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The effect of long or chopped straw on pig behaviour

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Short title: Pig behaviour with long or chopped straw

Abstract

In the EU, pigs must have permanent access to manipulable material such as straw, rope, wood etc. Long straw can fulfil this function, but can increase labour requirements for cleaning pens, and result in problems with blocked slatted floors and slurry systems. Chopped straw might be more practical but what is the effect on pigs' behaviour of using chopped instead of long straw? Commercial pigs in 1/3 slatted, 2/3 solid pens of 15 pigs were provided with either 100g/pig/day of long straw (20 pens) or of chopped straw (19 pens). Behavioural observations were made of 3 focal pigs per pen (one from each of small, medium and large weight tertiles) for one full day between 0600 and 2300h at each of ~40kg and ~80kg. The time spent rooting/investigating overall (709s/pig/h at 40kg to 533s/pig/h at 80kg), or directed to the straw/solid floor (497s/pig/h at 40kg to 343 s/pig/h at 80kg) were not affected by straw length but reduced with age. Time spent investigating other pigs (83 s/pig/h at

40kg), the slatted floor (57 s/pig/h), or pen fixtures (21 s/pig/h) were not affected by age or straw length. Aggressive behaviour was infrequent, but lasted about twice as long in pens with chopped straw (2.3 s/pig/h at 40kg) as in pens with long straw (1.0 s/pig/h at 40kg, p = 0.060). There were no significant effects of straw length on tail or ear lesions, but shoulders were significantly more likely to have minor scratches with chopped straw (p = 0.031), which may reflect the higher levels of aggression. Smaller pigs showed more rooting/investigatory behaviour, and in particular directed towards the straw/solid floor and the slatted floor than their larger pen-mates. Females performed more straw and pen-fixture directed behaviour than males. There were no effects of pig size or sex on behaviour directed towards other pigs. In summary, pigs spent similar amounts of time interacting with straw/solid floor when long and chopped straw were provided, and most aspects of pig-directed behaviour and injuries were not affected by straw length. There was an increase in pigs with minor shoulder lesions with chopped straw, perhaps because of increased aggression. The use of chopped straw as an enrichment material for pigs warrants further investigation in larger and more detailed studies.

Keywords: swine, straw, manipulable substrates, rooting behaviour, enrichment

Implications

Pigs must have access to manipulable substrates to investigate and root, as required by EU directive (2008/120/EC). Without substrates, pigs may redirect exploratory behaviour towards other pigs and injure other pigs' ears and tails. In a small study of 39 pens of growing pigs at a commercial farm, we compared long straw with chopped straw which may be more practical for many indoor farms. Straw length had

no effect on: duration of interaction with straw/solid floor, pen fixtures or other pigs; or on ear and tail injuries. Shoulder scratches and aggressive behaviour were slightly increased from a low base with chopped straw. Chopped straw may be suitable substrate for pigs, but warrants further and more detailed investigation in larger studies.

Introduction

Even when they are fed *ad libitum*, growing pigs spend a considerable part of their active time showing foraging and investigatory behaviour, involving sniffing, rooting and chewing (Day *et al*., 1995; Zwicker *et al*., 2013). In pens with limited or no access to suitable materials that pigs can use as a focus for these behaviours, they re-direct their behaviour towards the floor, walls, other pen fixtures and towards other pigs, which can result in damaging behaviours such as ear, flank or tail biting (Day *et al*., 2008; Studnitz *et al*., 2007; Van de Weerd *et al*., 2006).

Since 2001 (The Council of The European Union 2001), EU directives (Latest revision: The Council of The European Union, 2008) require that 'To enable proper investigation and manipulation activities, all pigs must have permanent access to a sufficient quantity of material such as straw, hay, wood, sawdust, mushroom compost, peat or a mixture of such which does not adversely affect the health of the animals'. These directives have been implemented in national laws across member states, so for example Denmark requires that "pigs are given a sufficient quantity of straw or other manipulable material that can satisfy their needs for materials to occupy them and enable rooting" (Danish Government, 2003).

Straw can be used as a manipulable material for pigs, and is commonly provided in outdoor production as well as 'high welfare' indoor systems (e.g. Freedom Food, RSPCA 2012). Even small amounts (e.g. 10 - 15g /pig /day of straw), can reduce the incidence of behaviour directed towards other pigs such as ear chewing, belly nosing and tail biting compared to when no straw is present (Zonderland *et al*., 2008, Munsterhjelm *et al*., 2009). However, long straw is not a practical material for many commercial indoor pig farms as it can block slatted dunging areas and slurry pumps, interfering with manure handling (Day *et al*., 2008; Tuyttens 2005).

As an alternative to long straw, chopped straw has been suggested as being more practical, as it is less likely to block slatted floors (although blockage of pumps can still be an issue). Does chopped straw satisfy the behavioural needs of pigs? Day *et al*. (2008) found that using chopped straw (at 400g/pig/day on solid concrete floors) changed the way in which pigs interacted with it, for example ploughing it and licking at it rather than picking it up like they did with long straw. They also found that tail biting was higher with chopped than with long straw, and recommended that it was not a suitable material. In the Day *et al*. (2008) study, tail biting was recorded during behavioural observations and tail injuries were not reported. It can be difficult to tell by observation whether damaging biting or non-damaging 'tail in mouth' behaviour is occurring (Schrøder-Petersen *et al*. 2004).

In the present study, we investigated the effect of 100g/pig/day of chopped or long straw. The study took place at commercial finishing farm with part-slatted floors with an automatic slurry scraper underneath, which could cope with the quantity of straw used. Solid wastes can be problematic for liquid slurry systems based on vacuum

pumps (Day *et al*. 2008) . We used focal animal sampling at 2 and 9 weeks after the pigs arrived at the finishing farm (when they weighed ~40 kg and ~80 kg respectively). We observed investigatory and rooting behaviour directed towards the straw/solid floor, the slatted floor, pen fixtures and other pigs, as well as aggression and feeding and drinking. Behaviour records were supplemented by scoring injuries to tails, ears and shoulders.

Animals, materials and methods

Pigs and housing

The subjects of this study were 585 grower/finisher pigs of a standard Danish commercial genotype (Danbred Large white/Yorkshire x Duroc). They had been born and reared at a farm with 200 sows, where they had been tail docked and males castrated at 2-4 days of age.. Farrowing pens were equipped with crates, and had slatted floors. The sow and piglets were not provided with straw in the farrowing unit. In the weaner accommodation on this sow farm, they had been provided with a handful of chopped straw per pen each day (approximately 10g/pig/day). On arrival at the start of the study the pigs were weighed as a batch and had a mean weight of 33 kg. Information on carcass weights of each batch was also obtained from the abattoir when the pigs were slaughtered (80 (84) days after arriving at the farm, weighing 112 (107) kg; figures are for batch 1(batch 2 in brackets)). Thus, the productivity of the herd during the trial period was estimated at herd level (based on total feed consumption and growth) through AgroSoft. Pigs from 2 cycles were included in this study, referred to as batch 1 (June to August) and batch 2 (January to March). The pigs were housed in 39 mixed sex pens of 15 pigs per pen.

Testing took place in a commercial finisher pig building in Denmark with two sections. An 'all in all out' system on herd level was used, so each section was cleaned, disinfected and dried with a heat gun before each new batch of pigs. There were 24 pens per section, with space for 15 pigs per pen. The pens measured 2.4 × 4.8m (11.5 m^2; 0.77 m^2/pig) and the solid floor had a 3% slope. This space allowance was higher than the minimum required by EU rules which is 0.65m^2 for 85-110kg pigs (The Council of European Union 1991). The floor was 1/3 slatted (dunging area) and 2/3 solid (lying area). The slats were constructed from concrete, and the solid floor was concrete. Pairs of adjacent pens ('double pens') shared a central automatic feeder (with openings into each pen), and also shared a contact grid in the dunging area (1.15m long, 1m high; 11 vertical metal bars of 14 mm diameter). They were fed *ad libitum* on a complete mixed pelleted dry ration. Slurry was removed via an automatic scraper system under the slats, which was able to function with waste containing some straw (in contrast to slurry systems based on vacuum pumps designed for liquid slurry). Windows provided natural lighting. The room had an automatically controlled diffuse ventilation system. Roof-mounted vents automatically opened if the temperature rose by 2 °C more than the set room temperature. At the start of the study, the temperature of the lying area was set at 27 °C, and gradually lowered to 18 °C by the end of the study.

Experimental treatments

The 39 pens were allocated to two treatments: 'Long straw': in which 100g of long-straw was provided /pig/day (20 pens) and 'Chopped straw' in which 100 g chopped

straw, chopped to an average of 5-6 cm in length (Batch 1: Ferri chopper, Batch 2: Skjold chopper) was provided / pig / day (19 pens). The straw was provided manually once daily in the morning at 06:39h (mean, range 06:26h to 06:57h) on the solid floor at the back of the pen. Since adjacent pens sharing a feeder ('double pen') had an open pen divider in the dunging area, these were always provided with the same straw length. The distribution of double pens with long or chopped straw was randomly assigned within each section of the building. In batch 1 pigs were given wheat straw, but because of problems in the quality and length of the available wheat straw in the winter, the pigs received winter barley straw in batch 2.

Behavioural observations

At the start of the experiment, three focal pigs were designated in each pen and were given ear tags enabling individual identification. The three focal pigs were selected visually from within each of the categories 1/3 largest, 1/3 middle and 1/3 smallest pigs (estimated visually by the observer) to control for the possibility that size or dominance affects the behaviours of interest. Focal pigs were selected in such a way that both sexes were equally represented: For each double pen, we selected 2 female pigs and 1 castrated male in one pen, and 2 castrates and 1 female in the other pen (totalling 3 male castrates, 3 females).

Pig behaviour was video recorded (using an overhead video camera with an MSH Video Server) between 0600 and 2300h on two recording days: one at two weeks after arrival (when pigs had an estimated weight of approximately 40 kg) and one at 9 weeks after arrival (estimated weight approximately 80 kg). Artificial lighting was left on during the whole recording period. This time window was chosen based on

176 previous experiments which have shown that pigs are not very active at night
177 (Beattie and O'Connell, 2002).The day before each recording period, focal pigs were
178 spray marked to facilitate individual recognition. Due to technical problems, video
179 recordings were available for only 37 of the 39 pens at 40 kg, and all 39 pens at 80
180 kg.
181
182 Continuous focal observations of pig behaviour were recorded from video images.
183 The three focal animals in each pen were observed in a random order once an hour
184 for 15 mins each hour between 0600h and 2300h (totalling 240 minutes per pig on
185 each observation day). The frequency and duration of behaviours were recorded
186 using an ethogram shown in Table 1.
187
188 *Clinical scoring- tail, ear and shoulder lesions*
189 Every 14 days (on 4 occasions in total), each pig was scored to record the incidence
190 and severity of lesions to the tail (0 to 3 scale), ears (0 to 2 scale) and shoulders (0
191 to 2 scale), using a photographic and text scale. Definitions for the scores are given
192 in Table 2.
193
194 *Statistical analysis*
195 The total duration of rooting/exploratory behaviour was calculated by totalling the
196 behaviour directed towards the straw/solid floor, other pigs, pen fixtures and slatted
197 floor. The duration of each behaviour shown in table 1 was analyzed using a mixed
198 linear model (implemented with PROC MIXED in SAS). Straw length, pig age (2
199 weeks after arrival at the farm ~40kg and 9 weeks ~80kg), sex and size (small,
200 medium or large) were included as systematic effects, and the interaction between

straw length and age was included in models, but then removed as it was never significant. Pen was included as a random effect. Normality of the residuals and stability of variance was ensured by transforming data before analysis: we used the square root of the duration of the recorded variables. When transformation was necessary, back-transformed estimated means are reported, along with the range for this estimate, otherwise means and standard errors are reported. Fisher's exact tests (in-silico.net/tools/statistics/fisher_exact_test) were used to analyse the effect of straw length on the number of pigs (and the number of pens) affected by lesions to the tail, ears or shoulders.

Ethical considerations

The test protocol was approved by the Danish Research Committee. Represented in the Committee were Aarhus University, Copenhagen University, Danish Meat Research Institute and Danish Pig Research Centre.

Results

Herd level production figures suggest that the farm showed above average production performance. Daily weight gain during the test period was 958 g/day between 33 to 100 kg (Average for Danish farms in that year was 901 g/day, top 25% of farms achieved 975 g/day) and feed efficiency was 2.63 kg feed/ kg of growth (average farms = 2.86, top 25% 2.71). The mortality rate was 2.3% from the time the pigs were put into the pens until slaughter (average farms = 3.5%, top 25% = 2.9%). These data were only available at a batch level so treatment differences could not be investigated.

Focal observations of behaviour

Straw length had no significant effect on any of the behavioural categories recorded (shown as percentages of the observed time in Table 3). Pigs spent about 4 to 5 times as long on straw/floor directed behaviour (80 kg pig means Long straw = 36 min 14 s, Chopped straw = 31 min 47 s out of a 240 min observation) compared to behaviour directed towards pen mates (80 kg pig means Long straw = 7 min 9 s, Chopped straw = 7 min 44 s). There was an almost significant ($F = 3.66$, $p = 0.060$) effect of straw length on aggressive behaviour, although aggressive behaviour occurred at a very low level in both treatments (80 kg pig means Long straw = 3 s, Chopped straw = 6 s out of a 240 min observation).

There were effects of weight/age on behaviour. 40 kg pigs compared to 80 kg pigs performed more rooting/investigatory behaviour overall, and more which was directed at straw/solid floor (Table 3). There were also a number of effects of sex on behaviour. Compared to castrated males, female pigs spent more time on pen-fixture directed behaviour (female mean (range) = 0.71 (0.53 – 0.92), male = 0.49 (0.34 – 0.66); $F= 6.71$, $p = 0.011$). There were no age or sex differences in pig-directed behaviour.

The size category of pigs influenced behaviour. Smaller pigs showed more 'Total rooting/exploratory' behaviour than larger pigs (small mean ± s.e. = 19.1 ± 0.8, medium = 17.3 ± 0.8, large = 15.5 ± 0.8, $F = 6.06$, $P = 0.0030$). Also, small focal pigs rooted the straw/solid floor more than large pigs (small mean ± s.e. = 12.8 ± 0.6, medium = 11.5 ± 0.6, large = 10.7 ± 0.6, $F = 3.47$, $P = 0.034$), and the small and medium pigs rooted the slatted floor more than large pigs (small mean (range) = 1.64

(1.27 – 2.06), medium = 1.77 (1.38 – 2.21), large = 0.83 (0.57 – 1.14), F = 9.90, P <0.0001). There was no effect of size on pig-directed behaviour however.

Pattern of behaviour over the day

For key behaviour categories, plots were made to investigate the effect of straw length and age on the pattern of behaviour over time (Figure 1). All pigs showed two activity peaks: in the morning at 0600 - 0700h when a person entered to provide straw, and also at around 1700h when a person entered to check on them. As with the analysis of the whole day, it was evident that any differences were due to age (weight) rather than straw length, with younger pigs being more active (Figure 1a), exploratory (Figure 1b) and performing straw-directed behaviour (Figure 1c) between about 0900 and 1600h. Pig-directed behaviour (Figure 1d) was low at 0600h, presumably because fresh straw was occupying pigs, and low at the end of the day when all activity reduced, but otherwise occurred at a similar level throughout the day. Pen-fixture directed behaviour (Figure 1e) was also low in the morning but increased during the afternoon activity peak.

Clinical scoring- tail, ear and shoulder lesions

Results for tail, ear and shoulder scoring at both the pen level (and the individual level) are shown in Table 2. Since outbreaks of damaging behaviour often affect multiple pigs in a pen, the pen level is a more appropriate level of analysis, and statistics are presented at the pen level: Tail lesions were rarely observed, although the two instances of injury both occurred in chopped straw pens. There was no effect of straw length on ear lesions (p = 0.12). Pens in which at least one pig had ‘few minor scratches’ were more common in chopped straw pens (p=0.031).

Discussion

Pigs need manipulable material to express their investigatory behaviour. One way of assessing whether this need has been met, is to record the proportion of time that pigs spend using the material as opposed to pen fixtures and furnishings (Van de Weerd *et al*., 2003). Studies of this kind have revealed that materials which are ingestible, odorous, chewable, destructible and deformable are attractive to pigs (Studnitz *et al*., 2007; Van de Weerd and Day, 2009; Van de Weerd *et al*., 2003). Both long and chopped straw possess all of these characteristics.

In our study, there were no differences overall between long and chopped straw in the time spent rooting/investigating the straw/solid floor, or in behaviour directed at pen fixtures, or the slatted floor part of the pen. There was also no suggestion of treatment differences at any time of day (Figure 1). Based on the amount of time spent therefore, there was no evidence that long straw was a better material for occupying pigs than chopped straw. Some caution is waranted however, since during observations, it was not possible to determine with certainty whether pigs were rooting at the straw or the solid floor, so these behaviours were combined into one category. As such, it is not possible to say for certain whether pigs were occupied by the straw itself. However, if chopped straw had been less attractive, or used up more quickly than long straw, then the duration of investigation of straw/solid floor would have been expected to decrease. Similarly, investigatory behaviour directed towards other locations, namely the slats, pen fixtures and other pigs might have been expected to increase (or increase later in the day) and it did not. This suggests that pigs were either occupied by the chopped straw, or (less

301 plausibly) that the presence of chopped straw somehow made the solid floor more
302 attractive.
303
304 Day *et al*., (2008) found that certain types of behaviours were performed more with
305 long straw (e.g. pick) while others were performed more with chopped straw (e.g.
306 plough, sweep). Can these different forms of investigation or interaction with a
307 material substitute for one another? Outdoor pigs prevented from rooting by nose-
308 ringing, perform investigatory behaviour for a similar duration as un-ringed pigs,
309 substituting grazing, chewing and sniffing (Studnitz *et al*., 2003ab). However, when
310 nose-rings were removed, rooting became the main mode of exploration. This
311 suggests that some substitution of different forms of investigatory behaviour is
312 possible, but that rooting is the preferred activity. A possible concern for our study
313 might be that by relying on the overall duration of all forms of interaction with the
314 straw/ solid floor, , the importance of certain behaviours is overlooked. If (as
315 suggested by the nose-ringing studies) rooting is the preferred mode of investigatory
316 behaviour, then we should be reassured by the finding that pigs are able to perform
317 rooting and related behaviours such as chew and sniff to a similar extent in both
318 chopped and long straw (Day *et al*., 2008). However, further work could investigate
319 behaviour with short and long straw in more detail, as well as the motivation to
320 perform the different forms of investigatory behaviour including rooting.
321
322 Is the amount of time spent using a material the best measure of its occupational
323 value or its animal welfare benefit? As well as observing the duration of interaction
324 with a material as we did, studies of choice and motivation can form a valuable part
325 of overall welfare assessment. When pigs were free to choose between 3 minutes of

326 access to either long, chopped or pelleted straw in a three-armed maze, they
327 showed no clear preference between them (Jensen *et al*., 2008). The choice
328 paradigm was effective though, since clearer preferences were obtained with
329 different combinations of three materials: Compost and peat were preferred over
330 wood-shavings. In a study on the motivation of pigs to access different materials,
331 where pigs learnt to push a panel repeatedly to gain access, pigs showed similar
332 motivation to work for 3 minutes of access to 100g rewards of long or chopped straw
333 (Pedersen *et al*., 2005), although peat and branches were both even more preferred
334 than straw. Taken together, these findings support our suggestion that chopped and
335 long straw may have equal value for pigs. However, some caution is needed here,
336 as the initial preference for 3 minutes of access to fresh materials may not tell us
337 much about how attractive materials are after several hours on the pen floor.
338
339 As well as occupying pigs need to root and investigate, the provision of substrates
340 has a role in reducing harmful pig-directed behaviours such as ear-, flank- and tail-
341 biting (Munsterhjelm *et al*., 2009; Van de Weerd *et al*., 2006; Zonderland *et al*.,
342 2008). Straw has been reported to be more effective than other substrates at
343 reducing tail biting lesions (EFSA AHAW, 2014). In the present study we found no
344 effect of straw length on the level of pig-directed behaviour. This contrasted with the
345 finding of Day *et al*., (2008) that tail biting was higher with chopped straw, atlhough
346 they did not report tail injuries, so some or all of their ‘tail biting’ may have been non-
347 injurious ‘tail in mouth’ behaviour which may be, but is not always a precursor to
348 damaging tail biting (D'Eath *et al*., 2014a; EFSA, 2007). However, the present study
349 had in total low levels of pig directed behaviour and combined different types of pig
350 directed behaviour (which may be motivationally distinct), so further studies are

needed to determine whether there are any differences between long and chopped straw in harmful social behaviour .

The almost significant ($p<0.06$) effect of chopped straw on aggression found here was unexpected.. The significantly higher number of pens in which at least one pig had a few minor shoulder scratches corresponds with this apparent increase of aggression (Turner *et al*., 2009). These results contrast with those of Day *et al* (2008) who found no effect of straw length on aggression. However, the low levels of aggressive behaviour, and the absence of any pigs with more than a few minor scratches, observed for both straw lengths suggest that the biological significance of this change is relatively minor.

Although not the main focus of our study, we saw effects of age/weight, size at a given age, and sex on behaviour. The age effects we observed were similar to those reported by others (Day *et al*., 2008; Jensen *et al*., 2010), with pigs showing more rooting/ investigation overall and straw-directed behaviour at ~40kg than at ~80kg. The smallest pigs in the pen performed more rooting behaviour (directed at the straw/solid floor and slatted floor). Since hunger can increase pigs' foraging and exploratory behaviour (reviewed by Studnitz *et al*., 2007), a possible explanation for this is that smaller pigs had more difficulty gaining access to food due to their low dominance rank. Also, we found that female pigs showed more straw/floor and pen-fixture directed behaviour, but no difference in pig-directed behaviour. As far as we are aware, these size and sex effects are not usually found- previous studies on exploratory behaviour in pigs generally make no mention at all of sex or size effects, or some studies state that they had no effect (size, Camerlink and Turner, 2013; sex,

376 Day *et al*., 1996). Possible effects of size and sex have been found in relation to tail-
377 biting, where some studies report that females (Schrøder-Petersen *et al*., 2004; Van
378 de Weerd *et al*., 2005; Zonderland *et al*., 2010) and smaller pigs (Zonderland *et al*.,
379 2011) are more likely to perform these behaviours, although many other studies
380 have not found these effects (e.g. Breuer et al 2005; Steinmetz and Pedersen 2009).
381
382 Fresh straw seems to be particularly attractive to pigs. In our study, straw was only
383 allocated once a day. Perhaps as a consequence, activity appeared to be more
384 directed at pen fixtures in the afternoon, as also found by others (Jensen *et al*.,
385 2010). Future studies should investigate the importance of frequency of straw
386 allocation and total straw quantity (Oxholm *et al*., in press) in addition to straw length.
387
388 There is an ongoing debate on the type and quantity of material needed to comply
389 with the EU directive (The Council of The European Union, 2001). The directives
390 reference to ‘a sufficient quantity to enable proper investigatory activities’ is rather
391 vague. Leaving aside the question of whether straw provides for proper investigatory
392 activities, one measure of ‘sufficient quantity’ is how quickly the material is used up.
393 In our study, chopped straw did provide a ‘permanent’ outlet for investigatory
394 behaviour in the sense that there was always some remaining when new straw is
395 allocated the next day, as reported by others using similar quantities (90g /pig / day,
396 Jensen *et al*., 2010). However, increasing quantities of straw above 92g/pig/day to
397 1092g and 2184g/pig/day promote further increases in exploratory/rooting behaviour
398 (Day *et al*., 2002). Although Day *et al.* (2002) found no effect of increasing straw
399 quantity on pig-directed behaviour. Other authors have proposed that higher
400 quantities of straw are necessary to keep pig-directed behaviours to a minimum

401 (200g/pig/day Olsson, 2011; 387g/pig/day Pedersen *et al*., 2013). In addition, the
402 threshold for the quantity of material provided to reduce harmful pig-directed
403 behaviours is likely to depend on whether the pigs in question are tail docked or not,
404 as docking reduces tail biting risk (D'Eath et al 2014b).
405
406 Although it was not systematically recorded in our study, farm staff reported that they
407 needed to manually clean the dunging area to remove accumulated long straw, to
408 prevent wet and dirty straw spreading to the solid part of the pen. They did not need
409 to do this when chopped straw was used, as pigs' activity pushed it down between
410 the slats. This observation is in line with suggestions of others that with slatted floors,
411 there is a lower labour requirement to maintain pen hygiene when using chopped
412 straw rather than long straw (Day *et al*., 2008; Tuyttens, 2005). However, our
413 practical experience in this project was that in the summer in particular, any kind of
414 straw can accumulate in the lying area and become dirty, increasing the labour
415 requirement to ensure good pen hygiene in comparison to pens without straw. In
416 addition, faecal contamination of substrates is thought to reduce their attractiveness
417 to pigs (Scott *et al* 2009). Further research is needed to quantify and overcome this
418 problem.
419
420 One shortcoming of our study was the use of wheat straw for one cohort of pigs and
421 barley straw for the other. This distinction does however highlight the issue that
422 "straw" can vary not just in length (as in our study) but in other ways that are
423 important to pigs such as odour, texture and taste, which are likely to be affected by
424 the type of crop, and the weather during that growing season.
425

426 Our study farm had a lower mortality than the average Danish farms, on which straw
427 is not usually provided, which might indicate that straw is beneficial. However, the
428 study farm was atypical in other respects, having high health status, all-in all-out
429 management, and lower stocking density (0.77 m^2/pig).
430
431 **Conclusions**
432 Providing long or chopped straw to pigs (at 100g/pig/day) resulted in a similar
433 duration of rooting/investigatory behaviour directed towards the straw/solid pen floor,
434 towards pen fixtures or towards other pigs, and there was no difference in the
435 number of lesions to ears or tails. There was an almost significant tendency for more
436 aggression in pens with chopped straw than in pens with long straw, and significantly
437 more pens with 'few minor scratches' on the shoulders, although aggression was
438 rare for both treatments. Our findings suggest that when allocated at 100g/pig/day in
439 commercial part-slatted pens, chopped straw and long straw might provide similar
440 opportunities for pigs to interact with a manipulable substrate. The reduced
441 requirement for manual cleaning of pens makes chopped straw a practical option for
442 many commercial farmers, although the quantity of straw used was too great for
443 many vacuum-pump based liquid slurry systems. The use of chopped straw as a
444 manipulable substrate for pigs warrants further research in larger and more detailed
445 studies.
446
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456

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572

573 ***Table 1*** The ethogram used during continuous observations of focal pig behaviour.
574

Behavioural Categories	**Definition**
Straw/solid floor-directed	The pig roots repeatedly with the snout on the solid floor with straw or by moving the snout back and forth. Pigs may also in connection with this behaviour either chew, carry or sniff the straw. It was not always possible to determine whether straw was present in the location where pigs rooted, so this category also included pigs rooting at the floor. We estimate that straw was the target of this behaviour 90% of the time.
Pig-directed	The pig has another pig's tail or ear in its mouth while biting, chewing or sucking on it. Or the pig rubs its snout on another pig in one of the following locations: (the back, shoulders, stomach, flanks or around the soft tissue between the front and hind legs).
Slatted floor-directed	The pig roots or sniffs at the slatted floor regardless of whether there is straw there or not, with its nose pressed against the floor and moving back and forth.
Pen fixture-directed	The pig rooting at pen partitions (open and closed), back wall or at the outside of the feeder by pressing its snout against the object and move it back and forth or up and down repeatedly. The pig may also have the object in the mouth and chewing on it.
Aggression	Agonistic behaviour: each pig tries to head-knock and bite at the head or flank of the opponent (fighting), also includes more minor forms of agonistic behaviour such as pigs pushing against one another, including parallel pressing (pigs stand side by side with heads in the same or opposite directions, pushing against each other).
Feeding / drinking	The pig has its head down in the feeder or drinker.

Table 2 Number of pens receiving scores for tail, ear and shoulder lesions (n = 39) by straw length treatment. Each pen was assessed on 4 occasions two weeks apart, and the highest score for any individual pig in the pen is shown. Data shown in parentheses are counts of scores for individual pigs, where each pig's highest score is shown. Fisher's exact tests at the pen level (2-tailed) showed no significant effect of straw length on tails p = 0.23 or ears p = 0.12, but shoulder scratches were more common with chopped straw p = 0.031.

Tails				Ears				Shoulders	
		Straw				Straw		Straw	
Definition	Score	Chopped	Long	Definition	Score	Chopped	Long	Chopped	Long
Not injured	0	17 (55)	20 (60)	Not injured	0	8 (39)	4 (31)	2 (31)	9 (44)
Small scratches on tip	1	0 (0)	0 (0)	Few minor scratches	1	10 (17)	16 (29)	17 (26)	11 (16)
Many scratches or large wound	2	1 (1)	0 (0)	Many scratches and/or some more severe (deep marks or with fresh blood)	2	1 (1)	0 (0)	0 (0)	0 (0)
Part missing	3	1 (1)	0 (0)	-	-	-	-	-	-

580

581

582 ***Table 3*** Behaviour of three focal pigs in each group allocated long or chopped straw and at 2 weeks (~40kg) and 9 weeks (~80kg)
583 after arrival at the farm, expressed as per cent of observed time. Data are based on 2 observation days, each with 16 hourly 15
584 minute focal pig observations. There were no significant interactions between straw length and age/weight.
585

Behaviour	Long	Chopped	P value (straw treatment)	~40kg	~80kg	P value (age/weight)
Total rooting/ investigatory	17.7	16.9	0.43	19.7	14.8	<0.0001
Pen mate directed*	1.95	2.29	0.37	2.30	1.94	0.35
Slatted floor directed*	1.25	1.52	0.28	1.58	1.19	0.13
Pen fixture directed*	0.65	0.54	0.48	0.57	0.61	0.74
Straw/solid floor directed	12.2	11.1	0.16	13.8	9.52	<0.0001
Feeding/drinking	9.04	9.54	0.46	9.64	8.94	0.29
Aggression*	0.01	0.02	0.060	0.0096	0.011	0.84

586

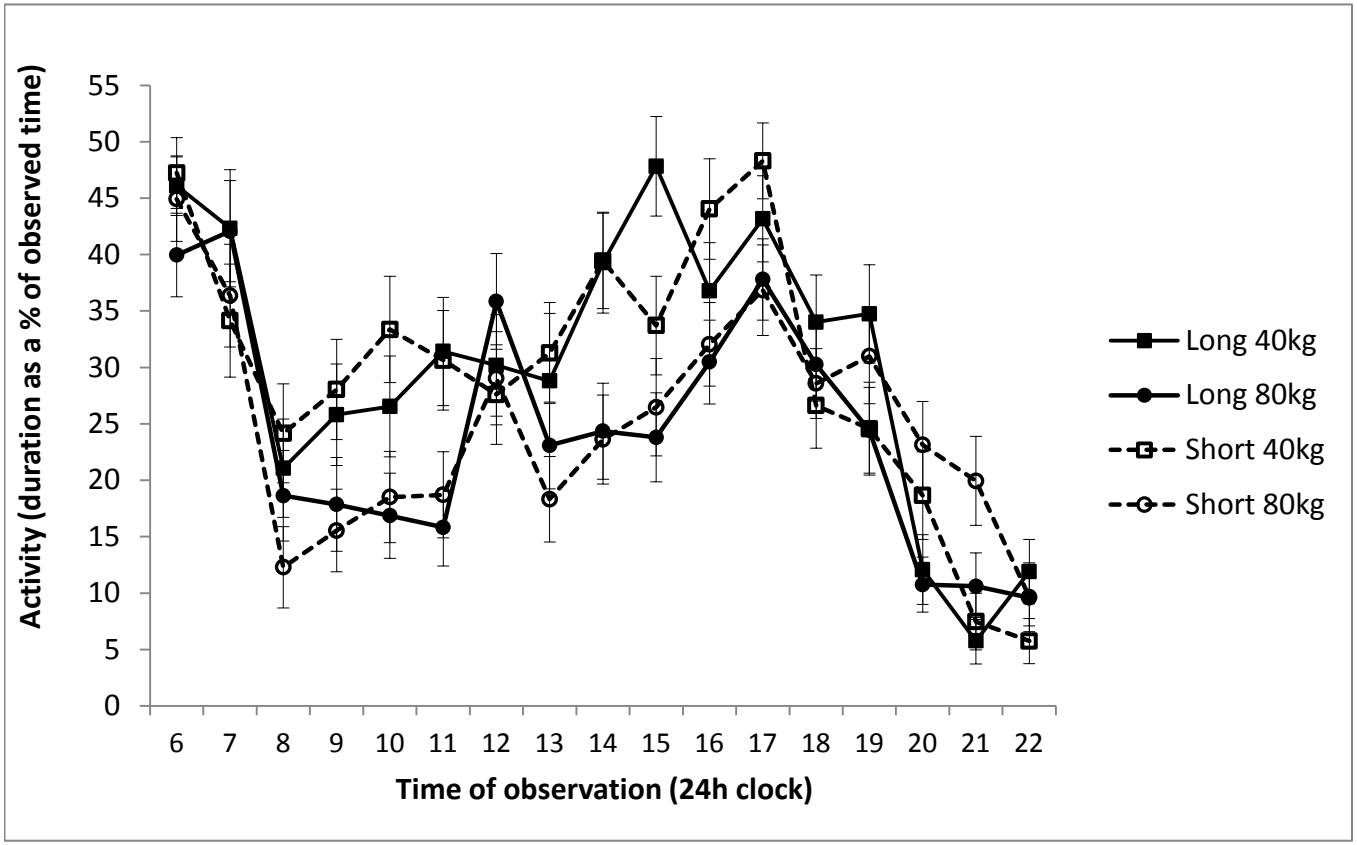
587 Data with * is back-transformed

588 **Figure Captions**

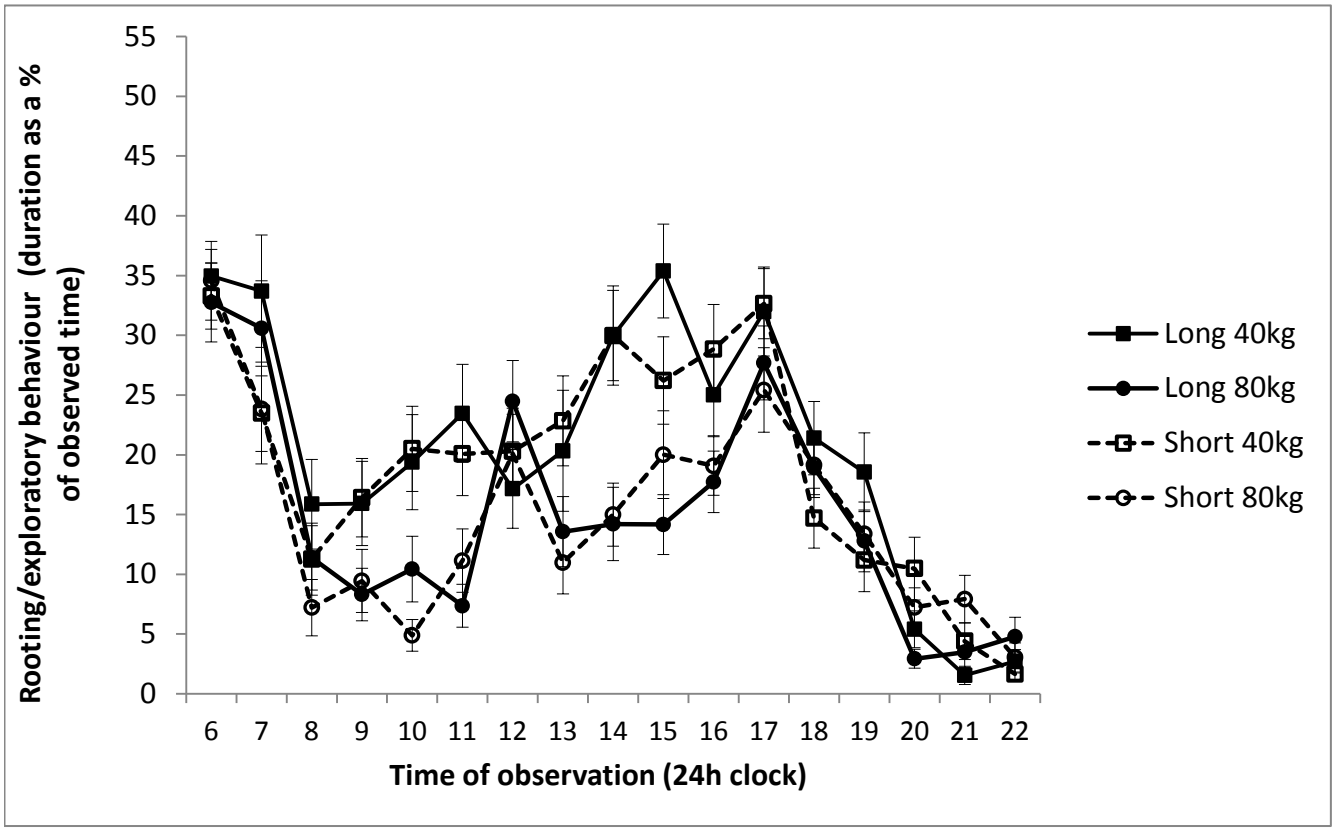
589

590 ***Figure 1*** Behaviour of three focal pigs in each group at different times of day by
591 age/weight (2 weeks after arrival at the farm ~40 kg or 9 weeks after arrival ~80 kg)
592 and by straw length (chopped or long). The data shown are mean (± s.e.) durations
593 as a % of total observation time. Data are based on 2 observation days, each with 16
594 hourly 15 minute observations. The different behaviours shown are: a) Total activity
595 (includes all behaviours from Table 1), b) Total rooting/investigatory behaviours
596 (includes behaviour directed at straw/solid floor, other pigs, slatted floor and pen
597 fixtures), c) Straw/solid floor directed, d) Pig directed, e) Pen fixture directed. Note
598 that different y axis scales are used for a – c, and for d – e.

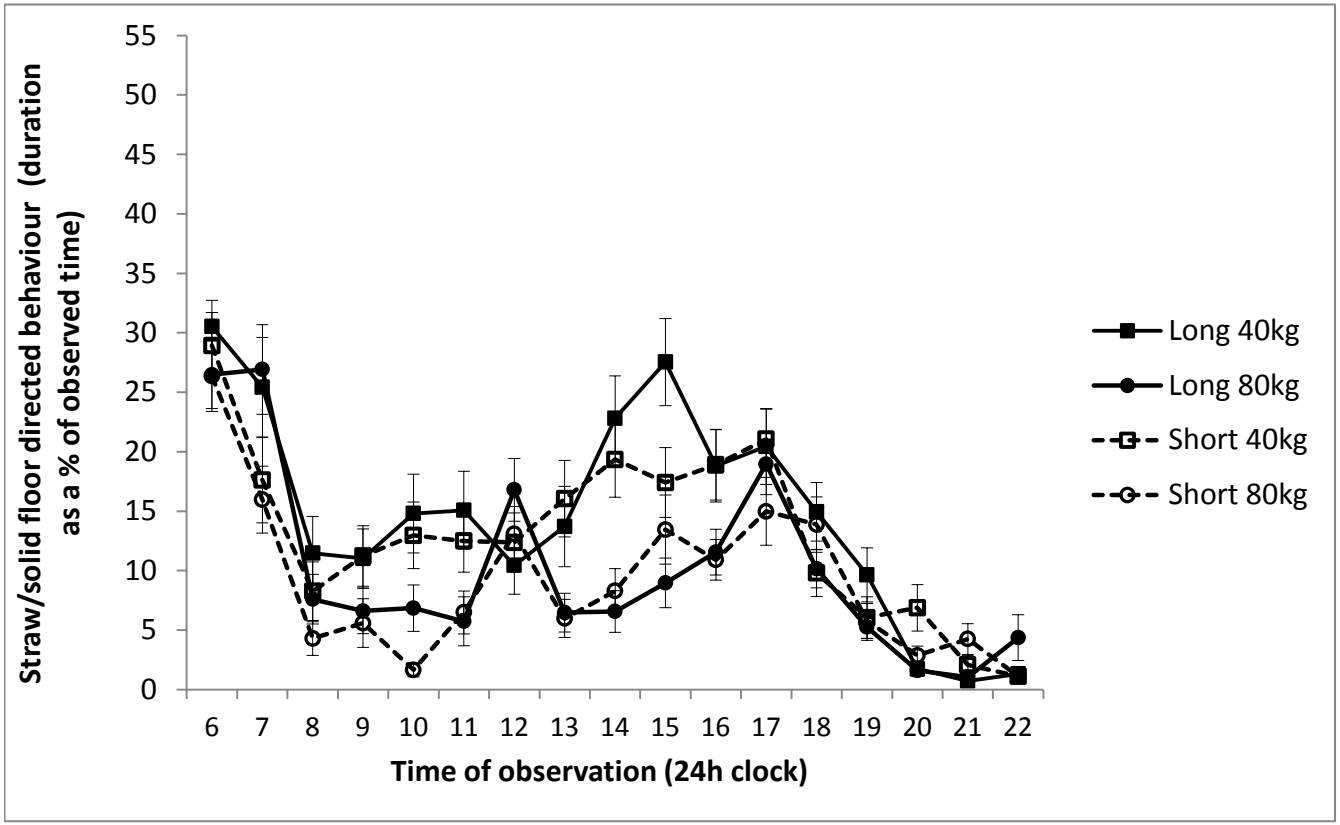
1a Total Activity



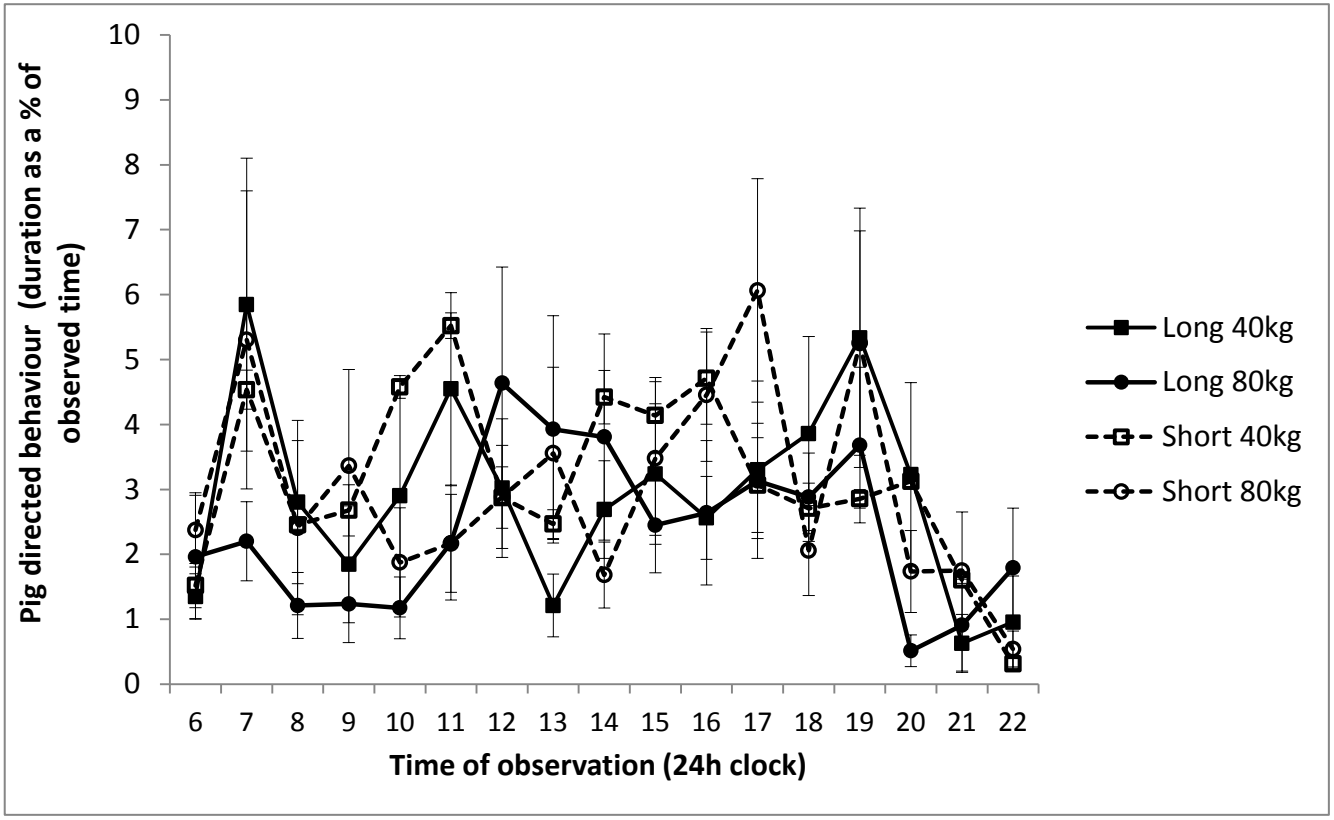
1b Total rooting/investigatory behaviour



1c Straw Directed



1d Pig Directed



1e Pen Fixture directed