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REGULAR ARTICLES

Impact of housing nursery pigs according to body weight on the onset of feed intake, aggressive behavior, and growth performance

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Abstract

Housing nursery pigs according to body weight is an observed common practice in production systems and, supposedly, improves growth performance and reduces body weight (BW) variation. This 42-day study evaluated the effects of housing nursery pigs according to BW on performance, onset of feed intake, and aggressive behavior. A total of 504 pigs were ranked by BW at weaning and categorized into three groups of 168 pigs each: light, medium, and heavy. Pigs were randomly distributed to unsorted pens (*Unsorted*) containing 6 pigs of each weight group and sorted pens with 18 pigs from just one group per pen (*Sorted*). From weaning to day 3, pigs were fed a diet containing 1% iron oxide dye and rectal swabs presenting red coloration were evaluated to assess feed intake onset. Eight pens were video recorded to evaluate aggressive behavior. Sorted-Heavy pigs delayed the onset of feed intake ($P \leq 0.011$) and presented more aggressive behaviors than Sorted-Light and Sorted-Medium pigs ($P \leq 0.036$). In *Unsorted*, onset of feed intake showed no differences between weight categories. Also, no differences were observed for aggressive behavior between *Sorted* and *Unsorted*. Final BW showed no differences between *Sorted* and *Unsorted* pigs. The within-pen weight coefficient variation (CV) was slightly different ($P = 0.042$) between *Sorted* and *Unsorted* pigs (13.3 and 15.6%, respectively), at the end of the study. Thus, sorting nursery pigs by BW did not improve growth performance and also, induce a lag of post-weaning feed intake onset and increased fights in Heavy pigs.

Keywords Growth rate · Nursery pigs · Behavior · Housing · Bodyweight variability

Introduction

In the past decades, the swine production chain has been increasingly focusing on strategies to reduce weight variation and its consequences (Patience et al., 2004). Sorting nursery pigs, as well as growing-finishing pigs by body weight (BW), is a widely used management practice with the goal of minimizing BW variation by the end of these phases (O'Quinn et al., 2001; Brumm et al., 2002). However, sorting is time-consuming and exhaustive for workers, especially in scenarios involving weaning several times a week.

Rushen et al. (1987) reported that sorting piglets by BW right after placement exacerbates the aggressive behavior, which could create a welfare concern and might affect how pigs start on feed intake. Furthermore, that moment highly depends on the weaning weight (Bruininx et al., 2001). It has also been documented that a shorter time between weaning and first feed intake increases the subsequent growth performance, especially for light-weight pigs (Wolter and Ellis, 2001). Although difficult to explain, the behavior of sorted piglets may be associated with time spent fighting (Rushen et al., 1987) to establish the hierarchy. Therefore, there is a need to understand the adaptation capacity of nursery piglets according to BW variation at placement, based on measures of aggression, the onset of feed intake, and their association.

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In the growing-finishing phase, unsorted pigs had a greater growth rate than those that were sorted, with no difference in within-pen BW variation (O'Quinn et al., 2001). Cámara et al. (2016) observed that a reduction in within-pen BW variation after weaning resulted in no advantages to BW variability at the end of the finishing phase, and even impaired feed efficiency when compared to high within-pen BW variation. However, Bruininx et al. (2001) reported improvement in feed efficiency in nursery pigs by minimizing within-pen BW variation, showing that the effect of sorting nursery pigs on growth performance is still controversial and scarcely studied. Thus, the present study evaluated the effects of sorting nursery pigs on growth performance, BW variation, the onset of feed intake, and immediate post-weaning aggressive behavior.

Materials and methods

Animals, housing, and diet

A total of 504 barrows and gilts (PIC 337 × Camborough) were weaned, with 23.9 ± 0.6 days of age and 7.0 ± 1.22 kg. At weaning, pigs were identified with an ear tag, and individual weight and gender were recorded. Pigs had no access to creep feeding in the pre-weaning period.

Nursery pens were equipped with a semi-automatic feeder with a stainless-steel tray with four 16-cm wide feeder spaces. All 28 pens accommodated 18 pigs and provided 0.25 m^2 of area/pig, respecting the minimum space suggested by Madec et al. (2003). Pigs were allowed ad libitum access to feed and water. Water was provided by two nipple drinkers per pen. The diets were corn- and soybean-meal based and were provided in a three-phase feeding program in meal form. The feed budget was 1 kg per pig of Phase 1 diet (3.6 Mcal/kg of metabolizable energy (ME), 21.9% crude protein (CP), 1.46% standardized ileal digestible (SID) lysine, 20.0% spray-dried whey, and 18.0% lactose), 4 kg per pig of Phase 2 diet (3.6 Mcal/kg of ME, 21.4% CP, 1.42% SID lysine, and 12.0% lactose), followed by a Phase 3 diet (3.5 Mcal/kg of ME, 20.1% CP, and 1.30% SID lysine) with approximately 17 kg per pig fed until the end of the trial.

Experimental design

At weaning, pigs were divided in three weight categories, namely Light (4.48 to 6.38 kg), Medium (6.39 to 7.52 kg), and Heavy (7.53 to 9.92 kg), respecting the original distribution in the population (33% for each category). Further, animals were distributed among four treatments ($N = 18$/pen): Sorted light-weight pigs; Sorted medium-weight pigs; Sorted heavy-weight pigs, and Unsorted pigs (6 animals of each weight category). In total, there were seven pens for each treatment.

Onset of feed intake

From day 0 to day 3 post-weaning, pigs were fed a diet containing a red fecal marker (iron oxide, 1%). The marker helped to determine, through rectal swabs, when each pig started its feed consumption. Rectal swabs were performed at 30, 42, 54, 66, and 78 h post-weaning (adapted from Sulabo et al., 2010 and Laskoski et al., 2019). The presence of red color in the swab at two consecutive moments was used to consider the pig as "eater" at the first dyed swab. The average time, in hours, for the onset of feed intake was calculated for each pen.

Aggressive behavior

Immediately after weaning, eight pens (two pens per treatment) were randomly selected to be recorded for the first 3 days post-weaning. Aggressive behavior was defined when a given pig initiated a physical contact (head-to-head or head-to-body knocks, parallel/inverse parallel pressings, and bites) with an opponent that exhibited a submissive behavior (Langbein and Puppe, 2004). Only one trained observer evaluated the images and registered one aggressive event when the fights lasted more than 1 s (Puppe, 1998).

Growth performance

Pigs were weighed weekly and feed intake was calculated by the amount provided minus leftover feed. Pigs were individually weighed on days 7, 21, and 42 to determine the within-pen CV, and weighed by pen on days 14, 28, and 35. Weekly collection of BW and amount of feed provided were used to calculate average daily gain (ADG), average daily feed intake (ADFI), and gain/feed (G/F) ratio.

Statistical analysis

Data were analyzed as a completely randomized design using the GLIMMIX procedure of the software SAS (version 9.4; SAS Inst. Inc., Cary, NC, USA). In all analysis, means were considered significantly different at $P \leq 0.05$. For multiple comparisons, the Tukey-Kramer test (balanced) or Tukey–Kramer adjustment (unbalanced) was used.

In a first statistical approach, growth performance (BW, ADG, ADFI, and G/F ratio) was analyzed with repeated-measure models, considering the effect of treatments (Sorted-Light, Sorted-Medium, Sorted-Heavy, and Unsorted). Another statistical approach consisted of grouping sorted weight categories and comparing them with the Unsorted group, according to O'Quinn et al. (2001). In both cases, pen was considered as the experimental unit. As the experimental units were unbalanced between the housing strategies (Sorted and Unsorted), the Kenward-Roger adjustment for degrees of freedom

was implemented in this later analysis. Additionally, when individual measures were obtained (onset of feed intake, BW, ADG, and CV of within-pen weight), subgroups within the Unsorted group were compared with their respective counterparts in the Sorted groups. In this case, the experimental units for *Unsorted* pens were the subgroups of six pigs of each weight category. Beta distribution was used to analyze the within-pen weight variation and a negative binomial distribution for analysis of the number of aggressive events.

Table 1 Impact of sorting nursery pigs according to their body weight on growth performance

Item	*Unsorted*	*Sorted*			*Sorted* (L/M/H)	SEM	*Sorted* vs. *Unsorted* $P<$[a]
		Light	Medium	Heavy			
N	7	7	7	7	21		
BW, kg							
Day 0	6.99[b]	5.64[c]	6.97[b]	8.38[a]	6.99	0.38	0.998
Day 7	7.42[b]	6.24[c]	7.42[b]	8.76[a]	7.47	0.11	0.665
Day 14	9.85[b]	8.44[c]	9.84[b]	11.4[a]	9.88	0.19	0.874
Day 21	12.6[b]	11.0[c]	12.7[b]	14.4[a]	12.0	0.27	0.751
Day 28	16.2[b]	14.3[c]	16.2[b]	18.3[a]	16.3	0.37	0.884
Day 35	20.9[b]	18.7[c]	21.1[b]	23.4[a]	21.1	0.49	0.705
Day 42	25.7[b]	23.2[c]	25.9[b]	28.2[a]	25.8	0.54	0.909
Days 0 to 7							
ADG, g	61.4[b]	90.0[a]	61.1[b]	50.0[b]	67.6	20.3	0.762
ADFI, g	127.1	127.2	127.0	127.4	125.7	8.0	0.859
G/F	0.52[b]	0.64[a]	0.45[b]	0.40[c]	0.48	0.31	0.506
Days 8 to 14							
ADG, g	347.2[b]	311.1[c]	350.4[b]	380.3[a]	342.4	10.6	0.652
ADFI, g	357.1	330.0	348.2	369.4	350.0	18.7	0.703
G/F	0.97	0.93	0.98	0.99	0.97	0.04	0.998
Days 15 to 21							
ADG, g	388.6[b]	360.0[c]	401.8[b]	444.5[a]	396.7	13.6	0.553
ADFI, g	538.6[bc]	501.7[c]	551.8[ab]	580.5[ab]	542.9	21.3	0.841
G/F	0.72	0.72	0.71	0.75	0.72	0.04	0.786
Days 22 to 28							
ADG, g	511.4[b]	463.0[c]	501.0[b]	560.3[a]	508.6	18.6	0.877
ADFI, g	691.4[b]	634.0[c]	694.0[b]	773.0[a]	698.6	27.7	0.796
G/F	0.74	0.74	0.71	0.72	0.72	0.04	0.363
Days 29 to 35							
ADG, g	664.3[b]	590.3[c]	701.3[ab]	720.6[a]	670.5	24.8	0.803
ADFI, g	930.0[b]	865.3[c]	958.1[b]	1029.0[a]	955.2	34.6	0.466
G/F	0.71	0.68	0.72	0.69	0.70	0.03	0.507
Days 36 to 42							
ADG, g	661.4[ab]	632.7[b]	681.1[a]	684.5[a]	664.3	18.0	0.875
ADFI, g	1100.0[b]	1062.2[b]	1158.2[a]	1190.5[a]	1139.5	36.2	0.277
G/F	0.60	0.59	0.59	0.57	0.58	0.05	0.267
Days 0 to 42							
ADG, g	438.9[b]	403.1[c]	444.1[b]	471.9[a]	439.9	8.24	0.942
ADFI, g	621.4[b]	580.0[c]	638.6[b]	680.0[a]	632.9	13.0	0.601
G/F	0.70	0.69	0.69	0.69	0.69	0.01	0.391

A total of 504 pigs were distributed according to their body weight as *Sorted* or *Unsorted* in pens at nursery placement. Means within a row with different superscripts differ ($P < 0.05$) between *Unsorted*, *Sorted-Light*, *Sorted-Medium* and *Sorted-Heavy* pens

BW body weight, *ADG* average daily gain, *ADFI* average daily feed intake, *G/F* gain/feed

[a] *P* value when compared *Unsorted* vs. *Sorted* pens (L–light + M–medium + H–heavy)

Table 2 Within-pen coefficient of variation of body weight according to sorting or unsorting pigs at placement on nursery

Days after placement	Groups			
	Unsorted ($N = 7$) (%)	*Sorted* ($N = 21$) (%)	SEM	*P* value
0	17.5	6.9	0.06	< 0.0001
7	18.3	12.2	0.07	< 0.0001
21	19.1	14.5	0.08	0.0001
42	15.6	13.3	0.08	0.0420

A total of 504 pigs were distributed according to their body weight as *Sorted* or *Unsorted* in pens at nursery placement. For this analysis, *Sorted-Light*, *Sorted-Medium*, and *Sorted-Heavy* pigs were grouped and compared to *Unsorted* pigs

Results

Sorted-Heavy pigs had the highest and *Sorted*-Light pigs the lowest BW ($P < 0.001$), whereas *Sorted*-Medium and *Unsorted* pigs had intermediate BW with no differences between them ($P = 0.803$; Table 1) along the 6 weeks of evaluation. No differences were observed between *Sorted* and *Unsorted* pigs at any week until day 42 ($P \geq 0.665$; Table 1). For the overall period (days 0–42), ADG and ADFI for *Sorted*-Heavy pigs were greater ($P \leq 0.042$) than other treatments (Table 1). *Sorted*-Medium and *Unsorted* pigs had no differences in ADG and ADFI ($P \geq 0.667$) but they differed from *Sorted*-Light pigs ($P \leq 0.019$). Greater G/F ratio was observed for Sorted-Light pigs on the first week ($P < 0.05$). No differences ($P \geq 0.267$) were observed for ADG, ADFI, and G/F in any specific week or during the overall period between *Sorted* and *Unsorted* pigs (Table 1).

The initial within-pen BW variation was different ($P < 0.0001$) between *Sorted* and *Unsorted* pens. Initial BW variation in the *Unsorted* pens was 2.5 times greater than for the *Sorted* ones (Table 2). However, the magnitude of difference decreased throughout the study. On day 42, the BW variation of *Unsorted* pens were 1.2 times greater ($P = 0.042$) than for the *Sorted*.

On the first day, *Sorted*-Heavy pigs engaged in more fights than *Sorted*-Light and *Sorted*-Medium pigs ($P \leq 0.036$), and Unsorted pigs had an intermediate number of fights (Fig. 1). However, no significant differences were observed on the second and third days ($P \geq 0.166$). There was no difference between *Unsorted* and *Sorted* groups ($P = 0.689$).

All piglets had a positive feed intake within 78 h post-weaning as confirmed by the colored swab. When the analysis considered six subgroups, *Sorted*-Heavy pigs exhibited a lag in feed intake onset ($P \leq 0.011$) compared with *Sorted*-Medium, *Sorted*-Light, and *Unsorted*-Light pigs. Within *Unsorted* pens, no difference was found between the three

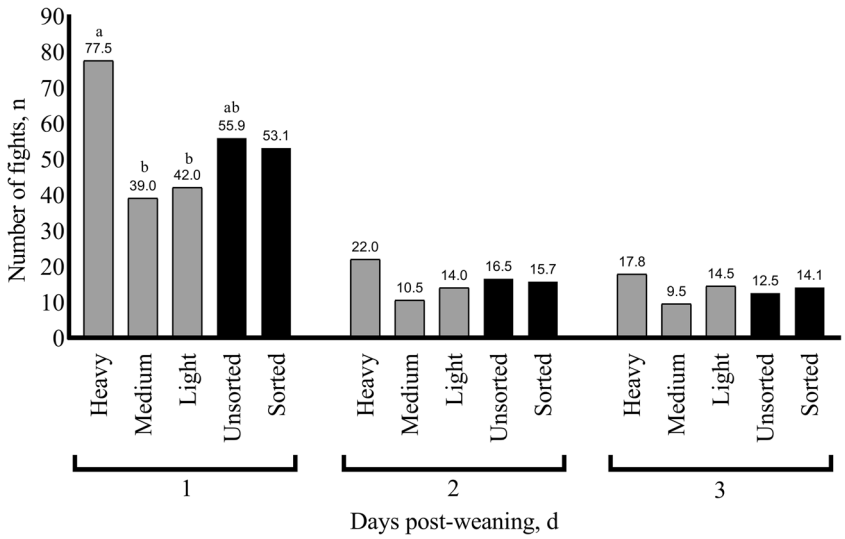

Fig. 1 Number of aggressive events per pen during the first 3 days after placement of pigs on nursery. Means within a day with different letter differ ($P < 0.05$). There was no difference ($P > 0.05$) between all Sorted vs. Unsorted pigs (dark bars)

Table 3 Time between weaning and the first positive rectal swab with red dye marker in pigs of different weight categories within each housing strategy

Groups	Number	Average of first positive swab, h	Minimum, h	Maximum, h
Sorted–Heavy	7	51.3[b]	48.1	54.5
Sorted–Medium	7	45.4[a]	42.2	48.5
Sorted–Light	7	43.3[a]	40.1	46.5
Unsorted–Heavy	7	47.3[ab]	44.1	50.4
Unsorted–Medium	7	47.3[ab]	44.1	50.5
Unsorted–Light	7	44.9[a]	41.7	48.0

[1] A total of 504 pigs were distributed according to their body weight as *Sorted* or *Unsorted* in pens at nursery placement. For *Sorted*, 18 pigs were present in each replicate, whereas for *Unsorted* each replicate consisted of 6 pigs. Means within a column with different superscripts differ ($P < 0.05$)

weight categories ($P \geq 0.396$; Table 3). The performance (BW, ADG and BW variation) was affected by weight category, but within the same weight category it was not affected by sorting management (Table 4).

Discussion

The feed intake behavior of weaned pigs is associated with many factors, including but not limited to the number of pigs/feeder hole (Laskoski et al., 2019), diet complexity (Wolter et al., 2003), and BW. Considering BW, lighter pigs in Sorted pens start feed intake earlier, and Unsorted pigs begin to eat simultaneously regardless of their weaning weight (Bruininx et al., 2001). Compared to the abovementioned findings, in the current study, the three BW categories within *Unsorted* pens started feed consumption in a similar time after weaning. However, *Sorted*-Light and *Sorted*-Medium pigs had an earlier onset of feed intake compared to *Sorted*-Heavy pigs. This could be associated with less aggressive events on the first day of these two BW categories. In fact, *Sorted*-Heavy pigs engaged in a greater number of fights in the first 24 h after weaning compared to other weight categories. This could be partially explained by the dominance of heavy-weight pigs and having a cohort with similar BW, thus taking longer to establish the social hierarchy (Rushen, 1987). Although the length of fights was not recorded, we speculate that *Sorted*-Heavy pigs could spend more time in aggressive interactions explaining their delayed onset of feed intake.

Heavy pigs spent more time defending the feeder area than actually eating (Brouns and Edwards, 1994). However, after social hierarchy is defined, pigs with low feed intake in the first 72 h tend to increase the consumption in subsequent days, generating a positive weight gain (Williams, 2003). In the current

Table 4 Body weight (BW), average daily gain (ADG), and variation of weight (CV) of nursery pigs from different categories of weight[1] within each housing strategy[2]

BW, kg	*Sorted*			*Unsorted*			SEM
	L	M	H	L	M	H	
N	7	7	7	7	7	7	
Day 0	5.64[c]	6.97[b]	8.38[a]	5.63[c]	6.97[b]	8.39[a]	0.15
Day 7	6.24[c]	7.42[b]	8.76[a]	6.12[c]	7.47[b]	8.68[a]	0.17
Day 21	11.0[c]	12.7[b]	14.4[a]	10.7[c]	12.8[b]	14.4[a]	0.17
Day 42	23.2[c]	25.9[b]	28.2[a]	23.2[c]	26.1[ab]	27.9[a]	0.37
ADG, g							
0–7 days	85.9	63.3	53.6	70.1	70.0	41.9	16.6
8–21 days	336.4[b]	374.6[a]	404.7[a]	324.7[b]	382.9[a]	405.7[a]	9.1
22–42 days	581.6[b]	628.0[ab]	656.0[a]	585.0[b]	631.7[ab]	644.4[a]	18.7
CV of BW, %							
Day 0	9.0[b]	4.7[d]	7.5[c]	10.3[a]	4.8[d]	7.1[c]	0.3
Day 7	15.1[a]	11.4[b]	11.5[b]	15.9[a]	8.6[b]	11.4[b]	0.9
Day 21	17.9[a]	14.1[ab]	14.0[ab]	20.1[a]	9.7[b]	14.0[ab]	1.8
Day 42	15.4[ab]	13.5[ab]	13.4[ab]	17.4[a]	9.2[b]	12.2[ab]	1.8

A total of 504 pigs were distributed according to their body weight as *Sorted* or *Unsorted* in pens at nursery placement. For *Sorted*, 18 pigs were present in each replicate, whereas for *Unsorted* each replicate consisted of 6 pigs. There were seven replicates per group. Means within a row with different superscripts differ ($P < 0.05$)

L light, *M* medium, *H* heavy

study, during the first week in the nursery, *Sorted* pigs had no impact on ADFI and ADG in comparison with *Unsorted* pigs. This result was observed in all weeks, which is in agreement with Cámara et al. (2016). Moreover, even that Sorted-Light and Sorted-Medium pigs started on feed earlier than Sorted-Heavy pigs, the average of ADFI was quite similar between treatments during the first 7 days on nursery. For the overall period, *Sorted*-Light pigs had the lowest ADFI and ADG, *Sorted*-Medium and *Unsorted* had intermediate values, and *Sorted*-Heavy pigs had greater consumption and weight gain.

In the first week, the absence of differences in ADFI but greater ADG resulted in a better G/F ratio for *Sorted*-Light pigs. The earlier feed intake onset and a fewer number of aggressive events could have contributed to the increase of the G/F ratio in *Sorted*-Light pigs. Furthermore, pens with only *Sorted*-Light pigs could be benefited by proportionally more space allowance per kilogram. The greater number of fights in pens of *Sorted*-Heavy pigs was expected, and it is a behavior that could affect their early performance (D'Eath, 2002). Therefore, more fights, delay in the onset of feed intake, and a similar ADFI could explain the worst G/F ratio of *Sorted*-Heavy pigs. The reduction in social interaction (Stukenborg et al., 2011) and the ad libitum access to feed may explain the absence of difference in G/F ratio among sorted-BW categories and, also, between the *Sorted* and *Unsorted* pigs, in subsequent weeks.

The fact that BW variability within pens demonstrated a small difference in favor of *Sorted* pigs may hide important points. Despite pens with *Unsorted* pigs had higher BW variation, the difference between Sorted and Unsorted pens at the beginning of the trial was 10.6%. Even though it remained statistically distinct at the end, there was a significant decrease to 2.3%. The reduction is validated by probability, starting with $P < 0.0001$ and ending with $P = 0.042$. These results are comparable with data reported by Cámara et al. (2016), in which the difference dropped from 13 to 3.8%, from beginning to the last week of the nursery phase. O'Quinn et al. (2001) observed a decrease in the probability of CV difference between Sorted and Unsorted pigs in the finishing phase, and from the eighth-week until the end of the period, the treatments exhibited the same within-pen variation. Although within-pen variation was slightly reduced for *Sorted* pigs in the present study, the variation among individual pigs as a whole group was similar between *Sorted* and *Unsorted* pigs (15.8 vs. 16.2%, respectively). Therefore, BW uniformity of pigs that will be sent to the growing-finishing phase is not affected greatly, no matter how the pigs are placed in nursery pens. It is important to mention that the different ranges of BW between weight groups at placement could be an interference factor in the present results. Nevertheless, the groups were formed respecting the frequency of weight distribution in the original population, trying to reproduce what occurs in commercial farms.

Based on findings of the present study, sorting pigs by BW at placement without any specific purpose results in no improvement in performance, onset of feed intake, and homogeneity of the batch.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Statement of animal rights The Institutional Animal Care and Use Committee of the Universidade Federal do Rio Grande do Sul approved the protocol used in this experiment according to the procedure PROPESQ-UFRGS 30545.

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