow characteristics and inter-observer reliability. Anim. Welfare 22, 219-231.

de Haer, L.C.M., Merks, J.W.M., 1992. Patterns of daily food intake in growing pigs. Animal Science 54, 95-104.

EFSA, 2004. Welfare aspects of the castration of piglets. Scientific report of the scientific panel for animal health and welfare on a request from the Commission related to welfare aspects of the castration of piglets, European Food Safety Authority, pp. 19-100.

Eliasson-Selling, L., Andersson, K., 1992. Sexual Maturation, Growth and Carcass Performance in Gilts. Acta Agriculturae Scandinavica, Section A - Animal Science 42, 8-13.

EuropeanCommission, 2010. European declaration on alternatives to surgical castration of pigs, European Commission, http://ec.europa.eu/food/animal/welfare/farm/docs/castration_pigs_declaration_en.pdf.

Ford, J.J., 1990. Differentation of sexual behaviour in pigs. Journal of Reproduction and Fertility 40, 311-321.

Fredriksen, B., Lium, B.M., Marka, C.H., Mosveen, B., Nafstad, O., 2008. Entire male pigs in farrow-to-finish pens—Effects on animal welfare. Appl. Anim. Behav. Sci. 110, 258-268.

Hay, M., Vulin, A., Génin, S., Sales, P., Prunier, A., 2003. Assessment of pain induced by castration in piglets: behavioral and physiological responses over the subsequent 5 days. Appl. Anim. Behav. Sci. 82, 201-218.

Hemsworth, P.H., Tilbrook, A.J., 2007. Sexual behavior of male pigs. Horm. Behav. 52, 39-44.

Kooij, E.v.E.-v.d., Kuijpers, A.H., Schrama, J.W., van Eerdenburg, F.J.C.M., Schouten, W.G.P., Tielen, M.J.M., 2002. Can we predict behaviour in pigs?: Searching for consistency in behaviour over time and across situations. Appl. Anim. Behav. Sci. 75, 293-305.

568 Krauss, V., Hoy, S., 2011. Dry sows in dynamic groups: An investigation of social behaviour when
569 introducing new sows. Appl. Anim. Behav. Sci. 130, 20-27.
570 Lagerlöf, N., Carlquist, H., 1961. The semen of boars of the Yorkshire breed between the age of five
571 and nine months, 4th Internation congress on animal reproduction and A.I., Den Haag pp.
572 818-821.
573 Langendijk, P., Dieleman, S.J., van Dooremalen, C., Foxcroft, G.R., Gerritsen, R., Hazeleger, W.,
574 Soede, N.M., Kemp, B., 2009. LH and FSH secretion, follicle development and oestradiol in
575 sows ovulating or failing to ovulate in an intermittent suckling regimen. Reproduction fertlity
576 development 21, 313-322.
577 Lindberg, C.A., 2001. Group life, in: Keeling, L.J., Gonyou, H.W. (Eds.), Social behaviour in farm
578 animals CABI, Wallingford, pp. 37-58.
579 Manteuffel, G., Puppe, B., Schön, P.C., 2004. Vocalization of farm animals as a measure of welfare.
580 Appl. Anim. Behav. Sci. 88, 163-182.
581 Marx, G., Horn, T., Thielebein, J., Knubel, B., von Borell, E., 2003. Analysis of pain-related
582 vocalization in young pigs. J. Sound Vibrat. 266, 687-698.
583 Meese, G.B., Ewbank, R., 1972. A note on instability of the dominance hierarchy and variations in
584 level of aggression within groups of fattening pigs. Animal Science 14, 359-362.
585 Price, E.O., 1985. Sexual behaviour of large domestic farm animals: an overview J. Anim. Sci. 61, 62-
586 74.
587 Prunier, A., Mounier, A.M., Hay, M., 2005. Effects of castration, tooth resection, or tail docking on
588 plasma metabolites and stress hormones in young pigs. J. Anim. Sci. 83, 216-222.
589 Prunier, A., Bonneau, M., von Borell, E.H., Cinotti, S., Gunn, M., Fredriksen, B., Giersing, M.,
590 Morton, D.B., Tuyttens, F.A.M., Velarde, A., 2006. A review of the welfare consequences of
591 surgical castration in piglets and the evaluation of non-surgical methods. Anim. Welfare 15,
592 277-289.
593 Rushen, J., 1987. A difference in weight reduces fighting when unacquainted newly weaned pigs first
594 meet. Canadian Journal of Animal Science 67, 951-960.

595 Rydhmer, L., Zamaratskaia, G., Andersson, H.K., Algers, B., Guillemet, R., Lundström, K., 2006.
596 Aggressive and sexual behaviour of growing and finishing pigs reared in groups, without
597 castration. Acta Agriculturae Scandinavica, Section A - Animal Science 56, 109-119.
598 Rydhmer, L., Lundström, K., Andersson, K., 2010. Immunocastration reduces aggressive and sexual
599 behaviour in male pigs. animal 4, 965-972.
600 Salmon, E.L.R., Edwards, S.A., 2006. Effects of gender contact on the behaviour and performance of
601 entire boars and gilts from 60 to 130 kg In: Science, B.S.o.A. (Ed.), British Society of Animal
602 Science Annual´s Conference, York p. 72.
603 Scott, D., Turner, S.P., D´Eath, R.B., unpublished. An investigation of mounting behaviour in pigs,
604 SAC, Edinburgh.
605 Shearer, I.J., Purvis, K., Jenkin, G., Haynes, N.B., 1972. Peripheral plasma progesterone and
606 oestradiol-17β levels before and after puberty in gilts. Journal of Reproduction and Fertility
607 30, 347-360.
608 Stolba, A., Wood-Gush, D.G.M., 1989. The behaviour of pigs in a semi-natural environment. Anim.
609 Prod. 48, 419-425.
610 van Putten, G., 2000. An ethological definition of animal welfare with special emphasis on pig
611 behaviour, In: Hovi, M., Garcia Trujillo, R. (Eds.), Second NAHWOA Workshop, Cordoba,
612 pp. 120-134.
613 Zamaratskaia, G., Babol, J., Madej, A., Squires, E.J., Lundström, K., 2004. Age-related variation of
614 plasma concentrations of skatole, androstenone, testosterone, oestradiol-17 beta, oestrone
615 sulphate, dehydroepiandrosterone sulphate, triiodothyronine and IGF-1 in six entire male pigs.
616 Reproduction In Domestic Animals = Zuchthygiene 39, 168-172.