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More tail damage among undocked than tail docked pigs in a well-managed conventional herd --Manuscript Draft--

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Abstract:	<p>The vast majority of piglets reared in the EU and worldwide is tail docked to reduce tail biting, even though the EU animal welfare legislation bans routine tail docking. Some well-managed farms experience very low levels of tail biting among tail docked pigs. At this point, there is little scientific evidence regarding the effect of tail docking on tail biting prevalences in these kinds of conventional farms. The aim of this study was therefore to compare the prevalence of tail injuries between docked and undocked pigs in such a well-managed conventional piggery in Denmark where pigs in usual practice were tail docked. This study included 1922 DanAvl Duroc × (Landrace × Large White) pigs (962 docked and 960 undocked). Docked and undocked pigs were housed under the same conditions, but in separate pens within the same stable. Pigs had ad libitum access to commercial diets in a feed dispenser. Straw was provided daily on the solid floor (10 g per pig per day), and each pen had two vertically placed soft wood sticks. Pigs were individually earmarked and gender was determined just before weaning. The stockpersons recorded antibiotic treatments, pigs moved to hospital pens and euthanized pigs. From weaning to slaughter, a trained technician recorded tail damages (injury severity and freshness) every second week. No tail damages were observed within the tail docked group, whereas 23.0% of the undocked pigs got tail bitten. On average, 4.0% of the pigs had a tail lesion on tail inspection days. The results showed more pens with pigs weighed 30-60 kg with tail lesions (34.3%; $P < 0.05$) than in pens with pigs weighing 7-30 kg (13.0%) and 60-90 kg (12.8%). Furthermore, more undocked pigs had to be moved to a hospital pen ($P < 0.05$). Finally, abattoir meat inspection data revealed more tail biting remarks in the undocked group ($P < 0.001$). In conclusion, this study suggests that housing pigs with intact tails even in well-managed conventional herds will increase the prevalence of tail bitten pigs considerably, and pig producers will need more hospital pens. Furthermore, the abattoir data indicate that meat inspection data severely underestimate the number of pigs experiencing to be tail bitten during the rearing period.</p>
Suggested Reviewers:	Sandra Edwards University of Newcastle sandra.edwards@ncl.ac.uk Professor Sandra Edwards has substantial research experience with the influence of

	<p>environmental enrichment on pig behavior and welfare.</p> <p>Paul Hemsworth University of Melbourne phh@unimelb.edu.au Professor Paul Hemsworth is the Director of the Animal Welfare Science Centre at the University of Melbourne and has considerable research interest with different aspects of pig behavior and welfare.</p> <p>Marion Kluivers-Poodt Wageningen Universiteit marion.kluivers@wur.nl Drs. Marion Kluivers-Poodt has substantial research experience with in tail biting</p>
Opposed Reviewers:	<p>Lene J Pedersen</p> <p>Lene J. Pedersen is involved in on-going research investigating environmental enrichment for growing-finishing pigs in Denmark. This has led to a dispute with the management of the Pig Research Centre. As several authors of this paper are employed by the Pig Research Centre this could potentially influence her review of the submitted manuscript negatively.</p> <p>Karen Thodberg</p> <p>Karen Thodberg is involved in on-going research investigating environmental enrichment for growing-finishing pigs in Denmark. This has led to a dispute with the management of the Pig Research Centre. As several authors of this paper are employed by the Pig Research Centre this could potentially influence her review of the submitted manuscript negatively.</p> <p>Anna Valros</p> <p>Anna Valros is involved in on-going research investigating environmental enrichment for growing-finishing pigs in Denmark. This has led to a dispute with the management of the Pig Research Centre. As several authors of this paper are employed by the Pig Research Centre this could potentially influence her review of the submitted manuscript negatively.</p>

1 **More tail damage among undocked than tail docked pigs in a well-managed**
2 **conventional herd**

3

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18 Short title: Tail docking and tail damage prevalence

19 **Abstract**

20 The vast majority of piglets reared in the EU and worldwide is tail docked to reduce
21 tail biting, even though the EU animal welfare legislation bans routine tail docking.
22 Some well-managed farms experience very low levels of tail biting among tail docked
23 pigs. At this point, there is little scientific evidence regarding the effect of tail docking
24 on tail biting prevalences in these kinds of conventional farms. The aim of this study
25 was therefore to compare the prevalence of tail injuries between docked and
26 undocked pigs in such a well-managed conventional piggery in Denmark where pigs
27 in usual practice were tail docked. This study included 1922 DanAvl Duroc ×
28 (Landrace × Large White) pigs (962 docked and 960 undocked). Docked and
29 undocked pigs were housed under the same conditions, but in separate pens within
30 the same stable. Pigs had *ad libitum* access to commercial diets in a feed dispenser.
31 Straw was provided daily on the solid floor (10 g per pig per day), and each pen had
32 two vertically placed soft wood sticks. Pigs were individually earmarked and gender
33 was determined just before weaning. The stockpersons recorded antibiotic
34 treatments, pigs moved to hospital pens and euthanized pigs. From weaning to
35 slaughter, a trained technician recorded tail damages (injury severity and freshness)
36 every second week. No tail damages were observed within the tail docked group,
37 whereas 23.0% of the undocked pigs got tail bitten. On average, 4.0% of the pigs
38 had a tail lesion on tail inspection days. The results showed more pens with pigs
39 weighed 30-60 kg with tail lesions (34.3%; $P < 0.05$) than in pens with pigs weighing
40 7-30 kg (13.0%) and 60-90 kg (12.8%). Furthermore, more undocked pigs had to be
41 moved to a hospital pen ($P < 0.05$). Finally, abattoir meat inspection data revealed
42 more tail biting remarks in the undocked group ($P < 0.001$). In conclusion, this study
43 suggests that housing pigs with intact tails even in well- managed conventional herds

44 will increase the prevalence of tail bitten pigs considerably, and pig producers will
45 need more hospital pens. Furthermore, the abattoir data indicate that meat inspection
46 data severely underestimate the number of pigs experiencing to be tail bitten during
47 the rearing period.

48

49 **Keywords:** pigs, tail biting, tail docking, housing, behaviour

50

51 **Implications**

52 Most growing pigs within the EU are tail docked to prevent tail biting. Tail docking is a
53 painful procedure, but so is tail biting to the bitten pigs. Even on well-managed farms
54 tail biting may occur among tail docked pigs from time to time. Our results indicate
55 that even in a well-managed conventional herd, more pigs will get tail bitten and more
56 hospital pens are needed for tail bitten pigs than if they are not tail docked. We also
57 found that abattoir estimates of tail biting prevalence are likely to greatly
58 underestimate on-farm prevalence.

59

60 **Introduction**

61 The majority of pigs reared worldwide are tail docked to reduce tail biting (EFSA,
62 2007). This is also the case in the EU despite animal welfare legislation banning
63 routine tail docking (2001/93/EC amendments to directive 91/ 630/ EEC). Despite the
64 tail docking procedure, tail lesions still occur, variously suggested as affecting
65 around 1-2% (Zonderland *et al.*, 2011a) or 3.1% (D'Eath *et al.*, 2016) of pigs. If pigs
66 are to be housed with undocked tails in existing housing systems within the EU, it will
67 most likely lead to a dramatic increase in tail bitten pigs (EFSA, 2014). A 50%
68 increase in severe lesions has been suggested (Valros and Heinonen, 2015), and

69 recent calculations stated 17% tail bitten pigs during growth, if pigs are to be housed
70 with undocked tails in today's conventional systems (D'Eath *et al.*, 2016). On the
71 other hand Finnish farmers, producing pigs with intact tails, reported in a survey
72 average tail lesion prevalences of 2.3% (median 1%, range 0 - 30%) on farm (Valros
73 *et al.*, 2016). However, these estimates need further evidence-based confirmation. In
74 most studies, levels of tail damage across herds were estimated based on recordings
75 made on pigs at slaughter (Valros *et al.*, 2004, Harley *et al.*, 2012, Keeling *et al.*,
76 2012). However, using abattoir meat inspection recordings to determine the level of
77 tail bitten pigs in herds will probably underestimate the number of bitten pigs (Keeling
78 *et al.*, 2012).

79 The first step towards a general termination of tail docking is therefore to
80 investigate the consequences of housing undocked pigs in conventional herds with
81 high-level management, high health status and low levels of tail biting among tail
82 docked pigs. Based on existing knowledge and risk factors related to tail biting
83 (Taylor *et al.*, 2012), it could rightly be assumed that tail biting will be less prevalent
84 in such herds. Consequently, if tail biting increases significantly in well-managed
85 herds, it will most likely be very difficult to house pigs with undocked tails in other
86 herds as well without a dramatic increase in tail bitten pigs. The aim of the present
87 study was therefore to compare the level of tail biting between pens with docked and
88 undocked pigs in a herd with low occurrence of tail biting among tail docked pigs and
89 high-level management.

90

91 **Material and methods**

92 This study was conducted in accordance with the guidelines of the Danish Ministry of
93 Justice Act no. 382 (June 10,1987), Act no. 333 (May19,1990), Act no. 726

94 (September 9,1993) and Act no. 1016 (December 12, 2001) with respect to animal
95 experimentation and care of animals under study.

96 The study was carried out at a commercial Danish farm (Vrå, Denmark) with
97 high-level management (high health status, high growth rate, low mortality, well-
98 functioning stables) from March 2014 to August 2015. The experimental farm was
99 considered a low-risk herd as regards to tail biting (Taylor *et al.*, 2012).

100

101 *Housing and experimental design*

102 In total 960 undocked and 962 docked (906 females, 948 castrated males and
103 68 unknown gender) Danish Duroc × (Landrace×Yorkshire) pigs from 12 batches
104 were included in the study: 47 pens with undocked tails and 48 pens with docked
105 tails. In each pen 20.4 (+/- 1.1) pigs were randomly allocated to each experimental
106 pen housing undocked and docked pigs separately. Two weeks after arrival, the
107 farmer moved one or two of the smallest pigs from each pen to a buffer pen.

108 Piglets were born in conventional farrowing crates at a different location. Every
109 fifth week a batch of 10-18 litters were randomly allocated to one of two treatments:
110 tail docked or undocked. On the day of parturition piglets had the sharp tips of their
111 needle teeth removed by grinding. At 4 days of age, the piglets of the “docked group”
112 were tail docked (half the tail). All piglets were given iron injections (Uniferon,
113 Pharmacosmos, Holbæk, Denmark) and male piglets were surgically castrated and
114 given a short-term analgesic. From 10 days of age piglets were offered solid creep
115 feed on the floor.

116 All pigs were ear tagged and their gender noted one week before weaning.
117 Piglets were weaned averagely 4 weeks after birth and moved to a stable, where
118 they were housed for 2 days before transport to the experimental farm. Docked and

119 undocked pigs were housed separately. Within the group, pigs were allocated
120 randomly to the pens. Pens were designed with two climate zones, with solid floor
121 and a cover in the lying area and slats in the dunging area. Pigs had *ad libitum*
122 access to a diet based on spring barley, wheat, fat and 30% concentrate (Danstart
123 VP30, Vilomix, Mørke, Denmark). Furthermore, each pen was equipped with two
124 vertical wooden laths standing on floor in a plastic retainer as enrichment.

125 The experimental farm consisted of four identical sections with 36 pens per
126 section. 6-13 pens per section were included in the study. Pens measured 2.4 x 5.0
127 m with 4.8 m² solid floor and 7.2 m² slatted floor (Figure 1). A 2.16 m² cover was
128 placed one meter above the solid floor. Two pens shared a dry feed dispenser with
129 two nipple drinkers (Figure 1). Two vertically wooden laths standing on the floor in a
130 retainer were positioned 0.4m apart on the pen wall between the feed dispenser and
131 the covering.

132

133 *Climate*

134 The indoor climate at the experimental farm was regulated by a negative
135 pressure ventilation system (SKOV A/S, Glyngøre, Denmark) supplemented with
136 ceiling air inlets. The air inlets opened when the room temperature was 2°C above
137 the set temperature. At weaning (day 0) the set room temperature was 24°C, and the
138 temperature was gradually decreased during the growing period to 17°C on day 112
139 when the study ceased. Two heating pipes placed along the wall in either side of the
140 section were regulated by the ventilation system. In addition, floor heating in the lying
141 area was turned on when the pigs arrived. The floor heating was normally turned off
142 around day 25.

143

144 *Feeding*

145 Pigs were fed with five different commercial compound diets (Table 1)
146 formulated to fulfill the Danish recommendations for pigs of this weight and genotype
147 (Tybirk *et al.*, 2016). From 7-9 kg (~10 days) pigs were floor fed 4 times a day (*semi*
148 *ad libitum*). From ~ 9 kg until slaughter pigs had *ad libitum* access to feed in the dry
149 feed dispenser.

150

151 Table 1 about here

152

153 *Management*

154 Each day pigs were inspected twice: at around 0900 and 1730. Pigs' health
155 conditions were monitored, and pigs with clinical signs of disease were treated with
156 antibiotics. The stockpersons continuously recorded pigs treated with antibiotic on
157 pen or individual level (depending on the disease). Throughout the study period, pigs
158 were treated for diarrhea, tail lesions, locomotion disorders, respiratory diseases,
159 brain/nerve disorders and other reasons (none of the above mentioned). Unthrifty
160 pigs, pigs with locomotion disorders or serious tail lesions (more than half the tail
161 missing for undocked pigs) were either euthanized or moved to hospital pens. The
162 farmer recorded the reason for euthanasia/death and transfer to hospital pens.

163 Daily, pens were provided with ~230 g of chopped wheat straw on the floor,
164 until the pigs reached an average weight of approximately 70 kg. In case the solid
165 floor got soiled due to defecation, the stockpersons stopped providing straw earlier.

166

167

168

169 *Tail biting management*

170 If tail biting occurred, a Bite-Rite (Ikadan Systems A/S, Ikast, Denmark),
171 consisting of four elastic plastic sticks, was suspended in the middle of the pen above
172 the slatted floor, and the amount of chopped straw provided was doubled (~460
173 g/pen, once daily). The development in tail damages was closely monitored the
174 following days, and pigs with severe tail injuries were moved to a hospital pen.

175

176 *Tail damage scoring*

177 The degree of tail damage was recorded every second week from weaning till
178 slaughter according to the scale in Table 2 using four parameters – tail damage, tail
179 length, wound freshness and tail swelling. In order to standardize observations, tail
180 scoring was performed by the same trained person throughout the study period. At
181 tail scoring the observer was standing in the middle of the pen checking each tail.

182

183 Table 2 about here

184

185 *Statistical analysis*

186 The statistical analysis was performed using SAS Enterprise Guide 7.1. Pigs
187 moved to hospital pens, pen level prevalence of tail damage and antibiotic treatments
188 were analyzed with pen as the experimental unit and pen as random effect within
189 batch. For the overall appearance of tail bitten pigs, each individual pig was the
190 experimental unit. In these analyses, pigs within pens within batches were included
191 as random effects. Furthermore, number of dead pigs was analyzed on batch level.

192 Pigs were categorized as either a tail biting victim or non-victim (binary
193 variable). Pigs scored with a fresh or healing tail wound were categorized as victims.

194 Pigs were split into three weight (age) classes: (1) weaning (7-30 kg, 5-12 weeks),
195 (2) grower (30-60 kg, 13-17 weeks) and (3) finisher (60-90 kg, 18-21 weeks) in order
196 to compare prevalence of tail biting in different weight (age) classes.

197 The effect of weight (age) on tail damage prevalence was analyzed using the
198 Generalised Linear Mixed Model procedure (GLIMMIX), with weight as fixed effect
199 and sex, batch and pen as random effects. Differences in pigs moved to hospital
200 pens, dead pigs and antibiotic treatments between docked and undocked pigs were
201 analyzed using a Students t-test. Finally, a chi-square test was used to analyze
202 slaughter data comparing tail biting remarks between docked and undocked pigs. P-
203 values lower than 0.05 were considered significant.

204

205 **Results**

206 No tail injuries were recorded among tail docked pigs. In contrast, 220 undocked pigs
207 distributed in 32 pens were observed with a tail wound at least once during the study
208 period. Twenty-one tail bitten pigs (9.5%) were moved to hospital pens due to tail
209 damage, and three tail bitten pigs (1.5%) were moved for other reasons. Thus, 89.0%
210 of the tail bitten pigs stayed in the home pen, and the wound healed with the use of
211 Bite-Rite and extra straw as enrichment. Furthermore, three tail bitten pigs moved to
212 a hospital pen had to be euthanized.

213 Of the 220 tail bitten pigs, 38 were logged twice with a tail lesion in the home
214 pen, and 4 were listed with a tail lesion three times. Injuries on pigs with 2 or 3 tail
215 lesion recordings could either be a new fresh wound or a healing wound. Overall, the
216 risk of being recorded with a tail lesion once, twice or three times during the study
217 period was 18.5%, 4.0% and 0.4%, respectively.

218 On average, 4.0% (CL; 2.6 - 5.3) of the pigs had a tail lesion on an
219 observation day. These bitten pigs were distributed in 20.9% (CL; 16.6 - 25.3) of the
220 pens. In addition, 50.0% of the tail bitten pigs were observed within the first 37 days
221 (~25 kg) in the pen. The recorded tail scores are listed in Table 3. By far the most
222 frequent score (93.8%) was 'part of the tail missing with a healing wound'.

223

224

Table 3 about here

225

226 More castrated males got tail lesions (124; $P < 0.001$; $F = 13.04$) compared to
227 gilts (82) with information about gender missing for 14 of the tail bitten pigs. More
228 pigs had tail lesions in the weight interval 30-60 kg than 7-30 kg ($P = 0.026$) and 60-90
229 kg ($P < 0.001$). Furthermore, fewer pigs between 60-90 kg compared to 7-30 kg
230 ($P < 0.001$) were observed with tail lesions (Table 4). At pen level, tail lesions were
231 more often present in pens with pigs weighing 30-60 kg than in pens with pigs
232 weighing 7-30 kg ($P < 0.001$) and 60-90 kg ($P < 0.001$) (Table 4).

233

234

Table 4 about here

235

236 Further, more pigs with undocked tails had to be moved to hospital pens
237 ($P = 0.03$; Table 5). Undocked pigs were mainly moved to hospital pens due to the
238 following reasons: tail damage (61.5%), other reasons (12.8%), brain/nerve disorders
239 (10.3%), locomotion disorders (7.7%), and diarrhoea (7.7%). For docked pigs the
240 reasons were: brain/nerve disorders (40.0%), other reasons (26.7%), diarrhoea
241 (13.3%), locomotion disorders (13.3%) and respiratory disease (6.7%). No difference

242 in dead or euthanized pigs was observed between docked and undocked pigs, but
243 more pigs with undocked tails were treated with antibiotics ($P=0.02$; Table 5).

244 Finally, more pigs with undocked tails got a tail biting remark during standard
245 meat inspection at the abattoir ($P<0.001$; Table 5).

246

247 Table 5 about here

248

249 Discussion

250 This study was designed to compare the tail biting prevalence between
251 docked and undocked pigs from weaning to slaughter under well-managed
252 conventional farm conditions in Denmark. In this study, none of the tail docked pigs
253 got tail lesions, which further supports the idea that tail docking is effective at
254 reducing damaging tail biting behavior (Sutherland and Tucker, 2011). The effect of
255 tail docking found in the current study is in agreement with most other studies. Di
256 Martino *et al.* (2015) reported increased risk of tail lesions among undocked fattening
257 pigs ($OR=20.82$) compared to tail docked, and Sutherland *et al.* (2009) described
258 more severe tail lesions among undocked pigs. In a survey of Dutch farmers,
259 conventional farmers rearing tail docked pigs agreed that tail docking is the most
260 effective way to reduce tail biting (Bracke *et al.*, 2013), although this need for tail
261 docking received less support from Finnish conventional farmers rearing pigs with
262 undocked tails (Valros *et al.*, 2016), with only 21% saying they would tail dock if it
263 was permitted.

264 The prevalence of bitten pigs varies greatly between studies. Di Martino *et al.*
265 (2015) observed 18.6% finishers with mild tail lesions (bite marks/small abrasions),
266 and 3.6% with tail wounds. On the other hand, a Dutch study with undocked weaners

267 reported considerably higher levels of tail injuries as 54% of the pigs were observed
268 with tail wounds and 35% with bite marks (Zonderland *et al.*, 2011b). In another study
269 83.4% (barren environment) and 45.3% (enriched environment) of the undocked pigs
270 were reported with a tail wound from weaning to slaughter (Ursinus *et al.*, 2014). This
271 suggests that increasing levels of enrichment reduce the level of tail damage. Among
272 finishers weighing 90-100 kg, Cagienard *et al.* (2005) observed 2.8% pigs missing a
273 part of the tail on 'animal friendly' farms due to tail biting compared to 21.9% on
274 traditional farms. In the present study, pigs were provided with straw daily, which
275 might explain the lower level of tail bitten pigs throughout the growing period
276 compared to some other studies. Overall, the large variation between studies is
277 probably due to variation in any or all of the many distinct risk factors associated with
278 tail biting (Schröder-Petersen and Simonsen, 2001, D'Eath *et al.*, 2014), different age
279 groups (weaner or finishers) and might also be due to different definitions of the
280 factors that constitute a tail wound.

281 Stocking density has been suggested as another risk factor influencing tail
282 biting prevalence (D'Eath *et al.*, 2014). Two epidemiological studies concluded that
283 increasing stocking density was associated with an increased risk of tail biting
284 (Moinard *et al.*, 2003, Scollo *et al.*, 2016). In our study, pigs were housed in the same
285 pen from weaning to slaughter causing a lower stocking density during the weaning
286 period (~0.6 m² per pig) than normally seen in conventional European herds (0.3 m² -
287 EU Council Directive 2008/120/EC). Thus, stocking density might influence tail biting,
288 but more experimental studies are required to estimate the effect.

289 Barrows are often more likely to become tail biting victims (Wallgren and
290 Lindahl, 1996, Kritas and Morrison, 2004, Valros *et al.*, 2004), and this is in line with
291 the present study. However, some experiments have failed to show a correlation

292 between gender and the risk of becoming a tail biting victim (Sinisalo *et al.*, 2012,
293 Scollo *et al.*, 2013, Di Martino *et al.*, 2015). These inconsistencies between studies
294 might be attributed to different grouping strategies and different settings (Sinisalo *et*
295 *al.*, 2012). The reasons why barrows in some studies more often become tail biting
296 victims are not fully understood.

297 We scored evidence of damaging tail biting behaviour in every age group from
298 weaning to slaughter, which is in accordance with a Dutch study (Ursinus *et al.*,
299 2014). In the Dutch study, the percentage of bitten pigs did not decline towards the
300 end of the finisher period in a barren environment. However, a decline in tail bitten
301 pigs in the end of the finisher period, as in our study, was observed among pigs
302 housed in an enriched environment.

303 When tail biting occur the severity of tail wounds can differ between pigs in the
304 same pen. Some pigs only get a bite mark, whereas others get actual wounds
305 (Zonderland *et al.*, 2011b). The severity of the wound is expected to affect the
306 healing duration. In our study, 11 pigs got a severe tail lesion with infections (swollen
307 tail) in the home pen. This number would probably be higher if pigs moved to hospital
308 pens were tail scored as well, but this was not the case. In comparison, 89% of the
309 tail wounds healed successfully in the home pen between two tail inspections. The
310 intervention, when tail damage occurred, was doubling the amount of straw and
311 hanging up a Bite-Rite. These results indicate that it is not necessary in every case to
312 move bitten pigs to other pens in order to stop the damaging tail biting behaviour.
313 However, there is a need for more experimental studies looking into the tail wound
314 healing duration using different intervention strategies as suggested by D'Eath *et al.*
315 (2014).

316 Previous studies have failed to discover differences in mortality between
317 undocked and tail docked pigs (Scollo *et al.*, 2013, Di Martino *et al.*, 2015), which
318 corresponds with our findings. However, in contrast to our findings, no differences in
319 the number of pigs moved to hospital pens between docked and undocked pigs were
320 reported by Scollo *et al.* (2013) and Di Martino *et al.* (2015). A likely explanation for
321 the dissimilarity between studies could be different management routines and
322 strategies in the experiments.

323 To our knowledge, the current study is the first to compare abattoir meat
324 inspection data between undocked and docked pigs originating from the same
325 piggery. When comparing the percentage of pigs scored with a tail lesion on the farm
326 (Table 4) with abattoir tail damage recordings (Table 5), our results indicate that
327 abattoir recordings heavily underestimate the number of undocked pigs experiencing
328 being tail bitten from weaning to slaughter. The prevalence of tail biting was highest
329 between 30-60 kg, and these wounds probably healed before slaughter. Healed tail
330 lesions will normally not be recorded during meat inspection, and the severely bitten
331 pigs will in many cases be culled in the herd (Taylor *et al.*, 2010), which might explain
332 the differences in prevalence.

333 Furthermore, a Danish abattoir survey of 1,173,213 tail docked pigs reported
334 0.85% tail damages during meat inspection (Alban *et al.*, 2015), and an Irish abattoir
335 study with 99% tail docked pigs reported 1.03% severe tail lesions (Harley *et al.*,
336 2012). As expected, these figures were slightly higher than for the docked group,
337 because the trial herd for our study was selected based on low tail biting abattoir
338 remarks among tail docked pigs. In addition, meat inspection data from a Swedish
339 survey (15,068 pigs) with undocked pigs showed tail damage prevalences of 1.2%
340 and 1.6% at two different slaughterhouses (Keeling *et al.*, 2012), which is in

341 accordance with the level found in the present study in the undocked group. In
342 agreement, a Finnish abattoir study reported 1.3% of pigs with tail damage, though
343 some pigs may have been tail docked (Valros *et al.*, 2004). Although no tail damage
344 was observed among tail docked pigs during the trial period of the present study, a
345 few tail docked pigs did get a tail biting remark at the abattoir. Perhaps tail damage
346 occurred after the study ended, during transportation or in the abattoir holding pens.

347 In conclusion, this study showed that many pigs got tail bitten if they were not
348 tail docked, even in a well-managed herd with low stocking density in the weaning
349 period. At pig and pen level tail lesions were more prevalent among 30-60 kg pigs,
350 than in the late finishing period from 60-90 kg. Intact tails did not increase the
351 mortality rate. However, more pigs had to be treated with antibiotics and moved to
352 hospital pens. In particular, the results suggest that caution should be taken when
353 recordings from the routine meat inspection at the abattoir are used to evaluate the
354 level of tail biting in a herd, because they probably highly underestimate the number
355 of bitten pigs.

356

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455 **Table 1** *Potential physiological energy, crude protein and lysine content in*
 456 *commercial diets*

Live weight	7- 9 kg ¹	9-17 kg ²	17- 35 kg ³	35- 55 kg ⁴	55- 90 kg ⁵
Potential physiological energy, MJ	8.5	7.9	7.8	7.9	7.7
Crude protein, %	18.4	17.7	18.3	16.5	14.7
Lysine,%	1.3	1.2	1.2	1.0	0.88

457 ¹ Hedegaard A/S, Nørresundby, Denmark, Minigris L-3

458 ² Hedegaard A/S, Nørresundby, Denmark,Maxigris L-7

459 ³ Hedegaard A/S, Nørresundby, Denmark,Maxigris voks

460 ⁴ Hedegaard A/S, Nørresundby, Denmark,Svine-voks primo

461 ⁵ Hedegaard A/S, Nørresundby, Denmark,Svine-voks sludeal

462 **Table 2** Tail biting scores (modified after Kritas and Morrison (2004) and Zonderland
 463 *et al.* (2008))

	Description
Tail damage	
No	No visible tail lesion. Earlier lesion is healed.
Red, clean and/or minor scratches	Red, clean and/or minor scratches
Tail wound	Visible wound
Tail length	
Intact	Full length tail
Part missing	A part is missing or structural changes appears
Wound freshness	
Fresh/ bleeding	Fresh blood is visible
Dried/ scab	Wound covered with a scab
Swelling	
No	No swelling
Yes	Swollen red tail indicating an infection

464 **Table 3** Tail scoring frequency and distribution (%)

Tail scores	n	%
Full length tail, scratches	1	0.39
Full length tail, fresh wound and swollen tail	1	0.39
Part missing and fresh wound	3	1.17
Part missing and healing wound	241	93.8
Part missing, healing wound and swollen tail	11	4.28

465 **Table 4** Percentage of pigs and pens with tail lesions among pigs with undocked tails in three weight intervals: 7-30 kg, 30-60 kg,
 466 60- 90 kg.

	7-30 kg		30-60 kg		60-90 kg		<i>P</i> -value
	Mean	CL	Mean	CL	Mean	CL	
Tail lesions pig level							
Number of pigs, n	959		933		919		
Pigs with tail lesions, %	5.0 ^a	4.0-6.1	6.6 ^b	5.3-8.2	1.4 ^c	0.91-2.2	<0.001
Tail lesions pen level							
Number of pens, n	47		47		47		
Pens holding pigs with tail lesion,%	13.0 ^a	8.2-19.9	34.3 ^b	24.3-46.1	12.8 ^a	7.3-21.6	<0.001

467 ^{a, b} Values within a row with different superscripts differ significantly at *P*<0.05.

468

469 **Table 5** Comparison of pigs moved to hospital pens (%), dead/euthanized pigs (%), antibiotic treatments (average per pen) and

470 *abattoir tail biting remarks (%) between docked and undocked pigs.*

	Undocked			Docked			P-value
	n	Mean	CL	n	Mean	CL	
Pigs moved to hospital pens, %	47 ¹	3.87	1.99- 5.75	48	1.53	0.57- 2.48	0.03
Dead/ euthanized pigs, %	12 ²	2.93	1.21- 4.64	12	3.67	2.32- 5.01	N.S (0.64)
Started antibiotic treatments, n	47 ¹	34.1	29.3- 39.0	48	26.5	22.2- 30.8	0.02
Abattoir tail biting remarks,%	853 ³	2.00	-	933	0.32	-	<0.001 ⁴

471

472 ¹ Pigs moved to hospital pens and started antibiotic treatments were analysed on pen level (n=47)

473 ² Dead/euthanized pigs were analysed on batch level (n=12)

474 ³ Number of slaughtered pigs

475 ⁴ Chi-Square = 11.24

476 **Figure captions**

477

478 **Figure 1** Experimental pen design.

Figure 1

