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Short communication: Preweaning socialization and environmental enrichment affect short-term performance after regrouping in commercially reared pigs

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ABSTRACT

On-farm practices like premature weaning and frequent regrouping induce stress to pigs. Early socialization or environmental enrichment in piglets reduce weaning stress, as suggested in previous studies. Little research with both effects and in commercial settings was found. The aim was to investigate the effects of preweaning socialization and environmental enrichment on life-long performance in 661 Danbred pigs. Two treatments were distinguished during the suckling period: control (**CON**, 24 litters) and enriched (**ENR**, 24 litters). Control piglets were raised in barren farrowing pens; ENR piglets were provided with six enrichment objects from birth, and two neighboring litters were socialized from Day (**D**) 14. Pigs were regrouped on D25 (weaning) and D71 (fattening), while keeping the same treatment. Individual body weight was recorded on D1, 14, 23, 27, 31, 38, 69, 79, and after slaughter (carcass weight, **CW**). Pigs were slaughtered in six batches. Estimated slaughter weight (**ESW**) was calculated by CW × 1.25. Body weight, CW, and average daily gain (**ADG**) were analyzed by linear mixed models. Slaughter age was analyzed by Wilcox Rank-Sum test. Body weight and ESW were adjusted to non-linear models to obtain the predicted growth curves of CON and ENR, from birth to the targeted market weight (**TMW**, 105 kg). Average daily gain during the suckling, nursery, and fattening periods, and from birth to slaughter, did not differ between treatments. However, ADG of ENR when moving pigs from farrowing to nursery (4-day period) and from nursery to fattening (10-day period), revealed a better performance than CON (+20.6 g/day, $P = 0.02$; +53 g/day, $P = 0.03$, respectively). Enriched pigs tended to be slaughtered 2.8 days earlier than CON ($P = 0.08$). On the other hand, the predicted growth curves showed a non-significant 2-day window of reaching TMW between treatments ($P = 0.23$). Results suggested that enriching the neonatal environment improved the short-term performance after regrouping, and may benefit the life-long performance by reducing time to reach TMW.

Implications

An improved performance demonstrates a crucial economic interest and a reliable welfare indicator. It is not clear whether the benefits of early environmental manipulations persist under commercial conditions, as most studies were conducted in research facilities. According to the study, raising commercially reared piglets in a physically and socially enriched environment, showed a sustainable weight gain after regrouping, and a tendency to be slaughtered earlier, compared to those in a barren neonatal environment. This represented a cheap and pragmatic strategy to ensure better adaptability of regrouping events in commercial farms.

Introduction

Intensive pig farming is often associated with poor animal welfare. Pigs are confined in stimulus-poor captive conditions, which failed to meet their ethological needs and thwarted the expression of key behaviors such as foraging and exploration (Godyń et al., 2019). These problems are exacerbated by stressful practices like early weaning and frequent mixing, resulting in poor performance and disease susceptibility (Godyń et al., 2019).

Prior research reported that enrichment of the neonatal environment can increase the resilience of piglets toward challenging situations (Godyń et al., 2019). Even minor modifications such as mixing with unfamiliar piglets (Salazar et al., 2018), or provision of enrichment objects (Yang et al., 2018) can reduce stress and aggression without compromising productivity. These strategies are of great interest in the swine industry, as they require few resources and installation.

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We aimed to study the effects of preweaning socialization and environmental enrichment on life-long performance in pigs. We hypothesized that physical and social enrichment of neonatal environment improves the life-long adaptability of pigs to novel regrouping events, which leads to higher growth and a shorter time to reach the targeted market weight (**TMW**), compared to those in the barren environment.

Material and methods

Animals, housing and diets

The study was conducted on a commercial farm in Lleida, Spain. A batch of 661 piglets from 48 Danbred sows (21 primiparous and 27 multiparous) was studied. Sows were moved to farrowing rooms prior to parturition. Piglets were individually ear-tagged and litter size was standardized between 13 and 14 piglets after parturition. Each farrowing pen was equipped with a feeder and a drinker (*ad libitum* water) in the front of the crate for the sow, and a nipple drinker (*ad libitum* water) in the lower part of the crate for the piglets. At weaning, 548 piglets (average 25 days of age) were moved to a nursery room, where they were regrouped according to treatment and BW, irrespective of litter origin and sex. Each pen was equipped with three feeders (two automatic and one manual) and five nipple drinkers (*ad libitum* water).

At the growing-finishing period, 442 pigs (average 71 days of age) were moved to a fattening unit until they were slaughtered. Pigs were regrouped according to treatment and BW, irrespective of nursery pen origin and sex. Each pen was equipped with a concrete box feeder containing *ad libitum* liquid feed. See Ko et al. (2020) for more details regarding the general management and housing conditions of each production stage. Pigs were selected by the farmer periodically and were transported by truck 1 day before slaughter. There were six slaughter batches in total, with 45 days of difference between the first and the last batch.

Sows were fed with a pelleted lactation diet (2450 Kcal/kg) twice a day. Piglets were fed with a mashed creep feed from the 2nd week until weaning. In the nursery, pigs were fed *ad libitum* with pelleted diets following a three-phase feeding program (2480, 2470, and 2460 Kcal/kg). In the growing-finishing period, pigs were fed with *ad libitum* liquid feed diet following a two-phase feeding program (2488 and 2477 Kcal/kg).

Experimental design

When piglets were born on Day (**D**) 1, litters were balanced by sow parity and randomly assigned to two treatments: control (**CON**; $n = 24$ litters) and enriched (**ENR**; $n = 24$ litters). Control piglets were raised in barren farrowing pens until weaning. Enriched piglets were provided with six enrichment objects per pen from birth (two hemp ropes, two rubber chew toys, and two handmade toys) and two neighboring pens were socialized from D14 until weaning (see Ko et al. (2020) for details regarding the enrichment objects).

Weighing

Pigs were individually weighed on 1, 14, 23, 27, 31, 38, 69, and 79 days of age. The BW_{1-69} was obtained by Balanzas Cobos PB-4040-60 (Spain) scale [precision: 10/5 g]. The BW_{79} was obtained by Meier Brakenberg (Germany) scale [precision: 100 g]. Carcass weight (**CW**) was obtained after the carcasses were split longitudinally [precision: 10 g].

Statistical analysis

Data were analyzed in R (R Foundation, Austria). The individual was the experimental unit. Statistical significance was set at $P \leq 0.05$; a tendency was considered when $0.05 < P \leq 0.10$. Results are reported as means ± SE.

Body weight, carcass weight, and average daily gain

Estimated slaughter weight (**ESW**) was calculated by CW × 1.25, assuming an 80% of carcass yield. Linear mixed model was the main model to compare different response variables between treatments. Details regarding the response variable, fixed effects, covariate, and random effects of each linear mixed model are presented in Table 1.

Slaughter age and predicted growth curves

Slaughter age (i.e. days from birth to slaughter) was not normally distributed. A Wilcox Rank-Sum test was applied to compare the slaughter age between treatments. To predict the time to reach TMW of 105 kg (T105, d), the double exponential Gompertz model in López-Vergé et al. (2018) was applied, by adjusting all BW and ESW into the following formula.

$$BW = A * e^{-e^{(b-(c*t))}}$$

A, *b*, and *c* are the parameters of the curve. *t* refers to the time (days).

Results

One CON sow was removed because of lameness before farrowing. Control had 10 primiparous and 13 multiparous sows, and ENR had 10 primiparous and 14 multiparous sows. Average litter size was 14.1 ± 0.1 (CON) and 14.0 ± 0.1 (ENR). During the suckling and nursery periods, 40 and 69 piglets were lost to follow-up, and 73 and 37 died, respectively. At slaughter, 100 pigs lost their traceability.

Body weight, carcass weight, and average daily gain

Average BW and average daily gain (**ADG**) in different stages, and CW are presented in Table 2. No difference ($P > 0.1$) of BW and CW was found between treatments. The BW_1 had a significant effect on all BW ($P < 0.0001$), ESW ($P = 0.03$), and all ADG ($P \leq 0.001$). Average daily gain in the suckling, nursery, and fattening periods, and from birth to slaughter, did not differ between treatments. However, when moving pigs from one facility to another (from farrowing to nursery and nursery to fattening), ADG of ENR were higher than those of CON ($P = 0.02$ and $P = 0.03$, respectively) after regrouping. There was an interaction between treatment and sex in ADG from farrowing to nursery ($P = 0.04$), where ENR female performed better than ENR male ($P = 0.02$, +21.3 g/day).

Slaughter age and predicted growth curves

Enriched tended to be slaughtered 2.8 days sooner than CON (194.9 ± 1.03 and 197.7 ± 1.28, $P = 0.08$). Fig. 1 (a) and (b) presents the predicted growth curves by treatment and sex effect, respectively. The horizontal line corresponds to TMW (105 kg). Neither treatment nor sex affected the time to reach TMW ($P = 0.23$ and $P = 0.43$, respectively). Numerically, ENR (192.2 ± 1.08) reached TMW 2 days earlier than CON (194.2 ± 1.21), and male (192.6 ± 1.21) reached TMW 1.3 days earlier than female (193.9 ± 1.08). There was no interaction between treatment and sex on the time to reach TMW ($P = 0.36$).

Discussion

We investigated the effects of enriching the neonatal environment physically and socially on life-long performance in pigs without modifying the routine management. Based on the results, ENR showed an improved ADG after two regrouping events, and a tendency of 2.8-day reduction to be slaughtered, compared to CON. As evidenced in Ko et al. (2020), piglets reared in an ENR environment in their early life

Table 1
Variables for the linear mixed models of BW, carcass weight (CW), estimated slaughter weight (ESW), and average daily gain (ADG) of pigs.

Response variable	Fixed effects	Covariate	Random effect(s)
BW_1	Treatment, sex	–	Sow
$BW_{14, 23}$	Treatment, sex	BW_1	Sow
$BW_{27, 31, 38, 69}$	Treatment, sex	BW_1	Nursery pen
BW_{79}, ESW	Treatment, sex	BW_1	Fattening pen
CW	Treatment, sex	Slaughter batch	Fattening pen
$ADG_{1–14, 14–23, 1–23}$	Treatment, sex	BW_1	Sow
$ADG_{23–27, 27–69}$	Treatment, sex	BW_1	Nursery pen
$ADG_{69–79, 79\text{-}ESW}$	Treatment, sex	BW_1	Fattening pen
$ADG_{1\text{-}ESW}$	Treatment, sex	BW_1	Sow, nursery pen, and fattening pen

was better adapted to novel environments and social encounters, and in this study, we found that these benefits also suggested a steady weight gain after regrouping.

A lack of difference in ADG between treatments during the suckling period indicated that preweaning environmental manipulations had no impact on performance. Similar result was reported in the literature (socialization: Camerlink et al., 2018; Salazar et al., 2018; enrichment: Yang et al., 2018). The trend of post-weaning growth check and subsequent improvement in 2 weeks after weaning, corresponds to Kanaan et al. (2012).

A 4-day-period of ADG from farrowing to nursery in ENR was higher than CON, agreeing with the results within 1-week post-weaning in

Table 2
Descriptive statistics of BW, carcass weight (CW), and average daily gain (ADG) of pigs by two treatments (control (CON) and enriched (ENR)) and sex.

Item	Treatment	n	df	Mean	Sex		SEM	F-value	*P*-value
					Male	Female			
Suckling period									
BW_1, kg	CON	324	3	1.38	1.43	1.34	0.02	0.04	0.85
	ENR	337		1.40	1.42	1.38	0.02		
BW_{14}, kg	CON	264	4	3.43	3.43	3.43	0.06	0.01	0.49
	ENR	287		3.45	3.44	3.46	0.06		
BW_{23}, kg	CON	244	4	5.06	5.08	5.04	0.09	0.63	0.63
	ENR	286		4.91	4.90	4.93	0.08		
Nursery period									
BW_{27}, kg	CON	262	4	5.11	5.15	5.09	0.09	2.31	0.18
	ENR	286		5.25	5.23	5.26	0.08		
BW_{31}, kg	CON	253	4	5.34	5.38	5.34	0.09	3.24	0.12
	ENR	278		5.45	5.48	5.42	0.08		
BW_{38}, kg	CON	252	4	6.25	6.31	6.22	0.11	1.06	0.48
	ENR	278		6.40	6.48	6.31	0.11		
BW_{69}, kg	CON	209	4	15.36	14.87	15.67	0.25	0.14	0.81
	ENR	239		15.29	15.47	15.10	0.23		
Fattening period									
BW_{79}, kg	CON	208	4	17.35	16.78	17.71	0.29	0.76	0.50
	ENR	234		17.85	17.90	17.80	0.28		
CW, kg	CON	153	4	91.09	90.62	90.72	0.62	0.05	0.84
	ENR	187		90.48	90.34	90.59	0.59		
ESW, kg[1]	CON	153	4	113.86	113.28	113.40	0.78	0.04	0.78
	ENR	187		113.10	112.92	113.24	0.74		
Suckling period									
$ADG_{1–14}$, kg/d	CON	264	4	0.154	0.151	0.156	0.004	0.14	0.49
	ENR	287		0.158	0.156	0.160	0.003		
$ADG_{14–23}$, kg/d[2]	CON	244	4	0.179	0.176	0.182	0.004	1.80	0.23
	ENR	285		0.162	0.161	0.164	0.004		
$ADG_{1–23}$, kg/d	CON	224	4	0.165	0.164	0.166	0.004	0.48	0.63
	ENR	286		0.160	0.158	0.161	0.003		
$ADG_{23–27}$, g/d[3]	CON	231	4	53.3	59.4	48.3	4.7	5.08	0.02
	ENR	271		73.9	63.3	84.6	5.7		
Nursery period									
$ADG_{27–69}$, kg/d	CON	207	4	0.249	0.241	0.253	0.005	0.14	0.60
	ENR	237		0.241	0.245	0.238	0.004		
$ADG_{69–79}$, kg/d[4]	CON	206	4	0.201	0.187	0.209	0.012	4.62	0.03
	ENR	232		0.254	0.247	0.261	0.013		
Fattening period									
$ADG_{79\text{-}ESW}$, kg/d	CON	146	4	0.809	0.809	0.809	0.007	1.32	0.36
	ENR	171		0.822	0.832	0.812	0.007		
Global ADG									
$ADG_{1\text{-}ESW}$, kg/d	CON	146	4	0.568	0.565	0.570	0.004	0.70	0.43
	ENR	172		0.575	0.578	0.571	0.004		

[1] Estimated slaughter weight (ESW) = CW × 1.25.
[2] After preweaning socialization in ENR.
[3] After regrouping (weaning) in CON and ENR.
[4] After regrouping (from nursery to fattening) in CON and ENR.

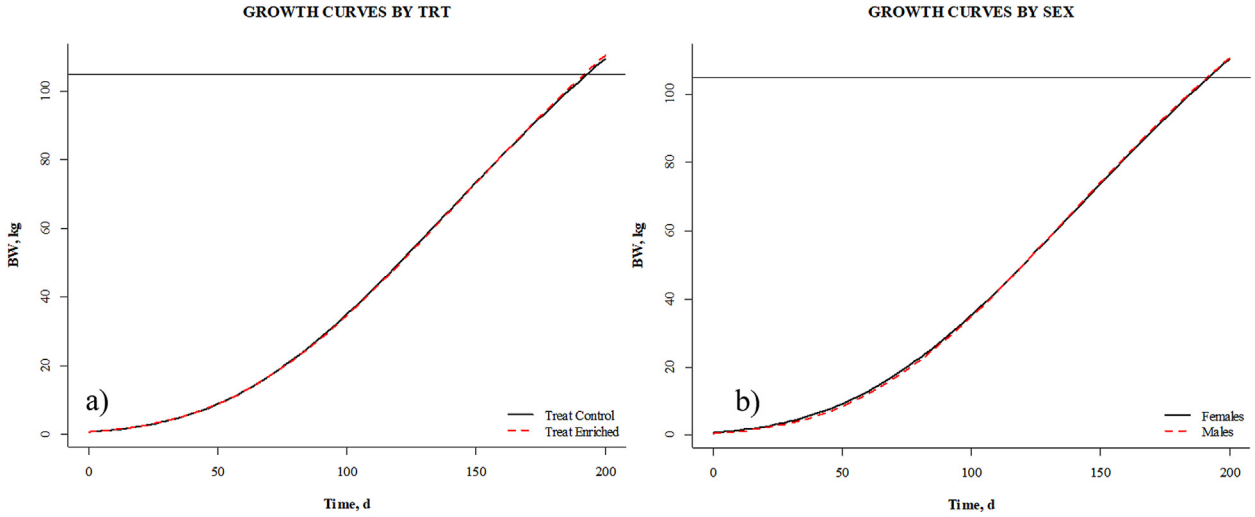

Fig. 1. Average growth curves of pigs by (a) treatment (TRT) (control vs enriched) and (b) sex (male vs female) from birth to slaughter ($n_{CON} = 133$, $n_{ENR} = 159$; $n_{Male} = 132$; and $n_{Female} = 160$). Targeted market weight was fixed at 105 kg, as the horizontal line shows.

Weary et al. (2002) and Hessel et al. (2006). It was likely due to reduced aggression (Salazar et al., 2018) and smaller stress (Yang et al., 2018; Ko et al., 2020) after weaning in ENR, leading to improved performance. In Weary et al. (2002), previously socialized weaners consumed more feed, resulting in greater weight gain post-weaning. As ENR exhibited 1.3-times more preweaning exploration than CON (Ko et al., 2020), the stimulation of chewing may be facilitated by the provision of enrichment objects (Oostindjer et al., 2010), which could contribute to a better adaptation to solid feed post-weaning.

A 10-day-period of ADG from nursery to fattening in ENR was still higher than CON. This could be due to better adaptability to regrouping, including a faster establishment of dominance relationships and less agonistic interactions when encountering unacquainted pigs. According to Camerlink et al. (2018), social skills learned from socialization or repeated regrouping events could last for a long time. Godyń et al. (2019) also concluded that piglets provided with enrichment at the neonatal stage were shown to perform better social behavior later in their lives.

As we did not find a conclusive effect on long-term performance, improving preweaning rearing conditions might not be an ultimate solution to optimize pig's welfare and productivity throughout the cycle. Providing constant enrichment could contribute to successful socio-cognitive development, lower stress level, and enhanced social skills, which in turn ensures the long-term benefits regarding welfare and productivity (Godyń et al., 2019). However, our study suggested that a low-cost and easy-to-implement strategy could benefit pigs in the short-term without major reconstruction of current facilities. Further investigation to develop strategies with similar features is worthy to enhance welfare and productivity of commercially reared pigs.

Ethics approval

The ethical approval reference number is FUE-2016-00441221 by Universitat Autònoma de Barcelona.

Data and model availability statement

None of the data were deposited in an official repository.

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H.-L. Ko: Conceptualization, investigation, formal analysis, original draft, writing – review & editing. S. López-Vergé: Methodology, formal analysis, data curation, writing – review & editing. Q. Chong: Investigation, original draft. J. Gasa: Resources, data curation, writing – review & editing. X. Manteca: Conceptualization, supervision, writing – review & editing. P. Llonch: Conceptualization, methodology, funding acquisition, project administration, investigation, supervision, writing – review & editing.

Declaration of interest

None.

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