The environmental impact of increasing weaning age

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Introduction

Increasing weaning age may be a means for dealing with the ban on antibiotic growth promoters, enabling piglets to develop a more mature gut to cope with the weaning process. There are implications for the environment in increasing weaning age, with a higher number of breeding animals possibly being required in later weaning ages to produce similar numbers of weaned pigs to earlier weaned breeding animals (3 to 4 weeks). This may result in greater nutrient loads to the environment (especially nitrogen). It was the aim of the current study to assess the effect of weaning age on slurry volume, and composition, and ammonia emissions.

Materials and Method

The effect of weaning age was investigated in terms of environmental impact using a block design with four replicates over time from February 2004 to May 2005. There were three weaning age treatments: four (21-28 days), six (35-42 days) or eight (49-56 days) weeks of age, 4ww, 6ww and 8ww, respectively. Treatments were run simultaneously. A total of 36 first parity sows and their litters (Large White × Landrace × White Duroc) were studied. Pregnant gilts were randomly allocated to treatment (weaning age) prior to farrowing. The pregnant gilts were moved to the farrowing accommodation (one treatment per room) approximately one week prior to farrowing. They remained in this accommodation until weaning when they were moved to the weaned sow accommodation (one treatment per room) where they remained until 12 weeks post-farrowing. The piglets remained in the farrowing accommodation until 12 weeks post-farrowing, however, the creep area was only accessible during the lactation period up to weaning. Pigs were fed with diets that were all formulated without antibiotic growth promoters and with reduced levels of zinc (<100 ppm) and copper (<25 ppm). The liveweight of sows, their P2 backfat thickness (mm; P2 measurements taken at the last rib and 65 mm vertically down from the midline) and their condition score (1-5; 1=poor, 3=satisfactory and 5=obese) were recorded. The litter size at birth, with numbers, and weights, of piglets born alive, dead or mummified was recorded. A weighed amount of feed was offered daily to sows and piglets, and weekly feed intake was recorded for both. Samples of feed were analysed for dry matter (DM) and total nitrogen (N). Weekly water consumption was recorded using volumetric water meters (litres). Individual liveweight of piglets was recorded at birth, four, six, eight and 12 weeks of age. Records were kept of all animals requiring veterinary treatment detailing; date, animal ID, condition and treatment administered. The weight of straw added to, and the weight of manure removed from, the farrowing rooms, were recorded on a daily basis. Representative samples, of straw and manure, were collected over each replicate study period and analysed for DM, total N, ammonium-N, nitrate-N, phosphorus (P), and pH. The amount of slurry, removed from each treatment room, was recorded and samples analysed for DM, total N, ammonium-N, nitrate-N, phosphorus (P), and pH. Ammonia (NH_3) emissions were calculated on a weekly basis.

A repeated measures analysis was used to analyse the liveweight, P2 and body condition of sows with blocking on replicate, and weaning age acting as treatment. The numbers of piglets in a litter were used as covariates in some analyses. Analysis of variance was used to analyse all other data with blocking on replicate, and weaning age acting as treatment. Duncan's multiple range test was used for post-hoc analysis.

Results and Discussion

Performance

A total of 375 animals were born over the course of the study (360 alive, 11 dead, 4 mummified). The mean performance results, per litter, are given in Table 1. The 8ww sows produced smaller litters, although the difference was not significant. Removals from this treatment group had greater proportional impact on litter size and fewer piglets were weaned from the 8ww sows than the other weaning age treatment sows.

Table 1: Mean number of piglets per litter

	4 week	6 week	8 week	SED	P value
Born alive	10.17	10.83	9.00	1.20	0.313
Born dead	0.17	0.42	0.33	*	*
Born mummified	0.25	0.08	0.00	*	*
Weaned	9.75[a]	9.96[a]	7.58[b]	0.56	<0.001

[ab]means within rows with different superscripts were significantly different (P=0.05)
*insufficient data for analysis

There was no effect of weaning age treatment on the liveweight, body condition score or on backfat (P2) of sows (Table 2).

Table 2: Mean liveweight, body condition score and P2 of sows

	4 week	6 week	8 week	SED d.f.=2	P value
Liveweight (kg)	196.4	190.0	191.2	5.8	0.508
Body Condition Score	2.71	2.76	2.84	0.11	0.499
P2 (mm)	22.39	22.16	22.53	0.78	0.891

Weaning age treatment had a significant effect on piglet liveweight, with the 8ww piglets being heavier than the 4ww and 6ww piglets (mean liveweight per replicate for each treatment; 12.09, 12.08 and 13.77 kg for 4ww, 6ww and 8ww treatments respectively, SED=0.56, d.f.=2, P=0.007).

Health

There were few recorded incidences of sow illness either pre-weaning or post-weaning. Two sows were removed from the study as a result of ill health. One sow was removed from the 8ww treatment in replicate two, two days post-weaning, as a result of a burst abscess on the shoulder. Another sow was removed from the 6ww treatment in replicate three, 18 days post-farrowing, as a result of a gastric ulcer. There were few recorded instances of piglets requiring veterinary treatment pre-weaning. The majority of piglets requiring veterinary treatment post-weaning were treated for scour and were in the four and six week weaning treatments.

Feed and Water

The total amount of feed and water consumed by the piglets and sows on a per sow basis is presented in Table 3. Overall, the amount of feed and water consumed was similar for the three different weaning age treatment systems, suggesting that N excretion and ammonia emissions are unlikely to be greatly impacted by the treatments.

Table 3: Total feed (kg) and water (l) consumed by piglets and sows over whole study per sow

	4 week wean	6 week wean	8 week wean
Feed (kg/sow)*	690.71	746.93*	743.14**
Water (l/sow)*	2364.30	2611.85*	2494.80**

* one litter effectively weaned at 18 days post farrowing due to sow illness
** one sow removed at weaning due to illness

The composition of the diets offered during the study is presented in Table 4.

Table 4: Composition of feed

	DM (%)	Total N (% as fed)	CP*
Weaner 1	89.53	3.48	21.75
Weaner 2	89.08	3.54	22.13
Weaner 3	89.28	3.66	22.88
Grower	87.88	3.56	22.25
Dry sow	88.10	2.13	13.30
Lactation	87.08	2.71	16.88

* CP=Total N x 6.25

Straw and manure

The data in Table 5 shows that treatment did not affect the total amount of straw used and manure (farm yard manure (FYM)) produced by the piglets and sows on a per sow basis. It should be noted that, after weaning, the sows were moved to separate fully slatted accommodation, and thereafter produced slurry only.

Table 5: Total FYM (kg) produced by piglets and sows over whole study per sow

	4 week wean	6 week wean	8 week wean
Straw (kg/sow)	56.04	63.34*	61.94**
Manure (kg/sow)	608.49	686.25*	699.41**

* one litter effectively weaned at 18 days post farrowing due to sow illness
** one sow removed at weaning due to illness

The composition of the straw used and the manure produced is presented in Table 6. The N and P content of the straw were within the normal range. Total N content of the FYM was at the upper end of the normal range, but NH_4-N, at 29% of total N, was typical of fresh FYM (Anon, 2000).

Table 6: Composition of straw and FYM (replicate means)

	Straw	SD	FYM	SD
pH	6.55	0.97	6.65	0.97
DM (%)	87.88	3.31	24.03	3.50
ammonium N (kg/t)	0.04	0.04	2.86	1.71
nitrate N (kg/t)	0.05	0.03	0.01	0.001
total N (kg/t)	5.57	2.75	9.74	2.38
phosphorus (kg/t)	0.69	0.24	2.51	0.79

Slurry

The means of sows for each treatment, for volume (litres) and the composition of slurry, collected from the time of sow entry into the farrowing accommodation to weaning, are presented in Table 7. There was no effect of weaning age on the mean volume of slurry produced pre-weaning. Slurry produced during this period resulted through seepage of liquid through the perforations in the plastic clips that were inserted into the slats and was of relatively low solids and nutrient content. Slurry total N content at c. 3 kg/m^3 was fairly typical of such low DM content pig slurry (Anon, 2000).

Table 7: Slurry volume and composition from the time of sow entry into the farrowing accommodation to weaning, sow means for each treatment

	4 week wean	6 week wean	8 week wean	SED (d.f.=2)	P value
Volume (litres)	418.0	509.0#	470.0	225.2	0.923
pH	8.33	7.88	7.95	0.23	0.197
DM* (g/l)	16.10	36.60	20.40	12.71	0.304
ammonium N (kg/ m^3)	2.52	2.69	2.70	0.42	0.898
nitrate N (kg/ m^3)	0.28	0.27	0.17	0.09	0.499
total N (kg/m^3)	2.83	3.61	3.10	0.72	0.569
phosphorus (kg/m^3)	0.24	0.84	0.38	0.40	0.350

*Due to the dilute nature of slurry, slurry solids content expressed as g/l.
N.B. due to sow illness, only 11 sows completed the study for the 6ww treatment

The means of sows for each treatment, for volume (litres) and the composition of slurry, from weaning to 12 weeks post-farrowing, are presented in Table 8. Weaning age did not affect the mean volume of slurry produced in the post-weaning period to 12 weeks post farrowing. Slurry total N content was fairly typical and well within the expected range for dilute pig slurry, although the NH_4-N content, at 86-90% of total-N was high (Anon, 2000; Chambers, 2004a). There were no significant treatment effects on slurry composition. However, the P content for the 8ww treatment whilst low was within the upper and lower 10 percentile range of pig slurry P analysis data (0.09 – 1.90 kg/ m^3) in recent studies (Chambers, 2004a).

Table 8: Slurry volume and composition from weaning to 12 weeks post farrowing, replicate means for each treatment

	4 week	6 week	8 week	SED	P value
Volume (litres)	1328.0	1213.0#	1012.0#	191.0	0.317
pH litter	7.85	8.10	7.95	0.19	0.454
pH sow	7.98	7.62	7.97	0.33	0.509
DM* (g/l)	33.7	34.2	24.6	6.10	0.280
ammonium N (kg/ m^3)	4.76	5.04	4.37	3.58	0.256
nitrate N (kg/ m^3)	0.59	0.58	0.66	0.14	0.842
total N (kg/m^3)	5.55	5.56	4.96	0.40	0.309
phosphorus (kg/m^3)	0.56	0.44	0.26	0.19	0.365

* Due to the dilute nature of slurry, slurry solids content expressed as g/l.
# N.B. due to sow illness, only 11 sows completed the study for the 6ww and 8ww treatments .

Excretion

Slurry and manure, jointly represent major sources of ammonia emission in pig production and might, therefore, be considered together. There was no effect of weaning age treatment on excreted N (13.80, 14.34, 12.78, kg/sow; SED = 0.84, d.f.=2, P = 0.190; treatments 4ww, 6ww, and 8ww, respectively).

Ammonia emissions

The weekly ammonia emissions (g NH_3-N.lu^{-1}.wk^{-1}), where lu = livestock unit (1lu = 500kg liveweight), are presented in Table 9. At six weeks post-farrowing, there was a trend toward more ammonia being emitted from the 4ww system (P=0.067) than from the other weaning age systems. At eight weeks post farrowing, there was a significant effect of weaning age treatment on the weekly ammonia emission, with less ammonia being emitted from the 8ww systems compared with the 6ww systems. There were no other significant affects of treatment. However, the amount of ammonia emitted per week increased the week after a group had been weaned. The post-weaning ammonia emissions remained higher than the pre-weaning emissions. This suggests that the increases in ammonia were associated with the change in housing at the time of weaning when the sows were moved to weaner accommodation, thereby increasing the emitting surface.

Overall there was no difference in the daily ammonia emissions per livestock unit with mean values of; 12.16, 12.81 and 10.30 g NH_3-N.lu^{-1}.day^{-1} for the 4ww, 6ww and 8ww treatments respectively (SED=2.13, d.f.=2, P=0.513). These estimates all compare quite favourably with (i.e. are lower than) the current emission factors in the UK Ammonia Emissions Inventory (Misselbrook *et al*, 2005) of c. 118, 185 and 185 g NH_3-N.lu^{-1}.wk^{-1}, for dry sows, farrowing sows (on straw or slats) and for weaners on straw, respectively.

Table 9: Ammonia emissions in grams per week per livestock unit[1] (g NH_3-N.lu^{-1}.wk^{-1})

Week	4 week wean	6 week wean	8 week wean	SED (d.f.=2)	P value
0	38.0	36.5	36.2	14.2	0.991
1	53.8	67.2	51.7	16.3	0.612
2	80.1	73.5	76.0	17.9	0.933
3	85.6	83.3	73.0	22.1	0.837
4	77.0	87.0	68.0	28.7	0.810
5	116.0	70.0	73.0	27.6	0.251
6	154.0	91.0	79.0	27.0	0.067
7	106.0	138.0	75.0	25.0	0.115
8	117.7[ab]	158.2[a]	77.2[b]	24.1	0.042
9	105.8	138.2	106.5	21.9	0.309
10	101.7	123.0	100.7	17.4	0.404
11	84.7	91.8	84.1	15.6	0.863
12	86.2	111.1	75.6	12.4	0.100

[ab]means within rows with different superscripts were significantly different (P=0.05)
[1] 1 livestock unit = 500kg liveweight

The mean N content in the main study components; feed, N retention (growth), ammonia emission, and excreta (measured excretal N output and "derived" excretal N output) are presented in Table 10. There was no effect of weaning age treatment on the N content in the feed consumed, in that retained, in that excreted or in that emitted as ammonia (Table 10). The N balance (using the measured N and "derived" excretal N output) is also presented in Table 10. The "derived" estimates of N excretion are based on the total feed N intakes from which are deducted the outputs N in liveweight gain and NH_3-N emission, the difference representing excretal N (Smith *et al*, 2000). The difference in measured N excretion compared to the derived N excretion varied between 5% and 13% (based on N intake) across the treatments (Table 10). This inconsistency is probably largely due to the error associated with sampling and analysis of the slurry and, particularly the solid manure. The sampling errors and imprecision associated with manure analysis are well known and Chambers (2004b) reported a range in DM content of samples taken from heaps of pig FYM of 24–49%, with significant differences in the associated nutrient content. Research has also demonstrated the difficulty in homogenising manure samples even under laboratory conditions (Farrington, 2005). There are also problems associated with the rapid sedimentation of pig slurry and which can only be overcome with confidence by continual agitation during the sampling process. The apparent shortfall in N may also be a consequence of losses via denitrification as N_2 or N_2O, which in a straw-based FYM system have been estimated at c. 1% of total N (Hüther et al., 1997) or at 7-18% of total ammoniacal N (TAN) (Amon et al., 1997). Denitrification losses were not accounted for in this study.

Table 10: Nitrogen partitioning in components, feed, N retained in liveweight gain, ammonia and excreta, treatment means (kg N per treatment group (3 sows and their litters per replicate over 12 weeks)

	4 week wean	6 week wean	8 week wean	SED (d.f.=2)	P value
Inputs (kg N)					
N Feed intake	61.6	57.2	56.8	5.96	0.683
Outputs (kg N)					
Retained	18.47	16.05	17.17	2.08	0.543
Ammonia emitted	1.76	1.58	1.31	0.29	0.346
Excreta measured	33.6	36.8	32.3	3.20	0.412
Total N outputs measured	53.83	54.43	50.78		
Derived					
Excreta derived[1] (kg N)	41.4	39.5	38.4	3.97	0.750
Diff derived – measured excretal N (% N feed intake)	12.6	4.8	10.7		

[1] Derived excretal N output by subtracting ammonia emission and retained N from the N intake in feed

Conclusions

There was no difference between weaning age treatments in the total amount of feed consumed. There was no effect of weaning age on daily ammonia emissions, but less NH_3-N was emitted by the 8ww system for at least part of the production cycle. However, there were fewer animals in this system in our study due the removal of one sow and coincidentally smaller mean litters. However, it is suggested that an eight week weaning system may require more breeding animals (to produce the same number of weaned pigs as the earlier weaning systems, hypothesis being tested in a larger study) which may increase excretal N output and the potential for increased environmental emissions. The results of this study suggest that increasing weaning age will not increase the nitrogen load to the environment.

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