Reducing variation in finisher performance – early (<35 kg) intervention.

Final Report
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Executive Summary

It is well-established that pigs with low weaning weights (<5.0 kg at 21 days) have compromised performance throughout the grower-finisher phase and the survivability of the piglet is significantly impacted by weaning weight (Morrison *et al.*, 2009). There always will be a percentage of pigs that fall below the targeted weight, if nothing is done to address this poorer performance then it will continue into the grower-finisher phase and variation will be increased.

If the performance of light weight weaners can be enhanced through nutritional interventions pre-35 kg live weight, with an aim to reaching 35 kg at the same time as their heavier counterparts, there is a chance to reduce overall variation at slaughter even if growth curves differ post-35 kg. We know that a small variation at weaning continues to increase over time. By resetting the starting point to 35 kg, when the pigs have a greatly enhanced capacity to eat, the increase in variation may be significantly reduced at slaughter.

The primary objective of this project was to reduce the variation in slaughter stock by enhancing the performance of light weight weaners with nutritional interventions up to 35 kg live weight, which would be assessed by measuring the comparative growth performance of light weight weaners post-35 kg when they had an extended period of nutritional intervention pre-35 kg.

This experiment was a randomised block design with weaner weight as the blocking factor. Three groups of weaner weights were investigated - a Control group, a Low group and a High group, with 8 replicates per treatment. Pigs were randomly allocated to the Control group to represent a normal population, the remaining pigs were then allocated to treatment based on live weight to a light weight group Low and a heavy weight group, High,. Pigs that were intermediate in weight were removed from the study, such that the Low and High groups were discrete.

The feeding program undertaken was based on the fundamental basis that we are feeding pigs as efficiently as possible and as such the standard feeding program was optimal for the Control and High treatments. As such we were looking at remedial diets for those pigs that were Low in body weight at weaning. Therefore the Control and High treatments received the standard program. The Low treatment received the modified feeding program.

The standard feeding program consisted of 6 diets. The Creep diet was fed for the first four weeks and then subsequent diets were fed to match the average weight of the treatment, such that diet transitions occurred at different stages for the Control and High treatments. The modified feeding program saw the Low pigs receive the Creep diet until they reached 35 kg live weight, where upon they transitioned directly to the Grower diet, with this and subsequent diets being fed to match the average weight as per the program the Control and High treatment received.

Low weight weaners are compromised when compared to weaners of heavier weight. In this study they consume less feed than their heavier contemporaries, they convert this at the same rate as their heavier counterparts and as a consequence they grow slower than a weaner of heavier weight. These results are similar to those of Rehfeldt et al. (2008) and Douglas et al. (2014a), although neither of these studies reported a 'stable' feed conversion between weight groups as seen here.

The pattern of growth observed in this study also suggests that the prolonged nutritional intervention of providing a 15.0 MJ DE/kg, 0.80 g available lysine/MJ DE creep diet for an extended period was not able to boost the performance of light weight weaners to that of larger weaners. Similarly, in the aptly named paper "Too late to catch up", Douglas et al. (2014a) suggests that "a higher specification diet post weaning may not improve the performance of low birth weight pigs", when the diet is offered in the grower phase.

However, another study by Douglas et al. (2014b) showed that the supplementation of low birth weight pigs with a higher specification diet did result in improved performance compared with low birth weight pigs fed a standard diet. However, in a direct comparison with higher birth weight pigs, performance did not match that of the higher birth weight pigs. It should be noted that the light weight pigs in this study were approximately 6.85 kg at 28 days of age.

Consequently, it is possible that we did achieve some response to the supplementation of light weight pigs with a higher density more digestible diet for a longer period. In fact, performance may have been worse and the differential in days to slaughter greater without this intervention.

This project shows that a compromised weaner will remain a compromised grower and finisher pig. Despite an intervention that increased feed costs per kg of gain by 15%, there was no ability to boost the performance of Low weight weaners to the mean level of the population, let alone to the performance of a higher weight weaner.

A lower weaning weight resulted in a lower feed intake, which resulted in a lower rate of gain, as no change in FCR was observed across the experiment. This reduced rate of gain resulted in pigs that took longer to reach marketable weight, such that each 100 gram reduction in weaning weight resulted in one extra day required to reach sale weight.

When these growth performance results were modelled, the High weaning weight group had an increase MOFC of $7 per pig when compared to the Control populations. The Low weaning weight group generated $2 less MOFC per pig than the Control population.

The main recommendation from this study to producers is that they should aim to reduce the impediments that requires them to wean pigs at a lighter than optimum weight, as any compromises made at weaning are conserved throughout the growth phase and are not easily rectified once they have been set in motion.

The main recommendation from this study to researchers and funding bodies is that it is hard to influence the performance of the pig post-weaning, and that return on expenditure is likely to be better from projects or interventions that result in a larger weaner being produced than from projects or interventions trying to remediate the compromised weaner.

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1. Background to Research

It is well-established that pigs with low weaning weights (<5.0 kg at 21 days) have compromised performance throughout the grower-finisher phase and the survivability of the piglet is significantly impacted by weaning weight (Morrison *et al*., 2009). There always will be a percentage of pigs that fall below the targeted weight, if nothing is done to address this poorer performance then it will continue into the grower-finisher phase and variation will be increased. Variation is generally lived with, with sorting of pigs being the major method employed to better target market requirements.

A significant amount of time and money has been expended by Pork CRC, APL and other groups to target the pig immediately post-weaning, but, generally to date, the results have not lifted weaner performance significantly. The transition from a liquid to a solid diet remains an issue, whether it be from an initial reluctance to consume the very different feed form or an issue with the capacity of the gut to adapt. However, once feeding has begun and the gut has adjusted to digest solid feed performance is generally very good. During the period pre-35 kg pigs convert feed to gain more efficiently than in the finisher phase, nutritional interventions within this period are therefore likely to have a greater impact, whilst not significantly increasing the total amount of feed consumed or the total cost of feeding in line with APL R&D priorities.

If the performance of light weight weaners can be enhanced through nutritional interventions pre-35 kg live weight, with an aim to reaching 35 kg at the same time as their heavier counterparts, there is a chance to reduce overall variation at slaughter even if growth curves differ post-35 kg. We know that a small variation at weaning continues to increase over time. By resetting the starting point to 35 kg, when the pigs have a greatly enhanced capacity to eat, the increase in variation may be significantly reduced at slaughter.

2. Objectives of the Research Project

The primary objective of this project was to:

- Reduce the variation in slaughter stock by enhancing the performance of light weight weaners with nutritional interventions up to 35 kg live weight.

The secondary objective of this project was to:

- Measure the comparative growth performance of light weight weaners post-35 kg when they had an extended period of nutritional intervention pre-35 kg.

3. Introductory Technical Information

It is generally accepted that low birth and weaning weights are associated with poor post weaning growth performance and that this adds greatly to the variation that is seen in pig performance, with this variation adding costs to the supply chain (Douglas *et al*., 2014a; Rehfeldt *et al*., 2008). Recent work conducted at the same time of this study (Douglas *et al*., 2014a & b) has shown that there may be some benefits to enhancing the diets of light weight pigs (6.85kg at 28 days), although in direct comparisons performance of light weight weaner pigs are likely still to be poorer than those of higher weight.

4. Research Methodology

4.1 Experimental design

This experiment was a randomised block design with weaner weight as the blocking factor. Three groups of weaner weights were investigated - a Control group, a Low group and a High group, with 8 replicates per treatment. Pigs were randomly allocated to the Control group to represent a normal population, the remaining pigs were then allocated to treatment based on live weight to a light weight group, Low and a heavy weight group, High. Pigs that were intermediate in weight were removed from the study, such that the Low and High groups were discrete.

4.2 Housing

Pigs were housed in weaner pens that consisted of open galvanised panelling with fully-slatted plastic floor tiles (1.0m x 2.8m). Water was supplied *ad libitum* via two nipple drinkers per pen and supplemental radiant heat was provided via a bar heater. Feed was offered to each individual pen with a 10 space round adjustable Tigsa transit feeder. Diets were offered *ad libitum* throughout the experimental period. Weekly feed disappearance was calculated from feed deliveries and weighed refusal on the final day of the week. Water usage was be monitored via individual water meters on each pen. Pens were weighed on a weekly basis within the weaner shed, upon entry and at the end of week 2 and 4 all pigs were individually weighed, whilst at the end of week 1 and 3 total pen weights were recorded.

After 4 weeks in the weaner facility pigs were transferred to the finisher facility in their treatment groups. The finisher shed consisted of open galvanised panelling with two-thirds solid concrete and one-third concrete slats. Water was supplied *ad libitum* via three nipple drinkers per pen. Feed was offered to each individual pen via a large adjustable Penguin type feeder. Feed was delivered by a FeedPRO™ intelligent feeding system (FeedLogic Corp., Wilmar, MN) which recorded feed delivered for each feeding event. Pigs were weighed individually to correspond with diet transitions, with feed intake data captured to correspond to these events. The objective of the study was to bring all weight groups to the common weight of 35 kg at the same time. As variation in market weight was the absolute measure of the success of this intervention all pigs ended the experimental period at the same time, in effect the experiment stopped when the first pigs reached market specifications. Pigs were identified by pen through an additional rotor brand and were marketed subject to marker specifications. Carcase weight, P2 and age at slaughter were available based on these brands.

4.3 Feeding program

The feeding program undertaken was based on the fundamental basis that we are feeding pigs as efficiently as possible and as such the standard feeding program was optimal for the Control and High treatments. As such we were looking at remedial diets for those pigs that were Low in body weight at weaning. Therefore the Control and High treatments received the standard program. The Low treatment received the modified feeding program.

The standard feeding program consisted of 6 diets (Table 4.1). The Creep diet was fed for the first four weeks and then subsequent diets were fed to match the average weight of the treatment, such that diet transitions occurred at different stages for the Control and High treatments (Figure 4.1).

The modified feeding program saw the Low pigs receive the Creep diet until they reached 35 kg live weight, where upon they transitioned directly to the Grower diet, with this and subsequent diets being fed to match the average weight as per the program the Control and High treatment received.

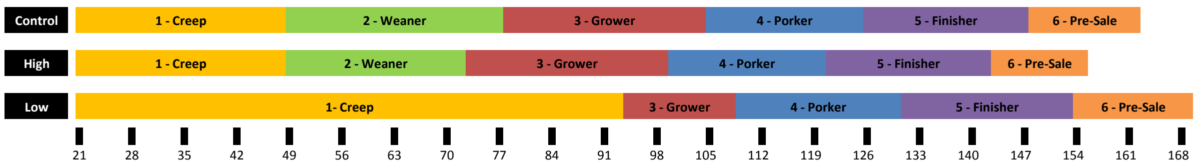

Figure 4.1 Feeding program of Control, High and Low weaning weight pigs during the experiment.

4.4 *Statistical analysis*

Data was analysed via a GLM ANOVA (GenStat 16th Edition, VSN International Ltd, Hemel Hempstead, UK) with differences determined by LSD ($P<0.05$).

Table 4.1. Diet formulations feed to Control, High and Low weaning weight pigs during the experiment.

Diet…	1 Creep 5-15kg	2 Weaner 15-25kg	3 Grower 25-50kg	4 Porker 50-70kg	5 Finisher 70-90kg	6 Pre-sale 90+kg
Ingredients						
Wheat	648.1	692.7	645.2	690.2	132.7	118.7
Barley					100.0	100.0
Sorghum					499.6	499.8
Millrun			100.0	100.0	100.0	100.0
Macadamia shell					11.3	26.7
Canola meal			100.0	100.0	78.7	78.0
Soybean meal	80.0	87.3	54.7	20.7		
Blood meal	9.33	17.3	22.0	20.0	23.3	22.7
Porcine plasma	20.0					
Meat meal	70.7	61.3	42.7	42.0		
Fish meal		40.0				
Fish protein isolate	20.0					
Chocolate milk powder	100.0	74.7				
Vegetable oil	29.3	10.7	22.0	13.3		
Monosodium glutamate	6.75					
Limestone			4.33	4.80	16.4	16.3
Dicalcium phosphate					8.0	8.0
Salt		2.00	2.00	2.00	3.00	3.00
Zinc oxide	3.00	3.00				
Choline chloride	1.00	0.73	0.33	0.47	0.47	0.47
Betaine	1.00	1.00				
MHA calcium	1.07	0.60	0.53	0.33	0.40	0.40
Lysine HCl	3.00	3.00	3.00	3.00	3.00	3.00
L-Threonine	1.00	0.93	0.20	0.13		
Xylanase	0.53	0.53				
Phytase			1.00	1.00	1.00	1.00
Organic acid[A]	1.00	1.00				
Flavour[B]	0.20	0.20				
Mycotoxin binder[C]	2.00	1.00				
Bentonite					20.0	20.0
Deodorase			1.00	1.00	1.00	1.00
Vitamin/mineral premix[D]	2.00	2.00	2.00	2.00	2.00	2.00
Analysis						
DEnergy (MJ DE/kg)	15.0	14.5	14.0	13.8	12.8	12.6
Available lysine (g/MJ DE)	0.80	0.80	0.70	0.65	0.55	0.55
Dry matter (%)	90.8	90.2	89.6	89.5	88.5	88.5
Crude protein (%)	22.3	22.0	20.7	19.5	14.8	14.7
Crude fibre (%)	2.09	2.26	4.03	3.92	4.55	5.50
Fat (%)	6.78	4.86	4.58	3.76	2.78	2.47
Lysine (%)	1.40	1.37	1.24	1.14	0.89	0.88
Methionine + Cysteine (%)	0.79	0.77	0.79	0.75	0.57	0.56
Threonine (%)	0.87	0.85	0.77	0.71	0.55	0.54
Tryptophan (%)	0.24	0.24	0.23	0.22	0.16	0.16
Calcium (%)	0.92	1.00	0.90	0.90	0.99	0.99
Phosphorus (%)	0.77	0.77	0.66	0.65	0.55	0.55

[A]Biotronic® Top3, Biomin Holding GmbH, Austria; [B]Pigortek 6661, Pancosma SA, Switzerland; [C]Mycofix, Biomin Holding GmbH, Austria; [D]Weaner vitamin/mineral premix in Creep and Weaner diets, Grower vitamin/mineral premix in Grower, Porker, Finisher and Pre-sale diets; DEnergy, digestible energy.

5. Results

Treatment groups differed significantly at the start of the experiment (*P*<0.001) and this difference was maintained over the whole experiment (*P*<0.001, Table 5.1). The low weaning weight pigs had the lowest daily feed intake and lowest rate of gain, whilst the high weaning weight group has the highest feed intake and highest growth rate. There was no difference in the efficiency of feed conversion between all three groups (*P*=0.499).

Table 5.1 Growth performance of the Control population and pigs of High and Low weaning weights across the whole experimental period.

	Start weight (kg)	**End weight (kg)**	**ADG (kg/d)**	**ADFI (kg/d)**	**FCR (kg/kg)**
Control	4.4^{a}	84.8^{a}	0.647^{a}	1.27^{a}	1.96
Low	3.8^{b}	80.2^{b}	0.617^{b}	1.20^{b}	1.95
High	5.2^{c}	75.9^{c}	0.680^{c}	1.36^{c}	2.00
SED	0.11	1.10	0.010	0.031	0.044
P value	<0.001	<0.001	<0.001	<0.001	0.499

[a,b,c]Means in a column with different superscripts differ significantly (P<0.05); ADG, average daily gain; ADFI, average daily feed intake; FCR, feed conversion ratio; SED, standard error of difference of means.

All pigs were sold at a common slaughter weight, with a subsequent difference in age at slaughter (*P*<0.001, Table 5.2). Low weight weaners took 13.5 more days to reach marketable weight than did those that were weaned at a heavier weight, with the control group intermediate. Pigs that were weaned at a heavier weight had a numerically lower backfat depth than the control and low weight groups (*P*=0.330).

Table 5.2 Carcase characteristics and age at slaughter of the Control population and pigs of High and Low weaning weights.

	HSCW (kg)	**P2 fat (mm)**	**Age at slaughter (d)**
Control	75.8	11.2	162.9^{a}
Low	75.1	11.3	169.9^{b}
High	75.5	10.6	156.4^{c}
SED	0.60	0.52	2.07
P value	0.488	0.330	<0.001

[a,b,c]Means in a column with different superscripts differ significantly (P<0.05); HSCW, hot standard carcase weight (Trim 1); P2 fat, depth of fat tissue 65 mm from the midline at the head of the last rib; SED, standard error of difference of means.

Despite the extended period of time that the low weight weaners received the high density creep diet, their average daily intake of energy was lower than the high weaning weight group (*P*=0.004). Similar to feed conversion, there was no difference in the rate of energy conversion between treatment groups (*P*=0.863). When feed costs were included there was no difference in the feed cost per kg of gain for the control population and the high weaning weight group, however, the low weight group cost 15% more per kg of gain as a result of the extended period on more expensive nutritionally denser diets.

Table 5.3 Average daily energy intake (ADEnI), average daily energy conversion ratio (ADEnCR) and feed cost per kg of gain of the Control population and pigs of High and Low weaning weights.

	ADEnI (MJ DE/d)	ADEnCR (MJ DE/kg)	Feed cost per kg gain
Control	16.5[ab]	25.5	$0.98[a]
Low	15.9[a]	25.9	$1.15[b]
High	17.7[b]	26.0	$1.00[a]
SED	0.42	0.61	0.022
P value	0.004	0.863	<0.001

[a,b,c]Means in a column with different superscripts differ significantly (P<0.05); DE, digestible energy; SED, standard error of difference of means.

The pattern of growth was not markedly different between treatment groups (Figure 5.1). Despite the low weaning weight group remaining on a 15 MJ DE/kg for approximately 10 weeks their growth was not able to be shifted closer to the Control or High groups. If the pig was weaned heavier it maintained its advantage throughout its life, conversely a compromised pig at weaning remained compromised throughout its life.

The coefficient of variation for weight showed a differing pattern between treatments (Figure 5.2). As expected the Control group, representing a 'normal' population of pigs had the highest CV. The High group maintained its lower CV, compared to the Control, throughout the experimental period whilst the Low group tended to show more variation that is potentially a result of the differing growth response of lighter, more compromised, weaners.

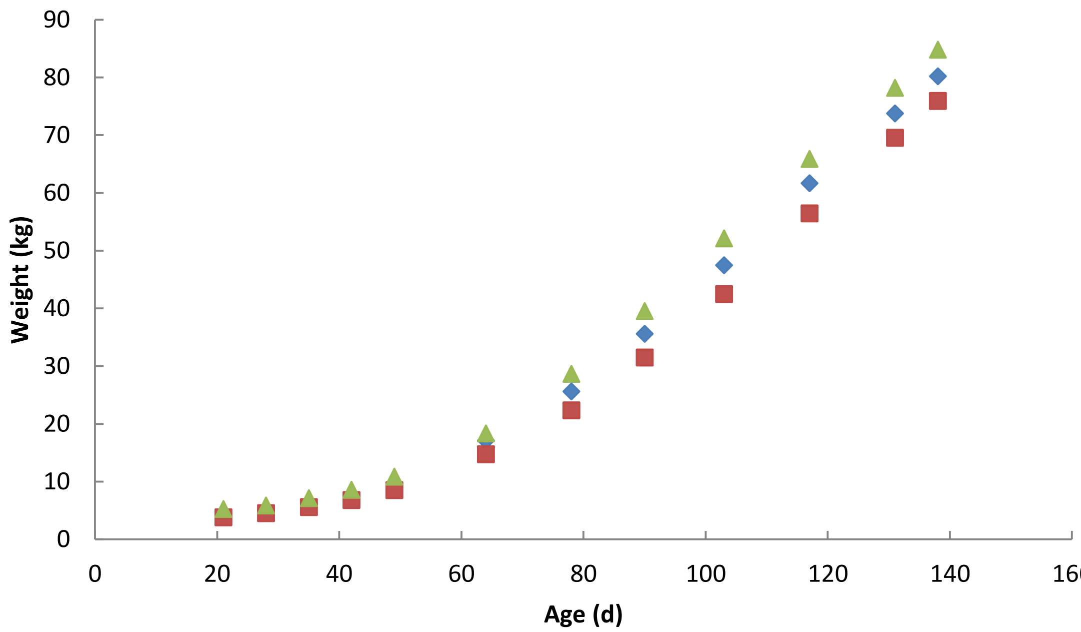

Figure 5.1 Weight for age growth curves for the Control (◆) population and pigs of High (▲) and Low (■) weaning weights.

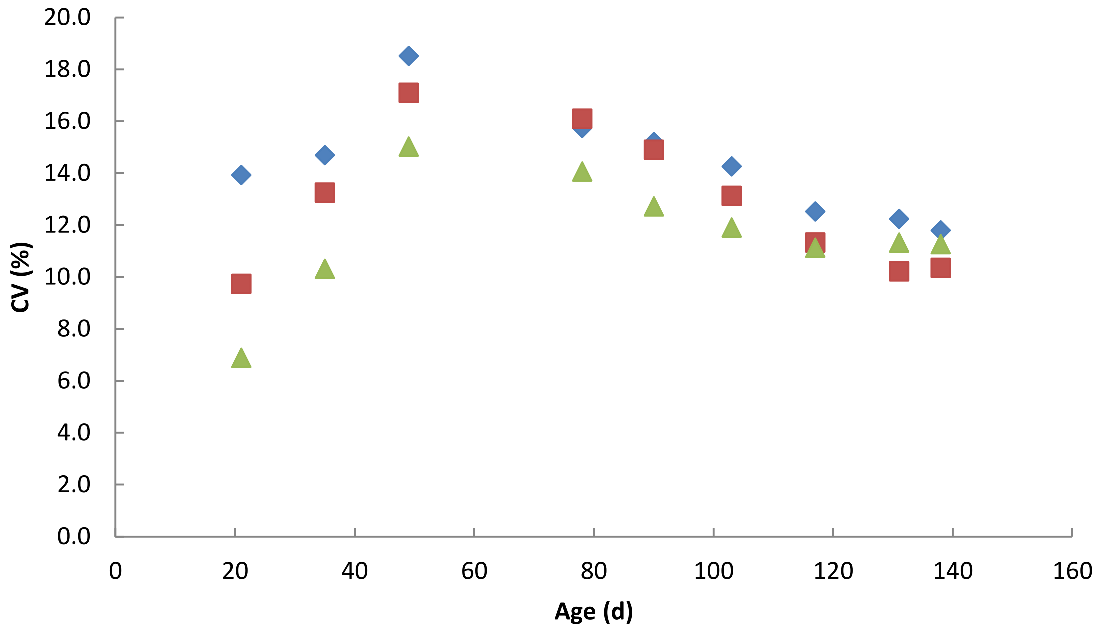

Figure 5.2 Coefficient of variation (CV) of weight over the experimental period for the Control (◆) population and pigs of High (▲) and Low (■) weaning weights.

Average daily gain in the periods between weigh events showed the advantage of the High weaners throughout most of the experimental period (Figure 5.3). Apart from the first week immediately post-weaning, the High group grew significantly faster than Low weight weaners through to 90 days of age. The fall in growth rates in the latter periods was a response to reduced energy content of finisher diets.

Average daily feed intake showed a consistent increase across the experimental period (Figure 5.4) with High weight weaners having a higher intake during each period. There was little consistency to the pattern of FCR with no significant differences seen throughout the experimental period (Figure 5.5).

When looking at intake from an energy basis (Figure 5.6), the Low weight group was still significantly lower, despite receiving a higher density creep diet for an extended period. There was no difference between groups in the efficiency of conversion of this energy to growth (Figure 5.7).

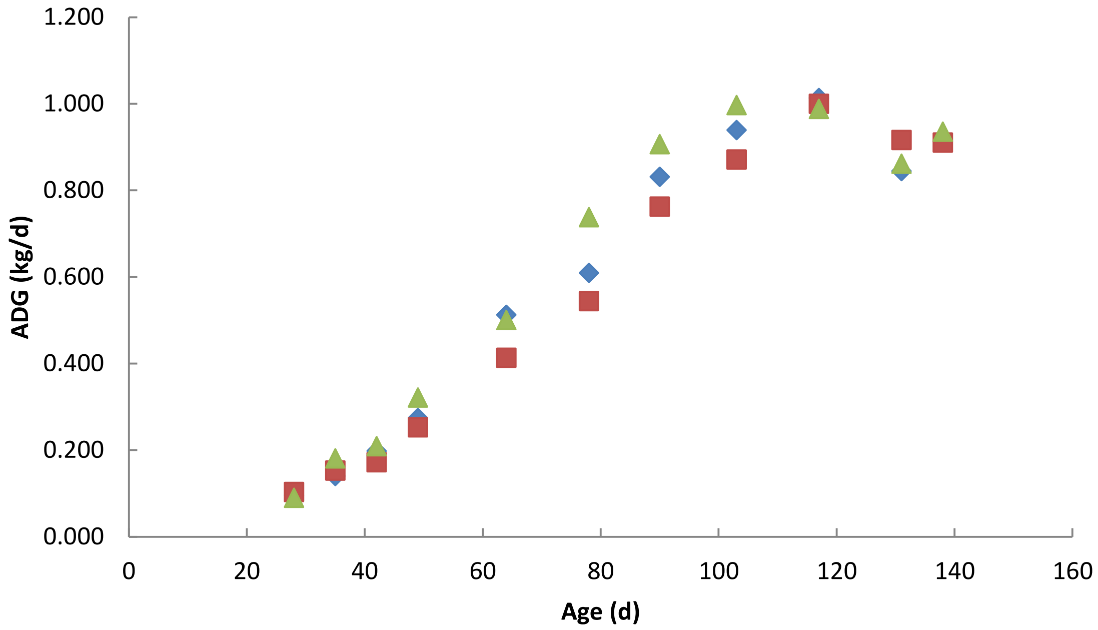

Figure 5.3 Periodic average daily gain (ADG) for the Control (◆) population and pigs of High (▲) and Low (■) weaning weights.

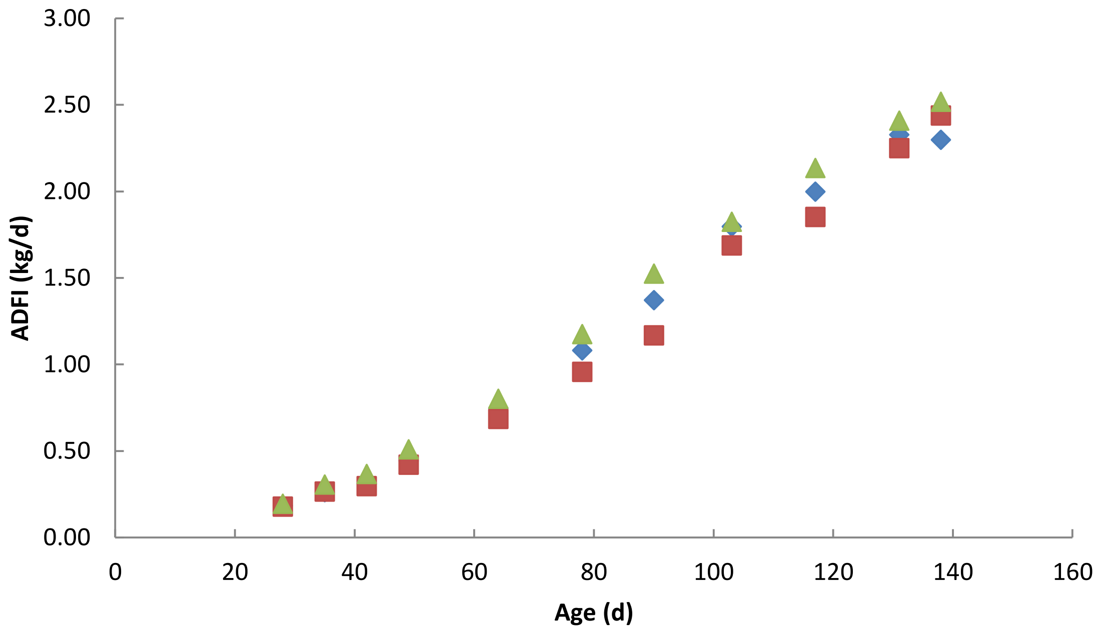

Figure 5.4 Periodic average daily feed intake (ADFI) for the Control (◆) population and pigs of High (▲) and Low (■) weaning weights.

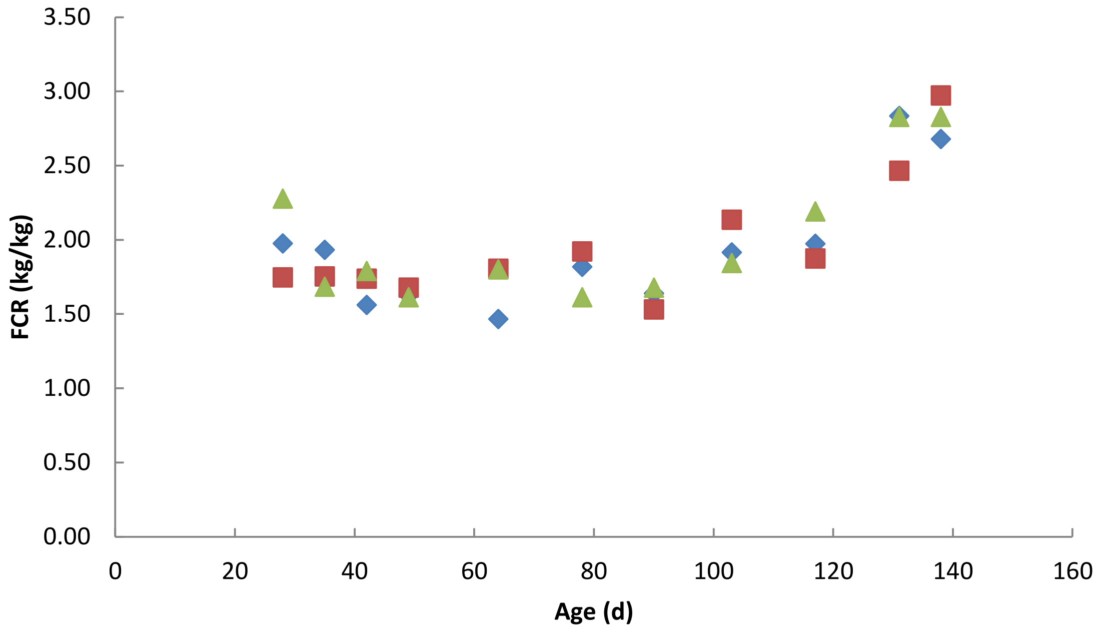

Figure 5.5 Periodic feed conversion ratio (FCR) for the Control (◆) population and pigs of High (▲) and Low (■) weaning weights.

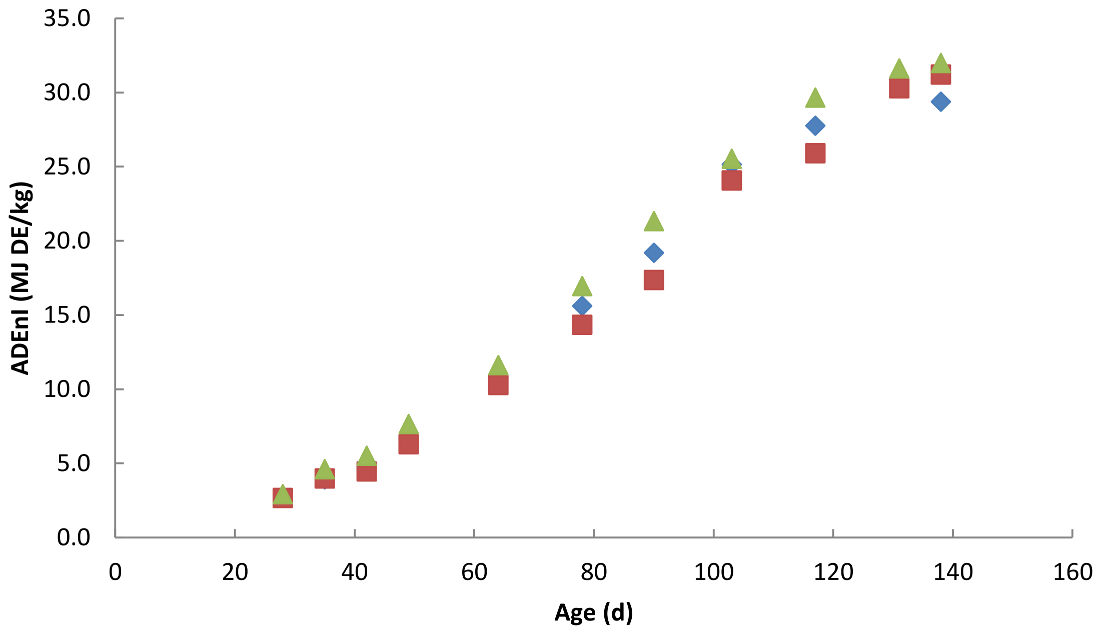

Figure 5.6 Periodic average daily energy intake (ADEnI) for the Control (◆) population and pigs of High (▲) and Low (■) weaning weights.

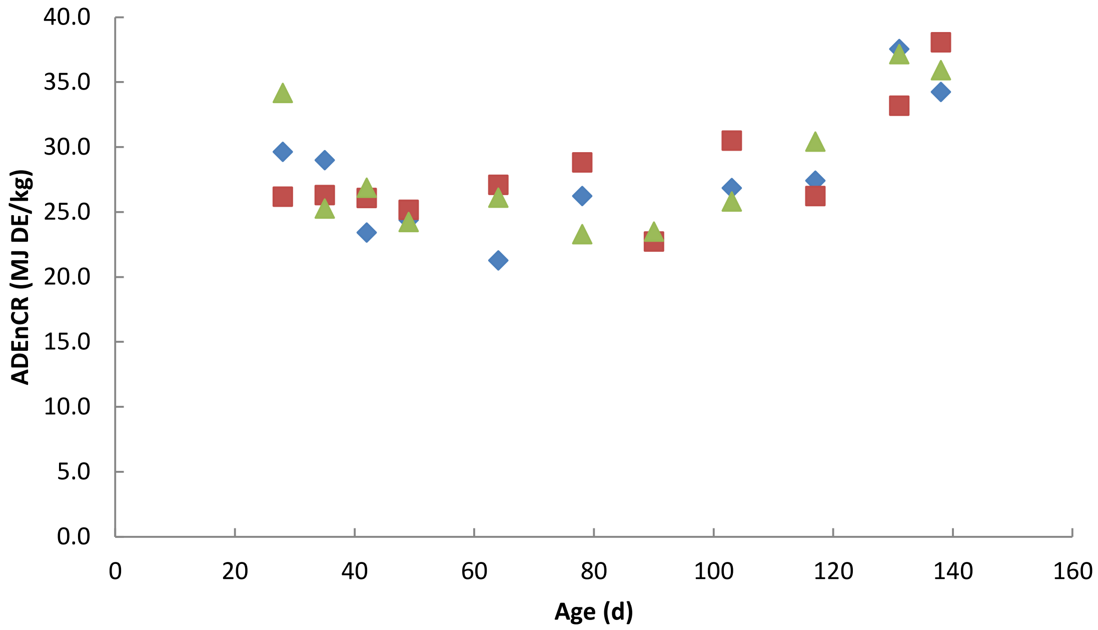

Figure 5.7 Periodic average daily energy conversion ratio (ADEnCR) for the Control (◆) population and pigs of High (▲) and Low (■) weaning weights.

When we compare growth performance on a weight basis there was little difference between the Control and Low weight weaning groups, with these two groups following the same pattern for ADG (Figure 5.8), ADFI (Figure 5.9) and energy intake (Figure 5.11).

In effect the High weaning weight groups had a lower feed and energy intake at the same weight as the other groups. A similar pattern was seen in growth rate, with the High group growing slower at the same weight, but plateau point appeared to be extended.

Patterns in the conversion of feed (Figure 5.10) and energy (Figure 5.12) were again more variable than other measures, but High weight weaners tended to convert more efficiently at the same weight.

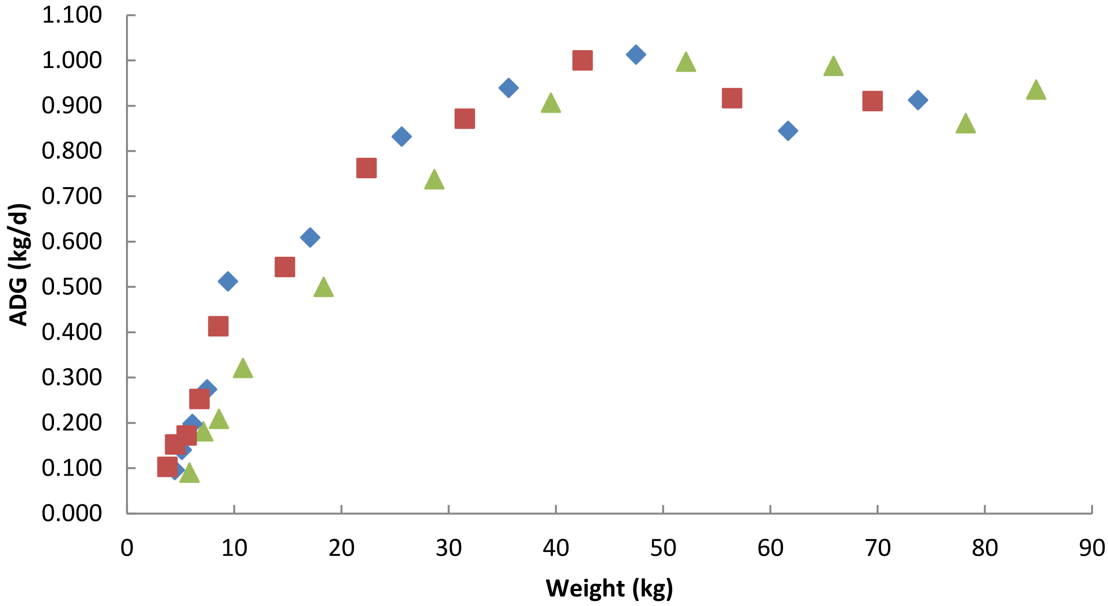

Figure 5.8 Average daily gain (ADG) for the Control (◆) population and pigs of High (▲) and Low (■) weaning weights plotted against live weight.

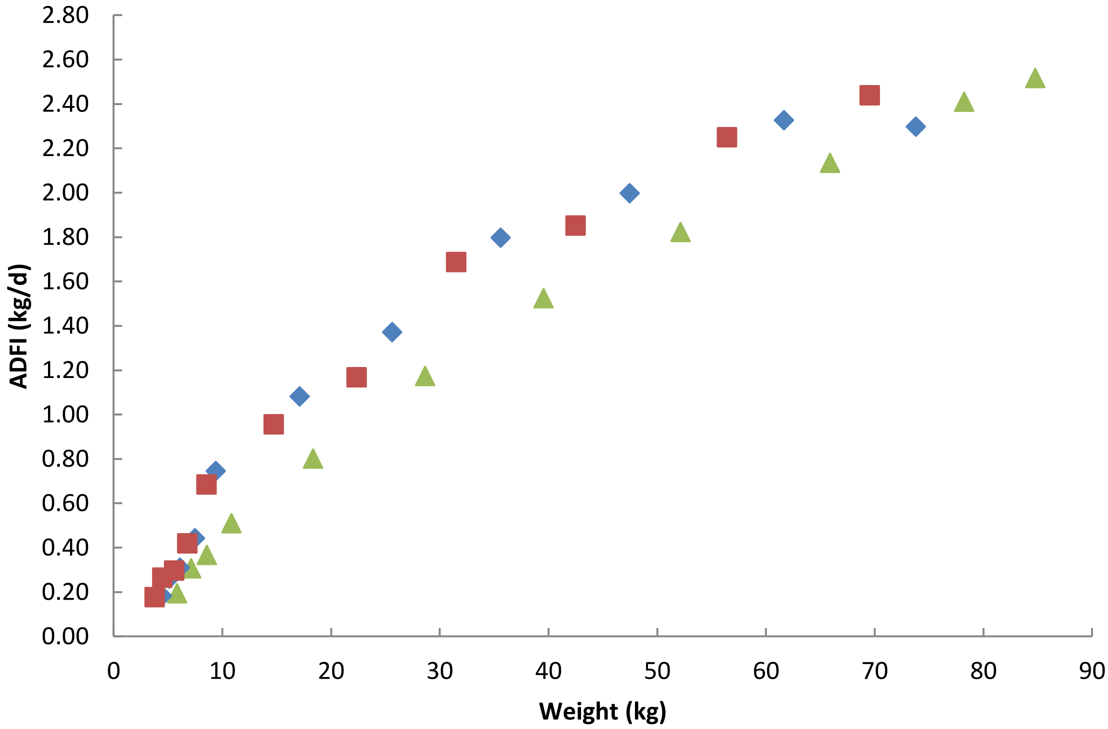

Figure 5.9 Average daily feed intake (ADFI) for the Control (◆) population and pigs of High (▲) and Low (■) weaning weights plotted against live weight.

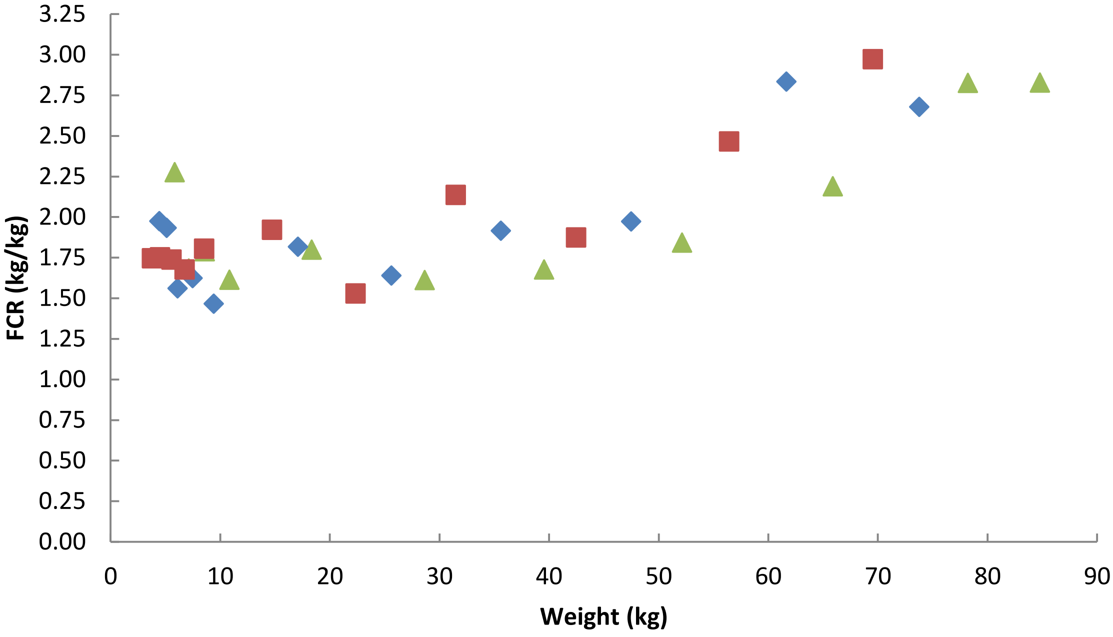

Figure 5.10 Feed conversion ratio (FCR) for the Control (◆) population and pigs of High (▲) and Low (■) weaning weights plotted against live weight.

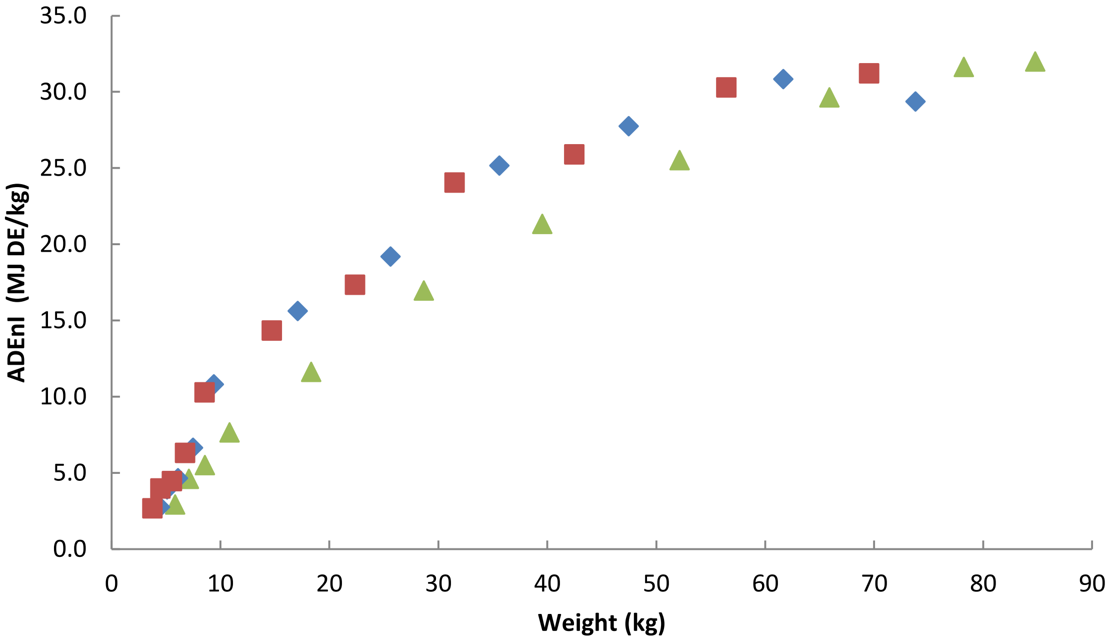

Figure 5.11 Average daily energy intake (ADEnI) for the Control (◆) population and pigs of High (▲) and Low (■) weaning weights plotted against live weight.

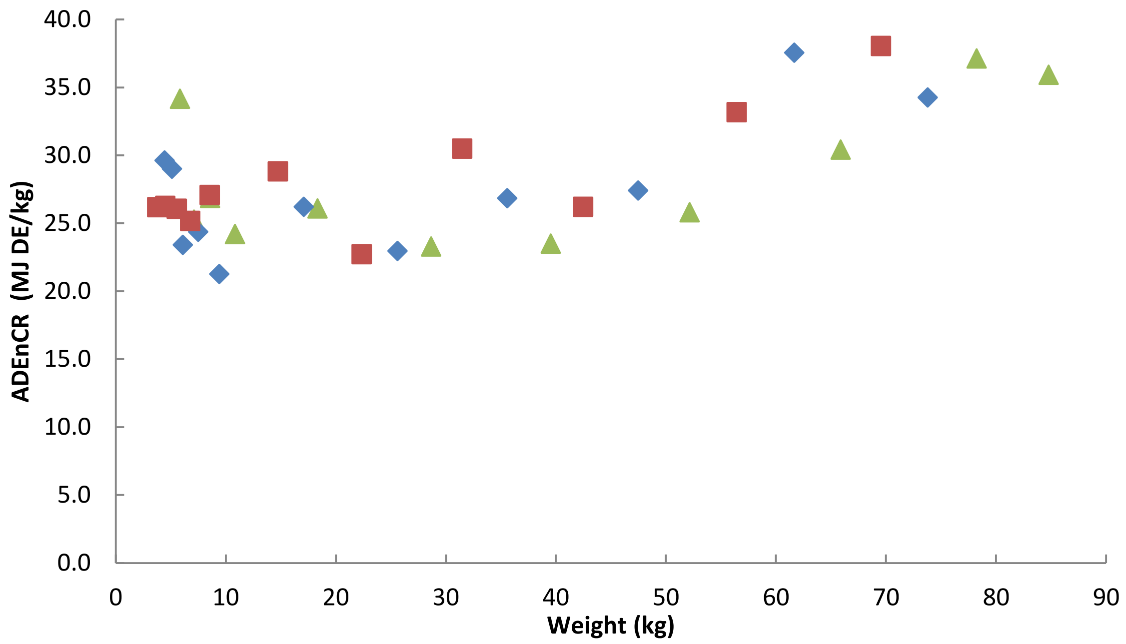

Figure 5.12 Average daily energy conversion ratio (ADEnCR) for the Control (◆) population and pigs of High (▲) and Low (■) weaning weights plotted against live weight.

6. Discussion

Low weight weaners are compromised when compared to weaners of heavier weight. In this study they consume less feed than their heavier contemporaries, they convert this at the same rate as their heavier counterparts and as a consequence they grow slower than a weaner of heavier weight. These results are similar to those of Rehfeldt *et al.* (2008) and Douglas *et al.* (2014a), although neither of these studies reported a 'stable' feed conversion between weight groups as seen here.

The pattern of growth observed in this study also suggests that the prolonged nutritional intervention of providing a 15.0 MJ DE/kg, 0.80 g available lysine/MJ DE creep diet for an extended period was not able to boost the performance of light weight weaners to that of larger weaners. Similarly, in the aptly named paper "Too late to catch up", Douglas *et al.* (2014a) suggests that "a higher specification diet post weaning may not improve the performance of low birth weight pigs", when the diet is offered in the grower phase.

However, another study by Douglas *et al.* (2014b) showed that the supplementation of low birth weight pigs with a higher specification diet did result in improved performance compared with low birth weight pigs fed a standard diet. However, in a direct comparison with higher birth weight pig's performance did not match that of the higher birth weight pigs. It should be noted that the light weight pigs in this study were approximately 6.85 kg at 28 days of age.

Consequently, it is possible that we did achieve some response to the supplementation of light weight pigs with a higher density more digestible diet for a longer period. In fact, performance may have been worse and the differential in days to slaughter greater without this intervention.

This project suggests that we cannot boost the performance of low weight weaners to those of the control, or higher weight groups. Whilst, there is some evidence that improvements in performance may be occurring to the low weight weaners through diet supplementation, we should still be trying to remedy the problem, rather than addressing the consequences.

7. Implications & Recommendations

This project shows that a compromised weaner will remain a compromised grower and finisher pig. Despite an intervention that increased feed costs per kg of gain by 15%, there was no ability to boost the performance of Low weight weaners to the mean level of the population, let alone to the performance of a higher weight weaner.

A lower weaning weight resulted in a lower feed intake, which resulted in a lower rate of gain, as no change in FCR was observed across the experiment. This reduced rate of gain resulted in pigs that took longer to reach marketable weight, such that each 100 gram reduction in weaning weight resulted in one extra day required to reach sale weight.

When these growth performance results were modelled (Peter Cook, *pers comm*), without accounting for difference in morbidity or mortality that are likely to be associated with lower weaning weight, then the High weaning weight group had an increase MOFC of $7 per pig when compared to the Control populations. The Low weaning weight group generated $2 less MOFC per pig than the Control population.

The main recommendation from this study to producers is that they should aim to reduce the impediments that requires them to wean pigs at a lighter than optimum weight, as any compromises made at weaning are conserved throughout the growth phase and are not easily rectified once they have been set in motion.

The main recommendation from this study to researchers and funding bodies is that it is hard to influence the performance of the pig post-weaning, and that return on expenditure is likely to be better from projects or interventions that result in a larger weaner being produced than from projects or interventions trying to remediate the compromised weaner.

8. Intellectual Property

There has been no protectable intellectual property generated from this project.

9. Technical Summary

This project has generated information about the comparative growth rate of different weight weaners. The pattern of growth of High, Low or Control weaners was similar despite nutritional intervention to boost low weight performance. This project showed that despite the offering of a highly digestible diet for a longer period, shifts in the efficiency of feed conversion were not possible, with Low, High and the Control population not differing in FCR across the experimental period. From this project it would appear that weaning weight, generally, predetermines the potential growth of the pig.

As a consequence, to maximise the return on expenditure, focus within both the research and commercial sectors should be targeted towards producing a higher quality weaner rather than trying to design a system or program that can handle weaners that are being compromised as a result of poor management, planning or a lack of capital resources.

10. Literature cited

Douglas, S.L., Edwards, S.A. and Kyriazakis, I. (2014a). Too late to catch up: A high nutrient specification diet in the grower phase does not improve the performance of low birth weight pigs. *Journal of Animal Science* 92, p. 4577-4584.

Douglas, S.L., Wellock, I., Edwards, S.A. and Kyriazakis, I. (2014b). High specification starter diets improve the performance of low birth weight pigs to 10 weeks of age. *Journal of Animal Science* 92, p. 4741-4750.

Morrison, R., Pluske, J., Smits, R., Henman, D. and Collins, C. (2009). The use of high cost weaner diets to improve post weaning growth performance. Report (2B-103) prepared for the Co-operative Research Centre for an Internationally Competitive Pork Industry, Roseworthy, SA.

Rehfeldt, C., Tuchscherer, A., Hartung, M. and Kuhn, G. (2008). A second look at the influence of birth weight on carcass and meat quality in pigs. *Meat Science* 78, p. 170-175.

11. Publications Arising

There are no publications currently arising from this study, it is anticipated that these results will be prepared for presentation at APSA 2015.