



Influence of mixing strategy on post weaning performances and agonistic behaviour of piglets

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ABSTRACT: Mixing litters at weaning is a common practice to reduce weight heterogeneity within the pens. A 40 days long experiment has been undertaken to investigate the effects of grouping strategy after weaning on growth performance and social behaviour of piglets. At 28 days of age, 360 male and female piglets were weaned and placed in 24 pens according to their weight and origin. Twelve pens contained 15 piglets originated from 12.7 litters per pen (1 or 2 piglets per litter; MIX) whereas 12 other pens gathered 15 piglets from 4.0 litters (2 to 5 piglets per litter; FAM). The average body weight was 7.9 ± 1.4 kg and 7.9 ± 1.3 kg for MIX and FAM treatments, respectively. The initial within-pen standard deviation of body weight was of 0.5 ± 0.2 kg in MIX group and 1.1 ± 0.1 kg in FAM group. Piglets were housed in fully slatted pens (4.4 m^2) and received ad libitum a phase 1 diet up to 12 kg of body weight, then a phase 2 diet. FAM piglets had a higher feed intake (+5%, $p < 0.05$) from day 1 to 20. Daily gain was thus higher during this period (+7%, $p < 0.05$) and from day 21 to 40 (+6%, $p < 0.05$). Accordingly, FAM piglets had a higher final body weight than MIX piglets (28.5 vs. 27.3 kg, $p < 0.001$). In spite of the initial difference, within-pen weight heterogeneities were similar among treatments on days 20 and 40. Direct observations of agonistic behaviour were made on days 1, 2 and 6. The results showed a higher frequency of short fights for MIX piglets ($p < 0.01$). Blood samples of 16 piglets per group were taken on days 1 and 8 to determine plasma concentrations of haptoglobin. This criterion was not influenced by the way that piglets were mixed. It can be concluded that pens should be constituted of piglets from a limited number of litters in order to reduce aggressions at weaning and improve post weaning performance.

Keywords: piglets, mixing, performance, behaviour, haptoglobin.

INTRODUCTION

Mixing unfamiliar pigs together is a common practice in pig production, particularly at the time of weaning, in order to minimise the within pen variation in weight and to give all pigs an equal ability to access the feeder.

After regrouping weaners or fatteners, aggressive interactions usually take place in order to establish a new dominance relationship (Blackshaw et al, 1987; McGlone et al, 1987; Arey and Franklin, 1995). These transient fights during the first 48 or 72 hours can lead to skin lesions and injuries (Olesen et al, 1996; Stukenborg et al, 2009), or unequal access to feed. The mixing of finishing pigs may also significantly depress their productivity (Tan et al, 1991). Stress and increased physical activity can imply greater energy expenditure and may affect the weight gain (Tan et al, 1991; Ekkel et al, 1995; Fels and Hoy, 2010). Other physiological and health parameters may possibly be also affected.

Different mixing strategies have been experienced in order to reduce stress and aggressive behaviour. Early

weaning (Pitts et al, 2000) or preservation of weight variability (Rushen, 1987; Francis et al, 1996; Andersen et al, 2000) can reduce aggressive interactions when regrouping weaning pigs. Sexing and regrouping piglets from the same litter also reduces agonistic behaviour at weaning (Colson et al, 2006).

This study aimed to investigate the effects of grouping strategy at weaning, especially the number of litters per group, on growth performance, behaviour parameters and health status.

MATERIALS AND METHODS

Experimental design

At 28 ± 1 days of age, 360 male and female piglets [(Large white x Landrace) x P76] were weaned in the farrowing farm. Litters were loaded separately in the truck and transported to Ifip Research Centre (Villefranche de Rouergue, France) where they were affected to 24 sex-mixed pens according to their weight and origin. Twelve pens contained 15 piglets from $12.7 \pm$

Table 1. Proportion of behaviours performed during the initial week after weaning as a function of the treatment¹

	FAM	MIX	P-value ²	
			Treatment	Period
head-butts	12.0 (5.4)	12.5 (6.2)	0.45	0.32
bites	7.5 (5.4)	9.4 (6.6)	0.07	0.05
short fights	2.6 (2.9)	4.1 (3.2)	<0.01	0.34
long fights	1.8 (2.5)	2.8 (4.0)	0.12	<0.01
belly nosing	1.0 (2.0)	0.9 (1.7)	0.44	<0.001
Agonistic index N1	24.4 (16.9)	32.8 (19.5)	<0.01	0.05

¹ Values are means \pm SD from 4 periods of observation for 12 pens per group.

² P values of one-way nonparametric analysis for the treatment or the period effect.

1.5 litters per pen (1 or 2 piglets per litter; MIX) whereas 12 other pens were constituted with 15 piglets from 4.0 \pm 0.0 litters (2 to 5 piglets per litter; FAM).

After sorting and grouping, average body weight was identical for MIX (7.9 \pm 1.4 kg) and FAM (7.9 \pm 1.3 kg) treatments. Nevertheless, the initial standard deviation in body weight within pens was higher (P < 0.001) for FAM group (1.1 \pm 0.1 kg) than for MIX group (0.5 \pm 0.2 kg). The pens were assigned to a weight category (light or heavy) for statistical purpose according to their relative initial weight. Piglets were housed in pens (4.4 m² each, i.e. 0.3 m² /piglet) with cast-iron slatted floors. Each pen had one stainless steel feeder (600 mm trough length) and one drinking bowl. Piglets received *ad libitum* a phase 1 diet up to 12 kg of body weight, then a phase 2 diet. Diets met the usual nutritional requirements and contained no antibiotic. Phase 1 diet was pelleted and phase 2 diet was distributed in meal form.

Data collection

Direct observations of aggressive behaviours were made for 20 min at the four following periods: 3 h (day 0), 20 h, 27 h (day 1) and 140 h (day 6) after mixing of the pigs. Two persons performed all the observations. Within each observation period, pens were observed 10 min by the first observer, then 10 min by the second one. The number of head-butts, bites, short and long fights, belly nosing was recorded for each pen.

Head-butt (HB) was defined as knocking another pig with the head without biting (closed mouth). Bites (B) included head-butts with bites or attempts of bites (open mouth) delivered by one single individual at moderate speed. Short fight (SF) was when two pigs performed head-butts and bites, with rapid movements. Long fight (LF) was defined as a longer fight between 2 pen-mates including head-butting, biting, as well as pushing and running away. Belly-nosing/sucking (BN) behaviour was when the pig performed rooting snout movements toward the belly of another pig. A synthetic agonistic index (AI) was calculated: AI = (HB*0.5) + (B*1) + (SF*2) + (LF*3) + (BN*0.5).

Piglets were individually weighed at the beginning (d0), the middle (d20) and the end (d 40) of the experiment, and feed consumptions were collected for each pen.

Blood samples were collected from 16 piglets per group on days 1 and 8 into vacutainer tubes with heparin and

centrifuged. The plasma concentration of haptoglobin, a major acute-phase protein, was measured by a colorimetric analysis (Le Floc'h et al, 2009).

Statistical data

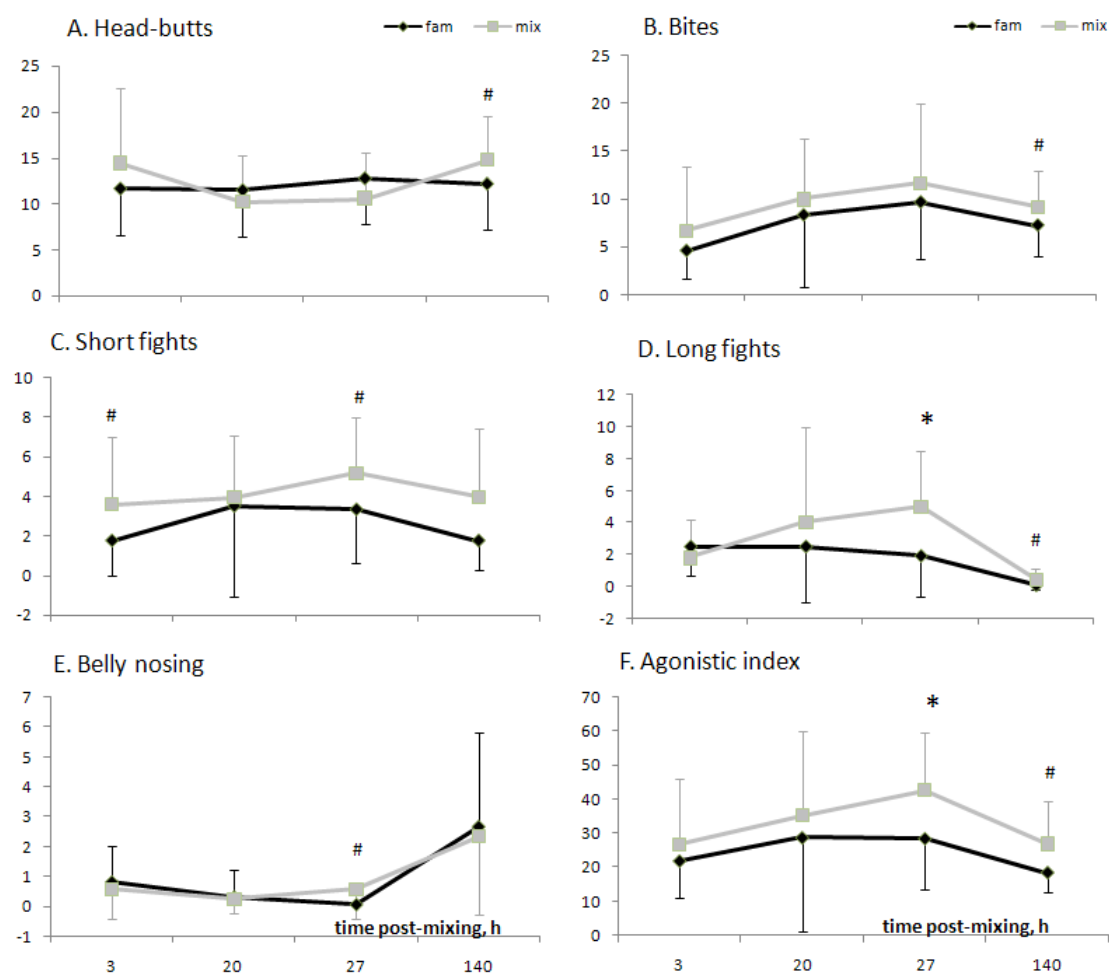
Analysis was performed using the procedures of SAS (SAS Inst., Cary, NC). Performance criteria were analysed using the GLM procedure with pen mean as experimental unit. The model included the main effect of treatment and the initial weight of the pen as covariate. The Tukey test was used for mean comparisons between treatments. Individual haptoglobin concentration was analysed using the MIXED procedure with treatment and initial weight as fixed effects and animal as subject of random effect of the time. Pen was considered as the experimental unit for agonistic activities. These variables were analysed using the NPAR1WAY procedure to consider influence of treatment. A Wilcoxon test was performed.

RESULTS

Overall performance and health status were good although an antibiotic treatment (40 mg amoxicillin trihydrate / kg live weight /d) was distributed to all pigs from d 1 to 4 of the experiment, and from d 34 to 36 because of coughing. In addition, 13 individual veterinary treatments were delivered to 5 FAM piglets and 7 MIX piglets, mainly for cough. One MIX piglet died on d 38 because of urinary tract infection and one FAM piglet died on d 19 from peritonitis.

Throughout the observation period (d 0 to 6), MIX pigs regrouped from a high number of litters had a higher frequency in aggressive behaviours (Table 1, Figure 1). Bites (P = 0.07) and short fights (P < 0.01) between unfamiliar piglets were more frequent than for piglets housed with a few familiar pen-mates. The frequency of agonistic interactions was significantly influenced by the observation time, as bites and long fights were more important at d 1 than at d 0. Within each observation period, differences between FAM and MIX pigs were found or tended to be observed for short fights 3 (P < 0.10) and 27 h (P < 0.10) after mixing, long fights 27 (P < 0.05) and 140 h (P < 0.10) after mixing, agonistic index 27 (P < 0.05) and 140 h (P < 0.10) after mixing. Head-butting and biting behaviours were similar for FAM and MIX piglets, from 3 to 27 h after mixing. Occurrences at 140 h tended to be higher (P < 0.10) for MIX piglets.

Figure 1. Number of observed agonistic behaviours as a function of time after mixing in FAM and MIX groups



Item was analyzed using the SAS NPARIWAY procedures. Results are presented as means \pm SD. # $P < 0.10$ (tendency); * $P < 0.05$.

Table 2. Effect of mixing strategy on plasma haptoglobin concentration¹

Day	1		8		RSE ²	P-value ²		
	FAM	MIX	FAM	MIX		T	Period	TxP
Haptoglobin, g/L	1.04	1.28	1.67	1.47	0.74	0.92	0.07	0.31

¹ Values are least-square means from concentrations measured for 16 piglet per group.

² Standard error of the residual (RSE) and P values of variance analysis for the effects of treatment (T), period (P) and TxP.

Belly nosing was rarely observed and varied little among treatments.

Plasma haptoglobin concentrations tended to be greater at d 8 than at d 1 ($P = 0.07$). There was no difference in haptoglobin concentrations between MIX pigs and those issued from a reduced number of litters ($P > 0.10$; Table 2).

The effect of treatments on piglet performance is presented in Table 3. Groups of piglets formed from a low number of litters had a significantly higher daily feed intake (DFI; +5.1%; $P = 0.04$) than other pens from d 1 to 20. During the later period, from d 20 to 40, DFI of FAM piglets was still slightly, but not significantly, improved (+3.1%; $P > 0.10$). For the overall experimental period, the difference was not significant (+3.8 %; $P > 0.10$).

Average daily gain (ADG) of FAM piglets was significantly improved during the phase 1 (+7.1 %, $P < 0.01$) and the phase 2 (+6.4 %, $P < 0.001$) periods. For the overall period, the mixing strategy improved the daily gain of about 32 g per piglet and per day (+6.6 %; $P < 0.001$). As a consequence, FAM pigs had a higher body weight than MIX pigs at d 20 (+410 g; $P < 0.01$) and at the end of the experiment (+1220 g; $P < 0.001$).

Surprisingly, in spite of an initial higher homogeneity in weight within pens for MIX pigs, there was no significant difference at d 20 and 40. Lastly, feed conversion ratio (FCR) was not significantly influenced by the treatment.

Table 3. Effect of mixing strategy on piglet post-weaning performance¹

	FAM	MIX	RMSE	P-value ²	
				Treatment	In. weight
Weight, kg					
Day 0 (weaning)	7.9	7.9	0.6	0.67	-
Day 20	14.5	14.1	0.4	<0.01	<0.001
Day 40	28.5	27.3	0.6	<0.001	<0.001
Within pen SD, kg					
Day 0 (weaning)	1.1	0.5	0.2	<0.001	0.56
Day 20	2.0	1.7	0.4	0.13	0.99
Day 40	3.3	3.4	0.8	0.84	0.50
Day 0 to 20					
DFI, g/d	430	409	24	0.04	<0.001
ADG, g/d	330	308	18	<0.01	<0.001
FCR, kg/kg	1.37	1.39	0.05	0.41	<0.001
Day 21 to 40					
DFI, g/d	941	913	134	0.59	<0.01
ADG, g/d	702	660	22	<0.001	<0.001
FCR, kg/kg	1.39	1.40	0.07	0.60	0.17
Overall period (d 0 to 40)					
DFI, g/d	679	654	53	0.25	<0.001
ADG, g/d	516	484	14	<0.001	<0.001
FCR, kg/kg	1.38	1.40	0.05	0.46	0.01

¹ Values in the table are presented as least-square means and root mean square error for 12 sex-mixed pens of 15 piglets each.

² P value of variance analysis including the effects of treatment and initial weight as covariate.

DISCUSSION

In this study, the increase in the fighting frequency on day 1 after weaning observed in both groups is in agreement with Olesen et al (1996) and Colson et al (2006) who reported that a social order was established 48 hours after the mixing. In contrast, the fights videotaped by Stukenborg et al (2009) had similar occurrence at 24 and 48 hours after weaning. Friend et al (1983) found that the number of fights among weaners increased in the first two hours and stopped after 3 hours, whereas in the study by Puppe et al (1997), more agonistic behaviours occurred at day 4 after weaning. Arey and Franklin (1995) found that the number of fights between growing pigs decreased from day 1 to 5 after mixing.

In the present study, the lower frequencies of fighting and biting in FAM pigs indicate that the mixing strategy affects behavioural responses after weaning. These findings are in agreement with those of Colson et al (2006) who reported that mixing litters at weaning leads to longer and stronger fighting than maintaining the littermate piglets together, and in accordance with earlier results of Friend et al (1983), Ekkel et al (1995), Francis et al (1996) and Puppe et al (1997). Between newly mixed growing pigs, Arey and Franklin (1995) also found that the number of fights increased with the number of unfamiliar pigs in the pen.

In the study reported by O'Connell and Beattie (2007), the average injury score also increased linearly with the number of litters per group at 1 week post mixing, but there were no differences recorded 6 weeks post mixing. Such observation is in agreement with results reported

by Colson et al (2006).

Otherwise, aggressive behaviour is known to be related to the weight variability. For example, Andersen et al (2000) showed that fighting duration was greater in groups with a small weight asymmetry. However, these authors found that this effect was not significant in standard pens with homogeneous floor. Furthermore, mean weight asymmetries tested by Andersen et al (2000) were more distinct (3.1 vs 1.2 kg) than those observed in the current study. In a research of O'Connell et al. (2005) a small difference of the within-group coefficient of variation in weaning weight [from 0.07 to 0.16 %] did not increase the variability and did not affect mean production performance.

The FAM and the MIX groups were both comparable for the head-butting and belly-nosing frequencies. These results are in agreement with the high number of short head butts occurring between littermate piglets on the day of weaning in the study of Colson et al (2006). These authors suggested that such low level interactions are necessary for the maintenance of social order, whereas more vigorous fights are needed to establish it. Furthermore, Colson et al (2006) also reported the appearance of fighting in the familiar pen-mates group one week after weaning, suggesting that social order is unstable and requires ongoing contacts between familiar individuals.

Haptoglobin is considered to be a reliable indicator of inflammation (Le Floc'h et al, 2009) and stress (Piñeiro et al, 2007). It was used in this experiment as a marker of health status of pigs. By grouping piglets of a large number of litters, a lower health status might come from the induced social stress, injuries and from a greater

possibility of infection by contact-related pathogens. However, the use of amoxicillin to control an outbreak of coughing could have exerted an anti-inflammatory effect and limited the plasma haptoglobin values. Cortisol would have been a more relevant indicator of stress experienced during regrouping (Ekkel et al, 1995; De Jong et al, 2000).

In this study, within-pen weight variability was similar for both treatments at the end of the experiment, whereas a higher homogeneity primarily resulted from MIX regrouping. This indicates that improving the within pen homogeneity at weaning by increasing the mixing of pigs from different litters does not necessarily result in a lower variability in body weight at 10 weeks of age. These results are in agreement with those of Meyer (2004) and O'Connell et al (2005) who found that piglets mixed at weaning to form uniform weight groups had a higher increase in within-pen coefficient of variation in body weight than others, grouped by litter or in mixed weight groups. O'Connell et al (2005) suggested that the high variability of growth during the post-weaning period could explain this.

The results of the present experiment suggest that growth and feed intake are improved for piglets with a better acquaintance. These results contrast with several previous studies (Friend et al, 1983; Blackshaw et al, 1987; Gonyou et al, 1988; Francis et al, 1996; Colson et al, 2006; Fels and Hoy, 2010) in which performance parameters were not or slightly affected by regrouping from 1 to 8 litters and were similar between groups at the end of the post-weaning period. Feed intake and growth, however, were lowered during the initial period from day 0 to 4 or 6 after weaning for piglets mixed from 4 litters compared to piglets issued from the same litter in the studies reported by Colson et al (2006) and Reynolds et al (2009). Weight measurements were continued in the study by Colson et al (2006), showing that there was no more difference from day 0 to 8 after weaning. Conversely, in the study of O'Connell and Beattie (2007), performance was affected to a greater extent in the second part of the post weaning period than during the first part. Authors suggested that some social stress possibly remained in the group, and was even exacerbated as animals got larger.

A mild increase of 10 g/d in overall post-weaning gain was showed by piglets mixed from 2 litters in the study reported by Fels and Hoy (2010), although these animals did not fight less than piglets regrouped from 6 litters. These authors suggested that a large number of litters could possibly contribute to the spread of pathogens and degrade the health status. One interesting result was that of Meyer (2004) who showed no difference when 2 or 6 litters were mixed but found that weight gain was reduced of 100 g/d when 12 to 16 litters were combined. Nevertheless, O'Connell and Beattie (2007)

found a decrease in feed intake and growth rate as well as an increase in body weight variability at 10 weeks of age, when increasing from 1 to 4 the numbers of litters per pen of 8 piglets each. These authors observed a large effect on performance when comparing a group from 3 rather than 4 litters with an improvement in ADG of 63 g/d (i.e. 12%).

The decreased performance induced by mixing is probably caused and aggravated by several factors. The aggression frequency did not appear correlated with the performance level (Friend et al, 1983; Gonyou et al, 1988). Conversely, in the study of O'Connell and Beattie (2007), the reduced performance and increased variability were likely related to aggressions associated with increasing the number of litters per group. Gonyou et al (1988) also suggested that an additional stressor accompanying regrouping may explain feed efficiency reduction. Indeed, adverse effects on performance associated with regrouping have been observed in the case of limited access to feed by growing pigs (Graves et al, 1978). McGlone et al (1987) showed that regrouping decrease performance only for heat-stressed piglets. Similarly, Dybkjaer (1992) observed a performance decrease and behavioural change for piglets mixed with non-littermates in a restricted space, in comparison with littermates housed without crowding. However, in the current study, adequate space allocation and ad-libitum distribution of feed should have limited the effect of aggressions on performance.

The mechanism leading to the decrease in performance remains poorly understood. It was suggested by Gonyou et al (1988) that the negative effects of aggression on productivity may be due either to direct effects such as energy expenditure or costs of recovery from injury or to indirect effects on feeding behaviour through a change in social order.

IMPLICATIONS

Increasing the number of litters per group when mixing piglets at weaning can lead to reductions in performance and welfare. This experiment suggests that a regrouping strategy taking into account a limited number of litters per pen could have positive effects on these behaviour and growth parameters. Further researches are necessary to determine whether this is also the case with larger groups.

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