Creep feeding – weaning age interactions with creep feeding

**Report prepared for the
Co-operative Research Centre for an Internationally
Competitive Pork Industry**

By

Rebecca Morrison, John Pluske, Rob Smits, Dave Henman, Cherie Collins

October 2008

Established and supported under the Australian Government's Cooperative

1. Executive Summary

The influence of creep feed composition and weaning age on creep feed consumption and post weaning growth performance were examined. Ninety-six sows (24 gilts and 72 sows) were selected at farrowing and the litters allocated to one of four treatments: piglets weaned at 22 days of age and offered a simple creep feed from 9 days of age to weaning, piglets weaned at 29 days of age and offered a simple creep feed from 9 days of age to weaning, piglets weaned at 22 days of age and offered a complex creep feed from 9 days of age to weaning, and piglets weaned at 29 days of age and offered a complex creep feed from 9 days of age to weaning. Pre-weaning growth performance was not influenced by creep feed composition, with the average daily gain from 9 days of age to weaning similar between the animals offered the simple or complex creep diets (234.6 and 231.3 g/d respectively, sed 6.93, P=0.641). Estimated creep feed intake measured via creep feed disappearance was small regardless of creep feed composition. Creep feed composition did however appear to influence total intake, with the litters offered the simple creep diet consuming more feed from 9 days of age to weaning than those offered the complex creep diets (776.3 and 461.4 g respectively for the simple and complex creep diets, sed 92.7, P=0.004). Individual creep feed intake was assessed at three time points (16 days of age, 19 days of age and weaning at either 22 or 29 days of age), allowing the characterisation of individual pigs as good eaters, moderate eaters, small eaters or non-eaters. Individual creep feed characterisation was similar between the four combinations of weaning age and creep feed composition (x^2=6.27, P=0.712). In addition, individual post foster weight did not influence creep feed characterisation, with the initial weights of the piglets characterised as good, moderate, small and non-eaters very similar (1.57, 1.63, 1.54 and 1.57 kg respectively, P=0.357, sed 0.055).
Pigs offered the simple creep diet during the pre-weaning period consumed more feed and gained weight faster during the initial 5 days post weaning compared to those animals offered the complex creep diet. Feed intake from weaning to 49 days of age also tended to be greater in the pigs offered the simple creep diet pre-weaning (P=0.053), with this difference reflected in daily gain from weaning to 49 days of age (P=0.051). Despite this, creep feed composition did not influence lifetime growth performance nor carcass composition. Based on the results of this investigation, the inclusion of expensive, highly digestible ingredients in creep diets does not appear to be warranted. Furthermore, there was a tendency for pigs weaned at 29 days of age to gain more slowly from birth to slaughter compared to the earlier weaned animals, suggesting that weaning later than 22 days of age may reduce lifetime growth performance.

Table of Contents

2. Introduction

Weaning of the piglet from the sow imposes a number of environmental and social stresses on the piglet as it adapts to a new environment and feed source. The piglets digestive system must adapt to allow the digestion of complex carbohydrates found in creep diets, rather than the high fat, highly digestible sows milk previously on offer (Williams 2003). These physiological adaptations occur at the same time as the additional stresses associated with the mixing of unfamiliar piglets, typically resulting in a growth check due to underfeeding while the piglet acclimatises to the new conditions and feed source (Le Dividich and Seve 2000; Smith and Lucas 1957). This growth check in the days immediately post weaning has been shown to have detrimental impacts on lifetime growth performance, with pigs that either maintain or loose weight during the initial 7 to 10 days post weaning requiring an additional 10 days to reach market weight compared to pigs that gain 250 g/day during this initial post weaning period (Tokach *et al*. 1992). Offering solid creep feed during lactation aims to reduce this post weaning growth check by facilitating the transition from sow's milk to solid feed prior to weaning and hence improving feed intake during the immediate post weaning period. Creep feeding during the latter stages of lactation also aims to supplement the piglet's nutritional intake as the sows milk production begins to decline. Although there is a substantial amount of literature relating to creep feeding, the results are not consistent. Several investigations have outlined the benefits of creep feeding during lactation on subsequent feed intake and growth performance post weaning (Bruininx *et al.* 2002; Bruininx *et al.* 2004), however these benefits are not always observed (Barnett *et al.* 1989) and may not influence lifetime growth performance (Lawlor *et al.* 2002).

Some of the variation in post weaning growth performance may be explained by individual creep feed intake pre-weaning. Individual piglets categorised as 'good' eaters of creep feed pre-weaning have been reported to have superior growth performance immediately post weaning compared to 'non eaters' (Pluske *et al.* 2007). The age of the piglet at weaning and the length of time creep feed is on offer prior to weaning may also influence the number of animals categorised as 'good' eaters, and hence the overall post weaning growth response. Piglets weaned at an older age are likely to consume more creep feed than those weaned younger, and as such offering creep feed during lactation may have limited benefits for early weaned animals. In addition, there is recent evidence to suggest an interaction between weaning age and the ingredient composition of the creep diet offered during lactation (Callesen *et al.* 2007). As such, further research is required under commercial conditions to determine the impact of offering different creep diets during lactation on lifetime growth performance and carcass composition when pigs are weaned at either 3 or 4 weeks of age. Therefore, the hypotheses of this experiment are: pigs offered complex creep feed from nine days of age to weaning at either 22 or 29 days of age will have the same growth performance to their counterparts fed simple creep diets during the same period; and secondly, that lifetime growth performance from birth to 152 days of age will be similar when pigs are weaned at either 22 or 29 days of age.

3. Materials and Methods

Animals and treatments

Ninety-six sows (24 gilts and 72 sows) were selected at farrowing and the litters allocated to one of four treatments: piglets weaned at 22 days of age and offered a simple creep feed from 9 days of age to weaning, piglets weaned at 29 days of age and offered a simple creep feed from 9 days of age to weaning, piglets weaned at 22 days of age and offered a complex creep feed from 9 days of age to weaning, and piglets weaned at 29 days of age and offered a complex creep feed from 9 days of age to weaning. The ingredient profile and nutrient composition of the two creep diets are displayed in Table 1. The main differences were the use of milk proteins, fishmeal and a highly digestible soybean meal concentrate (Soycomil) in the complex creep diet, while the simple creep diets utilised peas as a less expensive protein source. Creep feed was offered from 9 days of age till weaning in a creep feeder located at the front of the farrowing crate, adjacent to the heat lamp. Litters were selected over a six week period (16 litters per week; 4 gilt litters and 12 sow litters per week) starting in March 2008. All litters within each replicate farrowed within one 24 hour period.

Husbandry and management

All piglets were individually weighed within 24 hrs of birth (post fostering) and individually tagged for identification. Sows were offered ad libitum access to feed and water during the entire experimental period. Commencing at 9 days of age, creep feed was offered to each of the litters as described above. Piglets were individually weighed at the commencement of creep feeding (9 days of age) and again at weaning. Creep feed consumption was estimated every three to four days on a litter basis from 9 days of age to weaning by measuring the disappearance of creep feed from the feeder.

Individual categorisation of creep feed intake was achieved by assessing the presence of dye (Ravicol blue) in the faeces on three occasions prior to weaning from one litter per treatment group per replicate (24 litters in total). Individual creep feed intake was assessed on each of these 24 litters at 16 days of age, 19 days of age and again at weaning (either 22 or 29 days of age). Following a successful milk letdown, all piglets within the litter were removed from the sow and placed in individual polystyrene boxes lined with newspaper. Piglets remained here until sufficient faeces were excreted to allow assessment of the presence of dye in the faeces, following which the piglets were returned to the sow. After three assessments, individual piglets were categorised as non eaters (no dye present in faeces at any of the assessments), small eaters (dye present on one assessment occasion), moderate eaters (dye present on two assessment occasions), or good eaters (dye present on all three assessment occasions).

At weaning, piglets were moved to a commercial weaner facility. Piglets were group housed in pens of approximately 10 pigs of the same sex and creep feed/weaning age treatment. Piglets were offered a Superstarter diet from weaning to 34 days of age, followed by a Phase 1 weaner diet from 34 to 49 days of age, and a Phase 2 weaner diet from 49 to 68 days of age. The nutrient profiles of each of these diets are displayed in Table 2. Pigs were individually weighed 5 days post weaning (27 and 34 days of age for the early and late weaned treatment groups respectively) and again at 49 and 68 days of age. Pen feed intake was estimated by feed disappearance from weaning to 5 days post weaning, 5 days post weaning to 49 days of age and from 49 days of age to 68 days of age. At 68 days of age pigs were individually weighed and moved to the grower facility, with two weaner pens of the same weaning age and creep feed treatment combining to form one grower pen of approximately 18 pigs. All pigs were offered a commercial grower diet from 68 to 117 days of age, with pen feed intake again measured via feed disappearance. At 117 days of age pigs were individually weighed and moved to finisher pens, with the initial grower pen of 18 pigs split into two finisher pens to accommodate the larger animal size. Pigs were offered a commercial finisher diet from 117 days of age to slaughter at 152 days of age. The nutrient composition of the commercial grower and finisher diets are displayed in Table 3. A final finisher weight was obtained at 152 days of age, along with an individual carcass weight, carcass P2 back fat and dressing percentage for each animal at slaughter.

Statistical analyses

Differences in progeny growth performance due to the effects of creep diet composition and/ or weaning age were analysed using residual maximum likelihood (REML) mixed model analyses. The experimental unit for the pre-weaning growth performance data was the individual piglets with the model including the random effect for the sow and the fixed effects of creep feed composition, weaning age and sex. Creep feed disappearance measured on a pen basis was analysed using REML, with the fixed effect of creep feed composition and the random effect of replicate. The effects of weaning age and creep feed composition on individual creep feed characterisation were determined using chi-square analyses with only the piglets that were assessed at all three faecal assessment time points included in the analyses (i.e. piglets that died after an initial assessment were removed from the data set). The influence of post foster weight on creep feed characterisation was determined using REML, with the model including the random effect for replicate and the fixed effect of creep eating category.

The post weaning growth performance and carcass data were analysed using REML, with the random effects of replicate and the fixed effects of creep feed composition, weaning age and sex. The experimental unit for these analyses was the pen. All replicates were included in the analyses of growth performance to the end of the finisher period, while the carcass data includes only the first five replicates. The carcass data on the final replicate was not obtained due to an *Actinobacillus pleuropneumoniae* (APP) challenge in the final four days prior to the scheduled slaughter, and the subsequent withhold period on the necessary medication.

The influence of birth weight category (light <=1.2 kg, normal >1.2 kg) on post weaning growth performance and carcass composition was assessed. The experimental unit for these analyses was the individual pig, while the statistical model included the fixed effects of birth weight category, creep feed composition and weaning age and the random effects of replicate. Animals that did not reach the end of the finisher period were excluded from these analyses. The influence of individual creep feed categorisation on post-weaning growth performance was assessed on the sub-set of animals that had undergone the faecal assessments. This data was analysed using an analyses of variance for an unbalanced design, with the treatment effect of creep eating category and the block effect of replicate included in the model. In addition, weaning weight was included in the model as a covariate to assess the influence of individual creep feed categorisation on post weaning growth performance. The experimental unit for this latter analysis was the individual animal. All analyses were performed using Genstat 10th Edition (Payne *et al.* 2005).

Table 1. Ingredient composition and nutrient profile of the creep diets, % of diet (as fed basis)

Ingredient, %	*Simple Creep*	*Complex Creep*
Wheat	32.85	10.00
Groats	18.96	39.97
Peas	25.00	
Soybean meal	7.50	
Meatmeal	5.19	4.93
Fishmeal		5.23
Bloodmeal	2.00	1.50
Soycomil		4.17
Whey powder		30.00
Water	1.00	1.00
Tallow	4.00	1.40
Dicalcium phosphate	1.27	
Lysine HCL	0.35	0.19
Dl-methionine	0.15	0.07
Threonine	0.18	0.08
Isoleucine	0.08	
Tryptophan	0.06	0.053
Zinc oxide	0.28	0.28
QAF creep premix	0.30	0.30
Ronozyme P Liquid	0.015	0.015
Ronozyme	0.03	0.03
Endox	0.06	0.06
Formi R	0.3	0.30
Lysoforte	0.075	0.075
Biofix	0.05	0.05
Adimix 30 %	0.30	0.30
Ravicol Blue	0.02	0.02
*Estimated nutrient composition, %**		
Crude protein	21.82	20.54
Crude fat	6.51	5.50
Crude fibre	3.09	1.43
DE, MJ/kg	15.0	15.0
Total Lysine	1.46	1.42
Available lysine	1.27	1.28
Available lysine: DE	0.85	0.85

*Estimated from composition of ingredients (SCA 1987)

Table 2. Nutrient profile of each of the commercial weaner diets, % of diet (as fed basis)

Nutrient composition, %*	*Super Starter*	*Phase 1 Weaner*	*Phase 2 Weaner*
DE, MJ/kg	15.23	14.74	14.50
Crude protein	22.40	24.01	23.52
Crude fat	6.32	5.38	4.78
Crude fibre	1.58	2.49	2.85
Total Lysine	1.60	1.54	1.40
Available lysine	1.46	1.37	1.22

*Estimated from composition of ingredients (SCA 1987)

Table 3. Nutrient profile of the grower and finisher diets, % of diet (as fed basis)

*Nutrient composition, %**	*Grower*	*Finisher*
DE, MJ/kg	13.79	13.78
Crude protein	18.03	13.88
Crude fat	4.19	4.75
Crude fibre	3.83	3.80
Total Lysine	1.11	0.82
Available lysine	0.97	0.72

*Estimated from composition of ingredients (SCA 1987)

4. Results

Pre-weaning growth performance and creep feed intake

Creep feed composition had no influence on pre-weaning growth performance (Table 4), with the average daily gain from 9 days of age to weaning similar between the animals offered the simple or complex creep diets (234.6 and 231.3 g/d respectively, sed 6.93, P=0.641). In addition, the ingredient composition of the creep diet had no influence on weaning weight (6.89 and 6.90 kg respectively, sed 0.181, P=0.774). As anticipated, the older weaning age resulted in a greater weaning weight of these animals (5.99 and 7.80 kg respectively for the pigs weaned at 22 and 29 days of age, sed 0.181 P<0.001). There was no influence of sex on pre-weaning growth performance or weaning weight (weaning weight 6.85 and 6.92 kg respectively for female and male pigs, P=0.47, sed 0.100, Table 4).

Estimated creep feed intake measured via creep feed disappearance was generally small regardless of creep feed composition. Creep feed disappearance was variable between litters, with total creep feed intake for the litters weaned at 22 days of age ranging from 69 g to 1,940 g, while total intake for the litters weaned at 29 days of age ranged from 259 g to 2,150 g. Creep feed composition did influence total intake with the litters offered the simple creep diet consuming more feed from 9 days of age to weaning than those offered the complex creep diets (776.3 and 461.4 g respectively for the simple and complex creep diets, sed 92.7, P=0.004). As anticipated, weaning age influenced the estimated total creep feed consumption, 375.8 and 861.9 g in total per litter respectively for the animals weaned at 22 and 29 days of age, sed 93.8, P<0.001. Estimated creep feed intake per litter was measured every three to four days from 9 days of age till weaning at either 22 or 29 days of age. The influence of creep feed composition on creep feed disappearance over these time intervals is displayed in Figure 1. Creep feed disappearance up to 18 days of age was small and not influenced by creep feed composition. Interestingly, from 19 days of age to weaning at either 22 or 29 days of age litters offered the simple creep diet appeared to consume more creep feed than those litters offered the more expensive complex creep diet.

Individual creep feed intake was assessed at three time points (16 days of age, 19 days of age and weaning at either 22 or 29 days of age). This allowed the characterisation of individual pigs as good eaters, moderate eaters, small eaters or non-eaters, as displayed in Table 5. Chi-squared analyses of individual creep feed characterisation did not indicate any differences in creep feed consumption based on the four combinations of weaning age and creep feed composition (x^2=6.27, P=0.712). Similarly, the characterisation of individual animals was similar between those offered the simple and complex creep diets (x^2=0.69, P=0.876), and also similar between pigs weaned at 22 and 29 days of age (x^2=2.88, P=0.411). Individual post foster weight did not appear to influence creep feed characterisation, with the initial weights of the piglets characterised as good, moderate, small and non-eaters very similar (1.57, 1.63, 1.54 and 1.57 kg for the good, moderate, small and non-eaters respectively, P=0.357, sed 0.055). Furthermore, within each of these creep feed categories there was a similar range of initial post foster weights (good eaters: 0.94 to 2.18 kg, moderate eaters: 0.82 to 2.16 kg, small eaters: 1.08 to 2.2 kg and non-eaters: 0.92 to 2.4 kg) and a similar number of 'light' birth weight animals (animals with a post foster weight less than 1.2 kg, good eaters:7, moderate eaters: 7, small eaters: 5 and non-eaters: 8) Growth rates during the period that the creep feed was on offer (9 days of age to weaning) were similar between pigs of different creep feed eating categories (237.1, 225.0, 248.2, 257.4 g/d for the good, moderate, small and non eaters respectively, P=0.140, sed 14.37).

The influence of weaning age and creep feed composition on pre-weaning mortality is displayed in Table 6, while Table 7 displays the removals and combined deaths and removals figures. Chi-squared analyses indicated no differences in pre-weaning deaths/ removals between the four treatment groups (x^2=4.94, P=0.177).

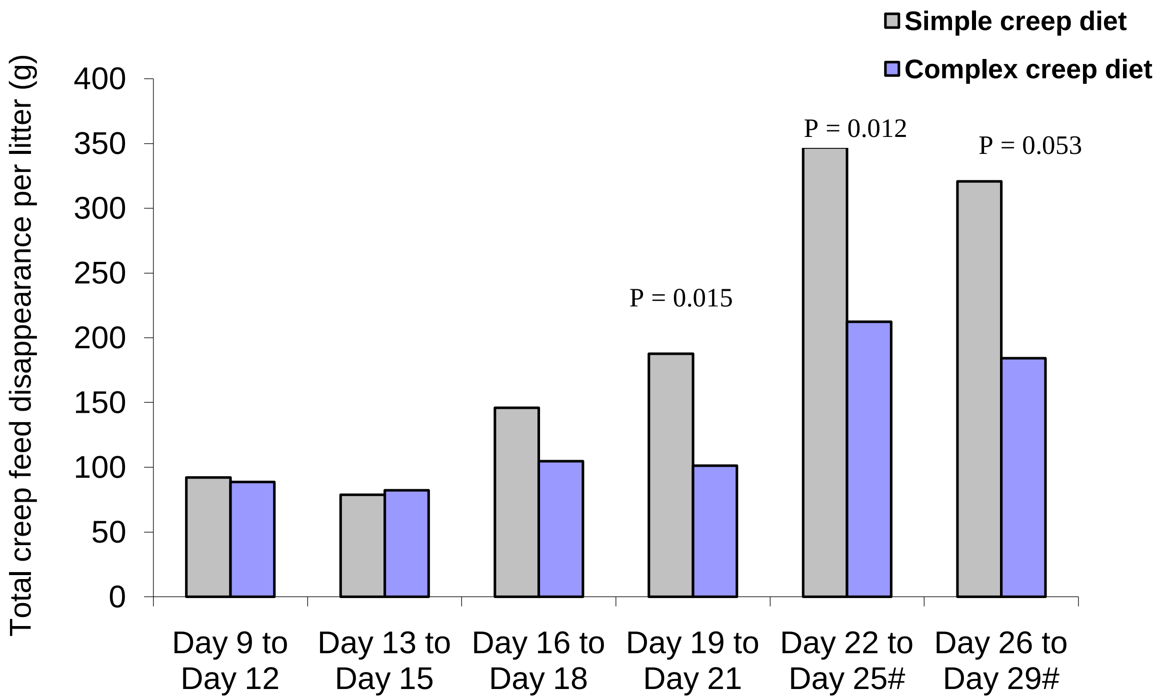

Figure 1. Total creep feed disappearance per litter every three to four days from 9 days of age to weaning. # Creep feed disappearance from 22 to 29 days only refers to the animals weaned at 29 days of age.

Table 4. Influence of creep feed composition and weaning age on growth performance to weaning

	Creep Feed		SED	Weaned 22 days of age		Weaned 29 days of age		SED	Significance			
	Simple	Complex	Creep feed	Simple Creep Feed	Complex Creep Feed	Simple Creep Feed	Complex Creep Feed	Creep x Weaning age	Creep Feed	Weaning age	Sex	Creep feed x Weaning age
Live weight (kg)												
Post foster weight	1.48	1.49	0.047	1.51	1.49	1.46	1.49	0.067	0.851	0.539	0.100	0.583
Weight 9 days of age	2.95	3.02	0.104	2.87	3.02	3.03	3.02	0.145-0.148	0.471	0.473	0.243	0.446
Weight weaning	6.89	6.90	0.181	5.96	6.01	7.82	7.79	0.253-.258	0.774	**<0.001**	0.469	0.820
Average daily gain (g/d)												
Post foster to 9 days of age	160.0	168.3	9.22	149.2	168.0	170.8	168.6	12.89-13.18	0.348	0.241	0.553	0.257
9 days of age to weaning	234.6	231.3	6.93	233.2	227.0	236.0	235.5	9.70-9.92	0.641	0.410	0.949	0.683
Post foster to weaning	208.9	210.3	6.49	201.0	204.1	216.8	216.5	9.07-9.27	0.792	**0.033**	0.838	0.796

Table 5. Influence of creep feed composition and weaning age on individual creep feed consumption assessed at 16 and 19 days of age, and again at weaning (either 22 or 29 days of age)

	Good eaters	Moderate eaters	Small eaters	Non-eaters	Total number of pigs assessed
Simple creep weaned 22 days of age	13 (23.6 %)[#]	15 (27.3 %)	14 (25.5 %)	11 (23.6 %)	55
Simple creep weaned 29 days of age	15 (24.6 %)	17 (27.9 %)	22 (36.1 %)	7 (11.5 %)	61
Complex creep weaned 22 days of age	13 (21.7 %)	12 (20.0 %)	21 (35.0 %)	14 (23.3 %)	60
Complex creep weaned 29 days of age	15 (25.9 %)	17 (29.3 %)	15 (25.9 %)	11 (19.0 %)	58

#Values in parentheses represent the percentage of the total number of animals assessed for that treatment group. Chi-square difference between creep feed composition/ weaning age treatments x^2=6.27, P=0.712.

Table 6. Influence of creep feed composition and weaning age on pre-weaning mortality

			Deaths								Total deaths
Weaning age	Creep feed	Total number of piglets initially allocated to treatments	Overlain	Unthrifty	Scours	Glassers	Splay	Menengitis	Savaged	Unknown*	
22	Simple	265	17	7	1	1				1	27 (10.2 %)
22	Complex	267	14	12	13						39 (14.6 %)
29	Simple	271	23	13	8			1	1	4	50 (18.5 %)
29	Complex	273	16	7	1		1			3	28 (10.3 %)

* Unknown – reason not recorded

Table 7. Influence of creep feed composition and weaning age on pre-weaning removals

						Total removals	Combined total deaths and removals
Weaning age	Creep feed	Total number of piglets initially allocated to treatments	Unthrifty	Scours	**Other		
22	Simple	265	13	1		14 (5.3 %)	41 (15.5 %)
22	Complex	267	8			8 (3.0 %)	47 (17.6 %)
29	Simple	271	6			6 (2.2 %)	56 (20.7 %)
29	Complex	273	3		7	10 (3.7 %)	38 (13.9 %)

** Other – Pigs were weaned into alternative facilities

Post-weaning growth performance

Pigs offered the simple creep diet during the pre-weaning period consumed more feed and gained weight faster during the initial 5 days post weaning compared to those animals offered the complex creep diet (Table 8). There were no main effects of weaning age on feed intake or daily gain during this 5 day period post weaning. However, there was an interaction between creep feed composition and weaning age such that the pigs weaned at 29 days of age and offered the simple creep diet gained weight faster than those weaned at 29 days of age and offered the complex creep diet pre-weaning, while pigs weaned at 22 days of age gained at a similar rate immediately post weaning. Feed intake from weaning to 49 days of age tended to be greater in the pigs offered the simple creep diet pre-weaning (P=0.053), with this difference also reflected in daily gain from weaning to 49 days of age (P=0.051). Weaning age also influenced the growth response from weaning to 49 days of age, with the pigs weaned at 22 days of age consuming more feed (397.5 and 359.0 g/d respectively, P<0.001) and gaining weight faster (347.6 and 328.9 g/d respectively, P=0.026) than those weaned at 29 days of age. These differences in post-weaning growth performance resulted in the pigs weaned at 22 days of age being heavier at the mid point of the weaner period (49 days of age) compared to those weaned at 29 days of age (15.24 and 14.33 kg respectively, P=0.009, sed 0.336). There was no main effect of creep feed composition on live weight at 49 days of age nor was there any interaction between weaning age and creep feed composition on live weight at 49 days of age.

There were no main effects of sex on daily gain during the weaner period (Table 8). Daily feed intake as estimated by feed disappearance was greater for females from 5 days post weaning to 49 days of age (468.2 and 443.3 g/d respectively for females and males, P=0.038, sed 11.20), and from weaning to 68 days of age (681.7 and 650.2 g/d respectively, P=0.014 sed 12.50). These differences in feed intake resulted in the males displaying an enhanced feed efficiency during this time (5 days post weaning to 49 days of age FCR 1.14 and 1.07 respectively for the females and males, P=0.003, sed 0.022; weaning to 68 days of age 1.35 and 1.31 respectively, P=0.026, sed 0.017). The difference in feed efficiency between the sexes from weaning to 68 days of age was primarily due to differences between the females and males weaned at 22 days of age (1.37 and 1.29 respectively) while the FCR for both sexes weaned at 29 days of age was the same (FCR 1.32, interaction weaning age and sex P=0.014).

Creep feed consumption during the pre-weaning period influenced post weaning growth performance, with the piglets classified as good eaters gaining weight substantially faster during the initial 5 days post weaning, P=0.021 (Figure 2). A similar pattern was also observed for the period from weaning to 49 days of age, with the non-eaters tending to gain weight slower than those pigs that consumed creep feed during the pre-weaning period. The influence of creep feed composition and weaning age on weaner mortality is shown in Table 9. Chi-squared analyses indicated that there were no treatment effects on mortality/removals during the weaner period (x^2=3.40, P=0.334).

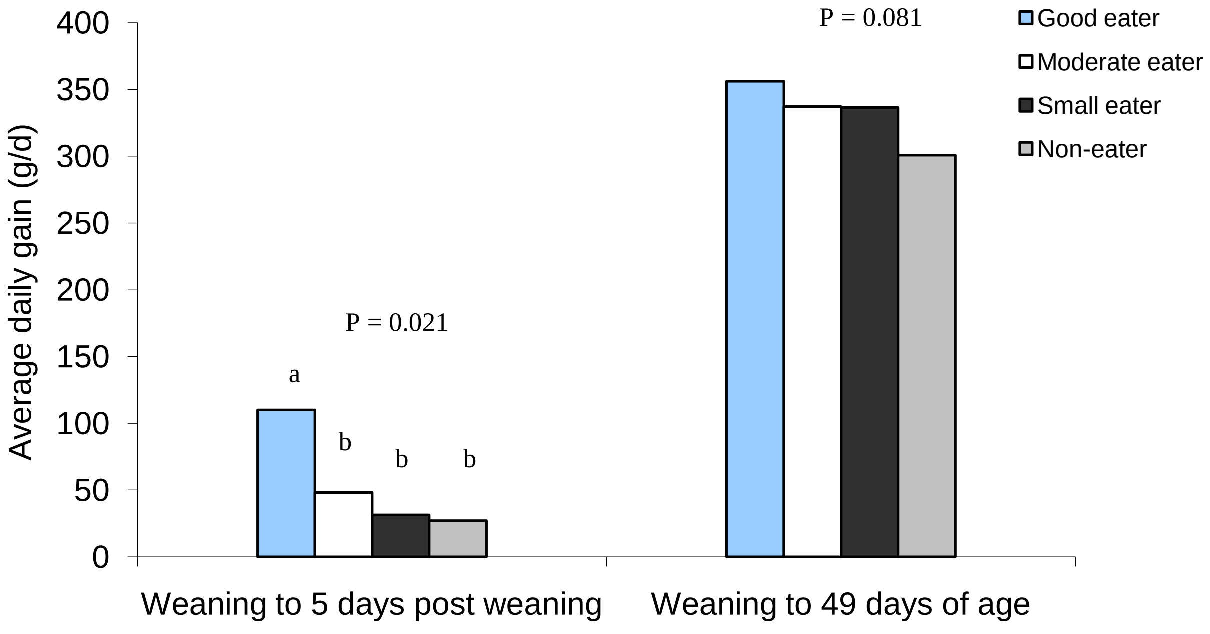

Figure 2. Influence of individual creep feed intake during the pre-weaning period on growth performance from weaning to 49 days of age.

Table 8. Influence of creep feed composition, weaning age and sex on weaner growth performance

	Creep Feed		SED	Weaned 22 days of age		Weaned 29 days of age		SED	Significance			
	Simple	Complex	Creep feed	Simple CF	Complex CF	Simple CF	Complex CF	CF x WA	CF	WA	Sex	CF x WA
Average daily gain (g/d)												
Weaning to 5 days post weaning	75.0	44.0	10.87	58.6	55.0	91.4	33.0	15.14-15.58	**0.007**	0.651	0.282	**0.012**
5 days post weaning to 49 days of age	420.0	409.7	10.12	412.6	409.4	427.3	410.0	13.98-14.64	0.334	0.452	0.671	0.499
Weaning to 49 days of age	346.6	329.9	8.37	351.3	343.8	341.8	315.9	11.55-12.11	**0.051**	**0.026**	0.805	0.288
Weaning to 68 days of age	508.7	495.6	8.32	495.9	496.8	521.6	494.3	11.60-11.93	0.149	0.179	0.286	0.094
Average daily intake (g/d)												
Weaning to 5 days post weaning	118.5	91.0	8.94	110.0	97.6	127.0	84.5	12.36-12.92	**0.004**	0.918	0.410	0.108
5 days post weaning to 49 days of age	464.4	447.1	11.17	457.6	470.2	471.2	424.0	15.55-16.20	0.146	0.131	**0.038**	0.008
Weaning to 49 days of age	387.7	368.9	9.82	395.4	399.7	380.0	338.1	12.63-14.21	**0.053**	**<0.001**	0.077	**0.018**
Weaning to 68 days of age	668.9	663.0	12.51	656.1	666.4	681.8	659.6	17.44-17.93	0.697	0.421	**0.014**	0.167
Feed efficiency (kg/kg)												
Weaning to 5 days post weaning	0.64	0.37	0.122	0.46	0.46	0.82	0.27	0.168-	**0.044**	0.560	0.121	**0.028**

	Creep Feed		SED	Weaned 22 days of age		Weaned 29 days of age		SED	Significance			
	Simple	Complex	Creep feed	Simple CF	Complex CF	Simple CF	Complex CF	CF x WA	CF	WA	Sex	CF x WA
(FCE)								0.176				
5 days post weaning to 49 days of age (FCR)	1.11	1.10	0.022	1.12	1.15	1.10	1.05	0.030-0.032	0.941	**0.008**	**0.003**	0.066
Weaning to 49 days of age (FCR)	1.12	1.13	0.021	1.13	1.16	1.10	1.09	0.029-0.031	0.592	**0.023**	**0.004**	0.288
Weaning to 68 days of age	1.32	1.34	0.017	1.32	1.34	1.31	1.34	0.024-0.025	0.209	0.798	**0.026**	0.749

CF – Creep feed
WA – Weaning age

Table 9. Influence of creep feed composition and weaning age on weaner mortality

			Deaths				Removals	Total deaths and removals - weaners
Weaning age	Creep feed	Total number of pigs commencing weaner period	Unthrifty	E.coli	Twisted bowel	Meningitis	Unthrifty	
22	Simple	224	8	4	1		1	14
22	Complex	220	6	2				8
29	Simple	215	2	2	1	1	1	7
29	Complex	235	3	3			2	8

Average daily gain and average daily feed intake during the grower and finisher periods were not influenced by creep feed composition or weaning age (Table 10). Feed efficiency during the grower period was however enhanced in the pigs offered the complex creep diet compared to those offered the simple creep feed (2.06 and 2.11 respectively, sed 0.019, P=0.013), while the pigs weaned at 29 days of age were more feed efficient than pigs weaned at 22 days of age (2.07 and 2.10 respectively, P=0.049) during this grower period. Males gained weight faster during the grower period compared to females (880.4 and 821.2 g/d respectively, P<0.001) and were more feed efficient (FCR 2.00 and 2.17 respectively, P<0.001, sed 0.019). The enhanced growth performance of the males during the grower period was not maintained during the finisher period (Table 10), possibly due to an outbreak of APP during this period. Feed efficiency during this time did however tend to be enhanced in the males (FCR 2.86 and 3.00 respectively for the males and females, P=0.074, sed 0.074). Responses to the main effects of weaning age and creep feed composition were similar between the sexes (no interactive effects, data not shown). Grower/finisher deaths and removals were similar between treatment groups (x^2=3.94, P=0.268). The lifetime performance of the pig (birth to 152 days of age) was not influenced by creep feed composition (P=0.240). There was however a tendency for those pigs weaned at 22 days of age to gain faster from birth to slaughter than those weaned at 29 days of age (616.1 and 610.4 g/d respectively, P=0.079).

There were no main effects of creep feed composition on carcass weight, P2 or dressing percentage (Table 12). Carcass weight tended to be greater in the animals weaned at 22 days of age compared to those weaned at 29 days of age (76.01 and 74.11 kg respectively, sed 1.07, P=0.077), while carcass P2 was also greater when pigs were weaned at 22 days of age compared to those weaned at 29 days of age, regardless of whether carcass weight was included as a covariant. Carcass weights were similar between the sexes (75.51 and 74.61 kg respectively for the males and females, P=0.386). There were no main or interactive effects of weaning age and creep feed composition on dressing percentage.

Categorisation of the individual animals that remained in the data set to slaughter as either light birth weight (<=1.2 kg) or normal birth weight (>1.2 kg) confirmed the influence that weight at birth has on lifetime growth performance and carcass characteristics. Of the total population of piglets that commenced this experiment, 20.8 % were at or below 1.2 kg at birth. The survival rate of these animals through to the end of the finisher period was poor, with only 44.6 % making it to 152 days of age. Daily gain from birth (or weaning) to the end of the finisher period was inferior in the light birth weight pigs (Table 13), resulting in a difference of 6.5 kg in carcass weight at slaughter. Body composition was also influenced by birth weight, with the light birth weight animals observed to have a greater P2 back fat depth compared to those born at heavier weights when carcass weight is included as a covariant (9.5 and 8.5 mm, respectively, P<0.001). Regression analyses also indicates that across a range of slaughter weights, light birth weight pigs have significantly more back fat at the P2 site than those born at heavier weights (P<0.001, Figure 3). There were no significant interactions between birth weight and creep feed composition or birth weight and weaning age on lifetime growth performance or carcass characteristics (Tables 13 and 14).

Table 11. Influence of creep feed composition and weaning age on grower and finisher growth performance

	Creep Feed		SED	Weaned 22 days of age		Weaned 29 days of age		SED	Significance			
	Simple	Complex	Creep feed	Simple CF	Complex CF	Simple CF	Complex CF	CF x WA	CF	WA	Sex	CF x WA
Average daily gain (g/d)												
68 to 117 days of age (end grower)	849.0	852.6	12.22	843.6	853.1	854.5	852.1	17.28	0.772	0.686	<0.001	0.630
117 to 152 days of age (end finisher)	798.7	777.9	23.63	819.7	775.1	777.7	780.6	33.02	0.393	0.419	0.206	0.277
Weaning to 152 days of age	701.4	689.1	10.15	689.6	683.5	713.1	694.7	13.28-15.35	0.319	0.113	<0.001	0.538
Birth to 152 days of age	619.0	607.4	8.69	619.1	613.0	618.9	601.9	12.31	0.240	0.079	<0.001	0.556
Average daily intake (kg/d)												
68 to 117 days of age (end grower)	1.79	1.75	0.027	1.78	1.79	1.80	1.72	0.039	0.222	0.464	0.397	0.110
117 to 152 days of age (end finisher)	2.32	2.24	0.045	2.38	2.56	2.26	2.22	0.063	0.065	0.065	0.896	0.361
Feed efficiency (kg/kg)												
68 to 117 days of age (end grower)	2.11	2.06	0.019	2.11	2.10	2.11	2.02	0.027	**0.013**	**0.049**	**<0.001**	**0.049**
117 to 152 days of age (end finisher)	2.94	2.92	0.074	2.94	2.96	2.94	2.88	0.104	0.767	0.632	0.074	0.592

CF – Creep feed
WA – Weaning age

Table 12. Influence of creep feed composition and weaning age on live weight and carcass characteristics

	Creep Feed		SED	Weaned 22 days of age		Weaned 29 days of age		SED	Significance			
	Simple	Complex	Creep feed	Simple CF	Complex CF	Simple CF	Complex CF	CF x WA	Creep Feed	Weaning age	Sex	CF x WA
Live weight (kg)												
Weaning	6.79	6.85	0.238	5.86	5.98	7.72	7.72	0.333-0.342	0.688	**<0.001**	0.984	0.781
5 days post weaning	7.16	7.07	0.225	6.16	6.25	8.17	7.90	0.315-0.323	0.809	**<0.001**	0.728	0.399
49 days of age	14.91	14.67	0.337	15.24	15.25	14.57	14.09	0.465-0.487	0.466	**0.009**	0.803	0.803
68 days of age (end weaner)	28.37	27.92	0.494	28.67	28.83	28.06	27.02	0.688-0.707	0.371	**0.015**	0.413	0.219
117 days of age (end grower)	70.18	70.01	0.727	70.20	70.85	70.16	69.17	1.028-1.029	0.817	0.241	**<0.001**	0.256
152 days of age (end finisher)	98.22	97.24	1.158	98.88	97.98	97.57	96.49	1.619-1.655	0.383	0.227	**0.002**	0.992
*Carcass characteristics**												
Carcass weight (kg)	75.43	74.69	0.966	76.53	75.49	74.32	73.90	1.487-1.522	0.478	0.077	0.386	0.738
Carcass P2 (mm)	8.7	8.7	0.23	9.0	9.1	8.5	8.2	0.32-0.33	0.799	**0.005**	0.061	0.473
Carcass P2 (HSCW covariant) (mm)	8.7	8.7	0.18	8.8	9.0	8.6	8.4	0.25	0.946	**0.023**	**0.002**	0.201
Dressing percentage (%)	76.44	76.31	0.238	76.56	76.00	76.32	76.62	0.331-0.343	0.801	0.612	**<0.001**	0.062

CF – Creep feed
WA – Weaning age
* Data not obtained on the final replicate due to treatment for an APP challenge and the subsequent withhold period

Table 13. Influence of birth weight category and creep feed composition on lifetime growth performance and carcass characteristics (individual animals used as the experimental unit)

	Birth weight		SED	Simple Creep Feed		Complex Creep Feed		SED	Significance		
	Light (<=1.2 kg)	Normal (>1.2 kg)	Birth weight	Light	Normal	Light	Normal	Creep x Birth weight	BW	CF	BW x CF
Growth performance											
ADG birth to 152 days of age (g/d)	585.3	641.1	8.72	595.0	643.0	575.6	639.3	6.96-15.91	**<0.001**	0.240	0.300
ADG weaning to 152 days of age (g/d)	664.5	726.0	10.14	674.9	727.9	654.2	724.0	8.09-18.64	**<0.001**	0.319	0.398
Carcass characteristics											
HSCW	69.36	75.86	1.262	70.59	76.20	68.13	75.51	0.930-2.345	**<0.001**	0.458	0.400
Carcass P2	8.6	8.6	0.32	9.0	8.4	8.3	8.7	0.24-0.60	0.427	0.938	0.077
Carcass P2 (HSCW covariant)	9.5	8.5	0.28	9.7	8.3	9.3	8.6	0.20-0.51	**<0.001**	0.307	0.187
Dressing percentage (%)	76.39	76.25	0.325	76.50	76.22	76.28	76.28	0.239-0.604	0.785	0.769	0.613

CF – Creep feed
BW – Birth weight category

Table 14. Influence of birth weight category and weaning age on lifetime growth performance and carcass characteristics (individual animals used as the experimental unit).

	Weaning age		SED	Weaned 22 days		Weaned 29 days		SED	Significance		
	22 days of age	29 days of age	Weaning age	Light	Normal	Light	Normal	Birth weight x Weaning age	BW	WA	BW x WA
Growth performance											
ADG birth to 152 days of age (g/d)	0.616	0.610	8.73	584.8	647.3	585.8	635.0	6.96-15.91	**<0.001**	0.079	0.459
ADG weaning to 152 days of age (g/d)	686.6	703.9	10.14	652.6	720.6	676.5	731.3	8.09-18.60	**<0.001**	0.113	0.449
Carcass characteristics											
HSCW	73.38	71.84	1.26	69.81	76.94	68.92	74.77	0.930-2.346	**<0.001**	**0.006**	0.518
Carcass P2	8.9	8.4	0.32	8.7	9.0	8.6	8.2	0.24-0.60	0.427	**0.003**	0.232
Carcass P2 (HSCW covariant)	8.8	8.4	0.19	9.5	8.7	9.5	8.2	0.20-0.51	**<0.001**	**0.047**	0.415
Dressing percentage (%)	76.23	76.40	0.325	76.23	76.23	76.55	76.26	0.239-0.604	0.785	0.540	0.624

WA – Weaning age
BW – Birth weight category

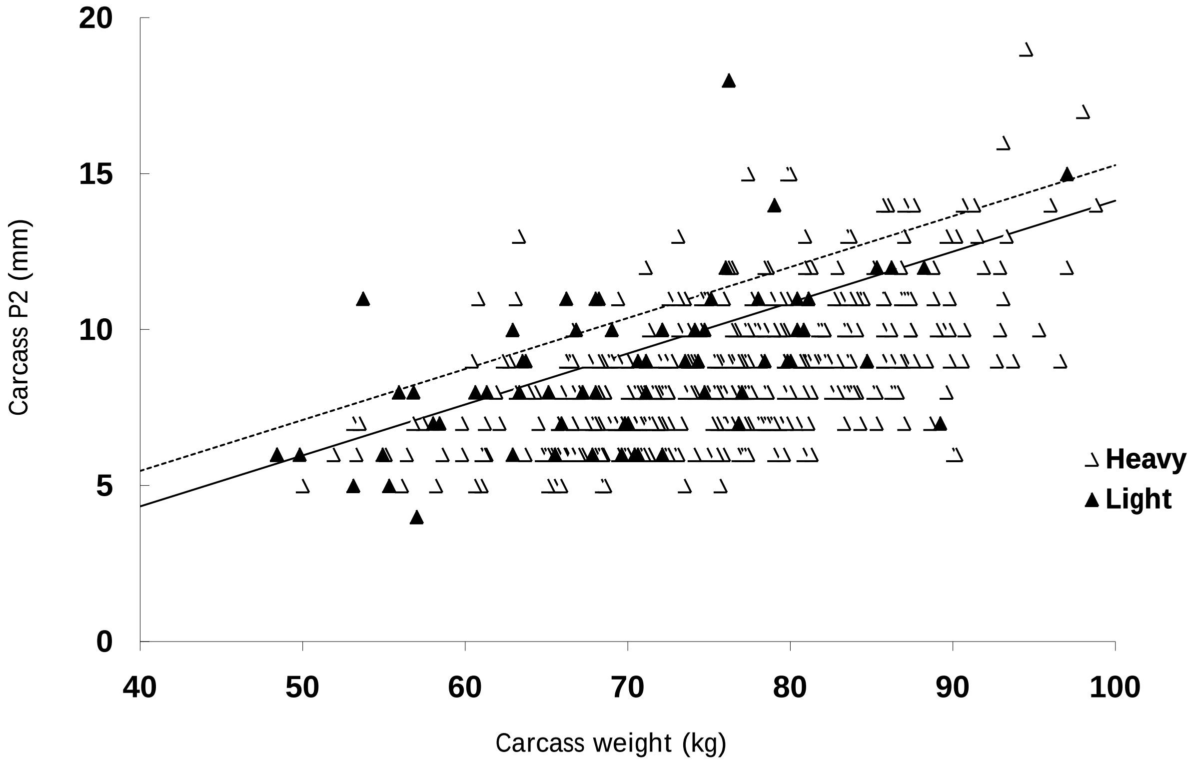

Figure 3. Influence of birth weight on carcass P2 at commercial carcass weights ($P<0.001$). Regression equations: Carcass P2 (mm) = -2.208 + 0.1634x (+1.140 light). $R^2=0.33$. The solid line represents the heavy birth weight pigs (> 1.2 kg), while the dashed line represents the light birth weight pigs (<=1.2 kg).

5. Discussion

The consumption of creep feed can vary considerably between litters of pigs, and in this investigation consumption was generally small regardless of creep feed composition. Creep feed intake was negligible prior to 21 days of age, supporting observations in previous investigations (Pluske *et al.* 2007). It is possible however, that supplying creep feed early does allow familiarisation with the feed, and as such, enhances feed intake when milk demand starts to outweigh milk supply from the sow during declining lactation. The maximum creep feed disappearance in this investigation occurred between days 22 and 25 (total disappearance over the three days of 346.8 g for the litters offered the simple creep diet and 212.3 g for the litters offered the complex creep diet). These estimates of creep feed intake are considerably lower than those observed in previous investigations. For example, Pluske *et al.* (2007) reported creep feed intakes of 300 to 400 g per litter per day between day 22 and day 25 after birth, with intakes maximised at just over 1000 g per litter per day at day 30. The reasons for these differences in creep feed intake are not clear, with the litter size in both studies similar, and the creep feed introduced at day 12 in the study by Pluske *et al.* (2007) and day 9 in this present investigation. Bruininx *et al.* (2002) also reported substantially greater creep feed intakes when the creep feed was offered from 11 days of age to weaning at 28 days of age. In this latter study, the authors reported average total intakes of 377 g per piglet from day 11 to day 28, while in comparison total litter intakes in this present investigation were 776.3 and 461.4 g respectively for the simple and complex creep diets. All three investigations have however noted the large variation in individual litter intakes, with Bruininx *et al.* (2002) reporting total litter intakes ranging from 445 g to 7,840 g, Pluske *et al.* (2007) reported a range of 5.82 kg to 8.59 kg, while total litter intakes in this current investigation ranged from 259 g to 2,150g for the litters weaned at 29 days of age.

Individual creep feed consumption, as indicated by the presence or absence of the dye in the faeces, was also variable between pigs within the same litter. Growth rates during the period that the creep feed was on offer were similar between pigs of the different creep feed eating categories, concurring with studies by Pluske *et al.* (2007). Of interest, the pigs classified as non-eaters displayed the greatest numerical daily gain during the creep feeding period. This result is in contrast to findings by Bruininx *et al.* (2004) in which the good eaters displayed significantly greater daily gains during the creep feeding period than either the moderate or non-eaters. The results from this present investigation may indicate that the non-eaters were able to obtain sufficient milk from the sow to maintain their growth performance without the need for supplemental feed. Given the qualitative nature of the creep feed characterisation, it is also possible that the piglets classified as good or moderate eaters consumed only a small amount of feed, enough to colour the faeces but not to substantially increase growth performance during the pre-weaning period. Individual creep feed consumption did not appear to be influenced by birth weight, with the light birth weight pigs represented in similar numbers across all creep feed eating categories.

Creep feed consumption during the pre-weaning period influenced post weaning performance, with the piglets classified as good eaters gaining weight faster during the initial five days post weaning, than those animals classified as moderate, small or non-eaters. These results support the observations by Pluske *et al.* (2007) in which the good and moderate eaters grew faster between weaning and 28 days post weaning (59 days of age) than the small/non eaters, with this response primarily due to the slower growth rates of the small/non eaters during the initial three days post weaning. Bruininx *et al.* (2002) suggests that piglets that are good eaters of creep feed prior to weaning spend less time engaged in exploratory behaviour of the feed and troughs and more time consuming the feed than those pigs who were non-eaters of creep feed prior to weaning. These authors demonstrated that the number of visits to the feeding station in which feed was consumed during the initial 24 hours post weaning was higher for the pigs that were good eaters pre-weaning than the non-eaters or those that had not been offered creep feed prior to weaning.

Creep feed consumption was greater from day 19 to day 25 in the litters offered the simple creep diet compared to the complex creep, while there was a trend for this to continue from day 26 to day 29. Creep feed composition did not influence weaning weight, although feed intake and daily gain immediately post weaning were greater for the pigs offered the simple creep diet compared to the complex creep. This was an interesting result that would require further confirmation given the small creep feed intakes observed in this investigation. The results do however suggest that the inclusion of expensive, highly digestible ingredients such as milk proteins in creep diets do not provide additional benefits to post weaning performance above that of a basic, higher fibre creep diet. It is also possible that the greater dietary fibre component of the simple creep diet may have stimulated a more rapid adjustment of the gastrointestinal tract to less digestible ingredients post weaning than the complex creep diet. The ingredient composition of the creep feed did not however have any lasting effects on lifetime growth performance or carcass composition.

The influence of dietary fibre on microbial populations, growth performance and nutrient digestibility for young pigs is an area of continuing research. Several authors have reported negative effects of fibre components on weaner growth performance, with the proliferation of bacterial pathogens linked to the concentration of fermentable substrates entering the large intestine (Pluske *et al.* 2003; Pluske *et al.* 1996) or the viscosity of the diet (McDonald *et al.* 2001). In contrast, other authors have reported benefits from the inclusion of fibre in otherwise low fibre diets (Mateos *et al.* 2006). In this latter experiment the authors suggest that piglets from 6 to 12 kg live weight have a requirement for 60 g NDF/kg diet (20 to 25 g crude fibre per kg diet), but that NDF concentrations above 77 g/kg diet may reduce feed intake and therefore impair growth performance. The creep diets used in this investigation contained 97.6 and 52.4 g NDF/kg creep diet for the simple and complex creep diets respectively. Given that these diets were offered only during lactation, further investigation would be required to determine the influence of different fibre components offered during lactation and immediately post weaning.

The tendency for pigs weaned at 29 days of age to gain more slowly from birth to slaughter compared to the earlier weaned animals suggests that these pigs were constrained by the sow's milk production during this final week pre-weaning. The increased creep feed consumption during this final period also supports this observation and suggests that in this commercial production system weaning later than 22 days of age may reduce lifetime growth performance.

Birth weight had a substantial impact on lifetime growth performance and carcass composition. Pigs born at weights at or below 1.2 kg grew almost 9 % slower from birth to slaughter compared to their heavier born counterparts. Birth weight was also observed to influence carcass composition, with the light birth weight pigs displaying greater P2 back fat depths across a range of commercial carcass weights. These results support previous investigations in which light birth weight animals have been observed to be fatter across a range of slaughter weights (Collins 2007) and to have a reduced meat percentage and loin muscle area than heavy birth weight pigs at slaughter (Rehfeldt and Kuhn 2006). These differences in carcass composition and muscle fibre development may also have an influence on meat quality, with drip loss reportedly higher in light birth weight animals (Rehfeldt and Kuhn 2006). Further investigation is required to assess management strategies to improve lifetime growth performance and carcass composition of these light birth weight animals.

6. Conclusion

Creep feed intake was highly variable both within and between litters, and generally small regardless of creep feed composition. Creep feed composition did not influence lifetime growth performance nor carcass composition, with birth weight having a greater influence on these performance parameters. Pigs classified as good eaters of creep feed pre-weaning gained faster in the 5 days immediately post weaning compared to the small or non-eaters, although the characterisation of creep feed eating category was not related to initial post foster weight. Based on the results of this investigation, the inclusion of expensive, highly digestible ingredients in creep diets does not appear necessary, with pre-weaning intakes and post weaning performance greater in pigs offered the simple creep diet during lactation. Furthermore, there was a tendency for lifetime growth performance to be improved when pigs were weaned at 22 days of age compared to those weaned at 29 days of age.

7. References

Barnett KL, Kornegay ET, Risley CR, Lindermann MD, Schurig GG (1989) Characterization of creep feed consumption and its subsequent effects on immune response, scouring index and performance of weanling pigs. *Journal of Animal Science* **67**, 2698-2708.

Bruininx EMAM, Binnendijk GP, Van der Peet-Schwering CMC, Schrama JW, den Hartog LA, Everts H, Beynen AC (2002) Effect of creep feed consumption on individual feed intake characteristics and performance of group-housed weanling pigs. *Journal of Animal Science* **80**, 1413-1418.

Bruininx EMAM, Schellingerhout AB, Binnendijk GP, Van der Peet-Schwering CMC, Schrama JW, den Hartog LA, Everts H, Beynen AC (2004) Individually assessed creep food consumption by suckled piglets: influence on post-weaning food intake characteristics and indicators of gut structure and hind-gut fermentation. *Animal Science* **78**, 67-75.

Callesen J, Halas D, Thorup F, Bach Knudsen KE, Kim JC, Mullan BP, Wilson RH, Pluske JR (2007) The influence of nutritional and management factors on piglet weight gain to weaning in a commercial herd in Denmark. *Livestock Science* **108**, 117-119.

Collins CL (2007) Protein restriction and compensatory growth responses in pigs. PhD Thesis, University of Melbourne.

Lawlor PG, Lynch PB, Caffrey PJ, O'Doherty JV (2002) Effect of pre- and post-weaning management on subsequent pig performance to slaughter and carcass quality. *Animal Science* **75**, 245-256.

Le Dividich J, Seve B (2000) Effects of underfeeding during the weaning period on growth, metabolism, and hormonal adjustments in the piglet. *Domestic Animal Endocrinology* **19**, 63-74.

Mateos GG, Martin F, Latorre MA, Vicente B, Lazaro R (2006) Inclusion of oat hulls in diets for young pigs based on cooked maize or cooked rice. *Animal Science* **82**, 57-63.

McDonald DE, Pethick DW, Mullan BP, Hampson DJ (2001) Increasing viscosity of the intestinal contents alters small intestinal structure and intestinal growth, and stimulates proliferation of enterotoxigenic *Escherichia coli* in newly-weaned pigs. *British Journal of Nutrition* **86**, 487-498.

Payne RW, Harding SA, Genstat Committee (2005) 'Genstat release 8 reference manual.' (USN International: Oxford, UK).

Pluske JR, Black B, Pethick DW, Mullan BP, Hampson DJ (2003) Effects of different sources and levels of dietary fibre in diets on performance, digesta characteristics and antibiotic treatment of pigs after weaning. *Animal feed Science and Technology* **107**, 129-142.

Pluske JR, Kim JC, Hansen CF, Mullan BP, Payne HG, Hampson DJ, Callesen J, Wilson RH (2007) Piglet growth before and after weaning in relation to a qualitative estimate of solid (creep) feed intake during lactation: A pilot study. *Archives of Animal Nutrition* **61**, 469-480.

Pluske JR, Siba PM, Pethick DW, Durmic Z, Mullan BP, Hampson DJ (1996) The incidence of swine dysentery in pigs can be reduced by feeding diets that limit the amount of fermentable substrate entering the large intestine. *Journal of Nutrition* **126**, 2920-2933.

Rehfeldt C, Kuhn G (2006) Consequences of birth weight for postnatal growth performance and carcass quality in pigs as related to myogenesis. *Journal of Animal Science* **84**, E113 - E123.

SCA (1987) 'Feeding Standards for Australian Livestock. Pigs.' (CSIRO Publications, Melbourne, Australia).

Smith H, Lucas IAM (1957) The early weaning of pigs II. The performance up to 56 days of age of pigs weaned at 8, 14 and 20 lb live weight. *Journal of Agricultural Science (Cambridge)* **49**, 405-408.

Williams IH (2003) Growth of the weaned pig. In 'Weaning the pig - concepts and consequences'. (Eds JR Pluske, J Le Dividich, MWA Verstegen). (Wageningen Academic Publishers: Wageningen, The Netherlands).