Commercial assessment of the impact of light for age pigs on feed efficiency and carcass composition

2H-101

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

By

CL Collins, K Witherden, M Tull, R Smits

Rivalea Australia, Corowa NSW

January 2010

Established and supported under the Australian Government's Cooperative Research Centres Program

Executive Summary

Marketing pigs at the optimal weight and carcass composition is critical to maximising returns for Australian pork producers. The aim of this study was to assess the impact that 'light for age' pigs contribute to feed: gain values, carcass weight and carcass composition under commercial situations. Piglets born to a subset of gilts and sows (10 gilts and 20 sows per week for five weeks, Large White x Landrace, PrimeGro™ Genetics) were individually identified and weighed within 24 hours of birth. Piglets were classified as light (birth weight (BW) ≤ 1.3 kg), medium (BW 1.4-1.6 kg) or heavy (BW≥ 1.7 kg) at birth. At weaning (average age 26.8 days ± 0.08 days), a total of 120 pigs per week were selected based on BW category and individually weighed. Pigs were weaned into group weaner accommodation (10 pigs per pen of the same sex and BW category, 0.54 m^2/pig). Pigs were transferred to grower accommodation at 40 days post weaning for three to four weeks until body size was sufficient for entry to pens fitted with electronic feeders. At 13-14 weeks of age pigs were transferred to the electronic feeder pens. Pigs were housed in groups of 30 pigs per pen of the same sex (mixed BW) with each pen containing three electronic feeders. Individual weight, feed intake, feed efficiency, P2 back fat depth and leg fat depth were measured periodically on each animal through to sale at sorted weights as they reached a target of 90 kg live weight.

During the weaner period, the light BW pigs consumed less feed than the medium or heavy BW pigs ($P<0.001$) and grew slower than the heavy BW pigs ($P=0.016$). Live weight at entry to the electronic feeders was influenced by BW (light BW: 42.3 kg medium BW: 45.3 kg and heavy BW: 48.3 kg, $P<0.001$). From 14 to 17 weeks of age, there was a tendency for the heavy BW pigs to gain weight faster than those born light ($P=0.095$), and to utilize feed for weight gain more efficiently ($P=0.057$). Live weight at 19 weeks of age was influenced by BW, with the average weight of the light BW animals 6.5 kg less than the heavy BW pigs.

Including live weight as a covariate in the analyses, the light BW animals displayed greater adipose tissue depths (P2 and leg fat) than the heavier birth weight animals at both 17 and 19 weeks of age. Carcass P2 was also significantly greater in the light BW animals. Birth weight had a significant influence on survivability, with the light BW pigs more likely to die or be removed from the group between weaning and the close out of the finisher period.

The results from this study confirm that pigs born at weights below 1.3 kg display reduced lifetime growth rates, an increased likelihood of illness and/ or mortality and are fatter at slaughter. The challenge for producers is to employ management strategies that cost effectively assist in improving the performance and health status of this group of animals.

Table of Contents

1. Introduction

Marketing pigs at the optimal weight and carcass composition is critical to maximising returns for Australian pork producers. One selling technique utilised to ensure the majority of pigs are sold at the optimal carcass specification is selling out at sorted weights. Many producers use automatic sorting systems within large pens of finisher pigs to assist in this selling strategy. These systems require the animals to proceed over a set of scales in order to reach the feeding area. Pigs that are identified as having reached the target selling weight are then automatically drafted out to a separate feeding area to be marketed. The aim is to sell out the finisher pen over a minimal number of weeks. Preliminary data indicates that 50-60 % of the finisher population sold at sorted weights reach the target live weight within the first 3 weeks. Of the remaining animals, a proportion take up to 14 additional days to reach the target weight, while 15 - 20 % are not sold out at the final sort and are moved to alternative housing. Reducing this sorting variability would provide significant savings to the pig industry through an increase in carcass weight, a reduction in feed costs and more efficient use of grower and finisher space

Light weight pigs at entry to the finisher period have failed to reach the lifetime growth rates of their heavier counterparts due to either a lack of potential (ie light weight at birth) or due to disease or negative social interactions during earlier growth periods. With the total number of muscle fibres remaining relatively stable throughout postnatal growth, compromised foetal growth and reduced development of individual muscle fibres *in utero* has a large influence on the piglets' capacity for postnatal growth. Pigs born at low birth weights have fewer muscle fibres at birth, but similar muscle fibre diameter compared to their heavier born counterparts (Handel and Stickland 1984; Hegarty and Allen 1978; Powell and Aberle 1981). These differences in body composition at birth result in slower postnatal growth rates and an increased time to achieve a targeted slaughter weight (Hegarty and Allen 1978; Rehfeldt and Kuhn 2006). A recent study under commercial conditions indicated that up to 30 % of pigs born weigh less than 1.2 kg, with only 3 % of these animals born at weights less than 800g. In this same study, 75 % of the pigs born at weights between 0.8 and 1.2 kg survived through to day 10, indicating that there is a substantial population of animals that may have reduced growth potential. Carcass composition also differs in light birth weight animals, with low birth weight or 'runt' animals observed to have a greater adipose tissue content across a range of commercial slaughter weights (Collins 2007; Powell and Aberle 1980) and to have a reduced meat percentage and loin muscle area than heavy birth weight pigs at slaughter (Rehfeldt and Kuhn 2006). Recent analyses of slaughter data from an experiment in Pork CRC project 2B-103 has also confirmed that current genotype pigs born at or below 1.2 kg have a greater P2 back fat depth at 22 weeks of age (P<0.001) compared to pigs born at heavier weights.

It is necessary to conduct a preliminary study to assess the impact that 'light for age' pigs contribute to feed:gain values and carcass weight/P2 under commercial situations. Dependent upon the outcomes from this initial study, further experiments will investigate measures to improve the growth performance of light for age animals, thereby reducing sorting variability, minimising feed costs and improving carcass composition at slaughter

2. Methodology

Animals and treatments

Piglets born to a subset of gilts and sows (10 gilts and 20 sows per week for five weeks, Large White x Landrace PrimeGro™ Genetics) were individually identified and weighed within 24 hours of birth. Piglets were classified as light (birth weight ≤ 1.3 kg), medium (birth weight 1.4-1.6 kg) or heavy (birth weight ≥ 1.7 kg) at birth. No other treatments or interventions were imposed during the pre-weaning period outside of standard husbandry practices. At weaning (26.8 days ± 0.08 days, mean ± SE), a total of 120 pigs per week were selected based on birth weight category and individually weighed. Pigs were weaned into group weaner accommodation (10 pigs per pen of the same sex and birth weight category, 0.54 m^2/pig).

Husbandry and management

Piglets were processed as normal within 24 hours of birth. A minimal cross fostering approach was undertaken to ensure all piglets had access to a viable teat on the sow. Piglets were weaned during the fourth week of lactation on a set day (average age 26.8 days ± 0.08 days) into an environmentally controlled weaner facility. Pen weights were recorded at weaning (day 0), day 21 and day 40. Pen feed intakes were calculated during these time periods as measured by feed disappearance and pen feed efficiency subsequently calculated. All deaths and removals were recorded and taken into account when calculating feed intake and feed efficiency by the adjustment of the number of days that pigs were on trial. Pigs were provided *ad libitum* access to commercial starter, weaner 1 and weaner 2 diets during this time (Table 1), while water was freely available via nipple drinkers within each pen.

At 40 days post weaning, pigs were transferred to grower accommodation for three to four weeks until body size was sufficient for entry to pens fitted with electronic feeders. At 13-14 weeks of age (average age 95.3 days ± 0.17 days) pigs were transferred to the electronic feeder pens. Pigs were housed in groups of 30 pigs per pen of the same sex (0.82 m^2/pig) with each pen containing three electronic feeders. Although pens remained single sex, each pen contained light, medium and heavy birth weight pigs within the one pen. Pens were partially slatted in an uninsulated building with side shutters that are controlled by temperature. Upon entry to the pens, pigs were individually identified with an electronic tag to enable the measurement of individual feed intakes within a group pen. Pigs were offered a commercial grower diet from 10 to 17 weeks of age and a commercial finisher diet from 17 weeks of age through to sale (Table 2). Pigs were individually weighed upon entry to the electronic feeders, while P2 and leg fat depth were also measured at this time. Individual weights, feed intake and feed efficiency were continually monitored at 21 day intervals until sale. In addition, individual weight, P2 back fat depth and leg fat depth were also measured at 19 weeks of age on all animals to ensure a final comparison point at a set age. Animals were sold out at sorted weights as they reached a target of 90 kg live weight. At sale, all animals were individually weighed and P2 and leg fat depth measured on the live animal. Pigs were slaughtered at a commercial abattoir and carcass weight and P2 back fat depth measured.

Table 1 - Nutrient composition of the common starter, weaner 1 and weaner 2 diets fed to 40 days post weaning, % of diet (as fed*)

	Starter	Weaner 1	Weaner 2
DE, MJ/kg	15.0	14.7	14.5
Crude protein	22.2	24.0	23.8
Crude fibre	1.7	2.5	3.0
Crude fat	8.1	5.0	4.2
Total Lysine	1.57	1.54	1.38
Available lysine	1.41	1.37	1.18
Available lysine: DE (g/MJ)	0.94	0.93	0.82

*Estimated from Rivalea Australia Pty Ltd composition data

Table 2 - Nutrient composition of the common grower and finisher diets offered to all pigs from 40 days post weaning, % of diet (as fed*)

	Grower	Finisher
DE, MJ/kg	13.8	13.8
Crude protein	19.6	15.1
Crude fibre	4.0	4.3
Crude fat	3.9	5.4
Total Lysine	1.13	0.84
Available lysine	0.98	0.72
Available lysine: D E (g/MJ)	0.71	0.52

*Estimated from Rivalea Australia Pty Ltd composition data

Statistical analyses

Differences in growth performance due to the effects of birth weight category were analysed using an analyses of variance for a randomised design. The experimental unit for the growth performance data during the weaner period was the pen. The individual animal was utilised as the experimental unit for the feed intake and growth performance data in the electronic feeders as all birth weight categories were represented within the one pen. Similarly, the individual animal was utilised as the experimental unit for the lifetime growth performance analyses and carcass composition data. Differences in mortalities and removals due to birth weight category were analysed using chi squared analyses. All analyses were performed using Genstat 10th Edition (Payne *et al.* 2005).

3. Outcomes

Growth performance

Pigs of three distinct birth weight categories were identified within 24 hrs of birth: light birth weight (mean 1.2 kg, range 0.6 – 1.3 kg), medium birth weight (mean 1.5 kg, range 1.4-1.6 kg), heavy birth weight (mean 1.9 kg, range 1.7-2.6 kg). A subset of these animals were selected at weaning (average age 26.8 days ± 0.08 days), by which time the magnitude of the differences in birth weight had increased, particularly with the heavy birth weight animals (light: 6.2 kg, medium: 6.9 kg, heavy: 7.9 kg). Of interest, in each replicate there were very few light birth weight male piglets to select at weaning, with many of the male pigs born less than 1.3 kg being unable to survive through to weaning. As such, there were less light birth weight pigs in total selected at weaning (n=190) compared to the medium birth weight (n=199) or heavy birth weight pigs (n=200).

The impact of birth weight category and sex on growth performance during the weaner period is displayed in Table 3. Pigs born light consumed less feed and grew significantly slower than the medium or heavy birth weight pigs during the initial 21 days post weaning. During the subsequent period from 21 to 40 days post weaning the light birth weight pigs continued to consume less feed than the heavier born pigs, although the differences in growth performance were not as great. Over the entire weaner period the light birth weight pigs ate less feed than the medium or heavy birth weight pigs ($P<0.001$) and grew slower than the heavy birth weight pigs ($P=0.016$). At the end of the weaner period, the light birth weight pigs were 1.4 kg lighter than the medium birth weight pigs and 3.3 kg lighter than the heavy birth weight animals.

Pigs were moved into the electronic feeders at an average age of 95.3 days and an average live weight of 42.3 kg for the light birth weight pigs, 45.3 kg for the medium birth weight pigs and 48.3 kg for the heavy birth weight pigs ($P<0.001$). Of the population selected at weaning, there was a greater percentage of medium birth weight pigs that were moved to the electronic feeders (88 % of those originally selected) compared to the heavy birth weight pigs (85 %) and the light birth weight pigs (77 %). The influence of birth weight category and sex on growth performance from 95 days of age through to sale is displayed in Table 4. During the initial 21 days in the electronic feeder pens there was a tendency for the heavy birth weight pigs to gain weight faster than those born light ($P=0.095$), and to utilize feed for weight gain more efficiently ($P=0.057$). From 14 to 19 weeks of age, the heavy birth weight animals tended to consume more feed than either the medium or light birth weight animals ($P=0.070$), although the differences in weight gain were not significant. Live weight at 19 weeks of age was influenced by birth weight, with the average weight of the light birth weight animals 6.5 kg less than the heavy birth weight pigs at the same age. There was a strong correlation between weight at 19 weeks of age and birth weight (correlation coefficient 0.269, $P<0.001$). Variation in live weight at 19 weeks of age was greatest in the heavy birth weight pigs (range 36-100 kg, coefficient of variation (CV) 16.6 %) compared to the medium (range 43-94 kg, CV 15.6 %) and light (range 35-97.5 kg, CV 15.3%) birth weight pigs. Animals were sold out at a target weight of 90 kg from 19 weeks of age. Pigs were sold out once a week if they were greater than 88 kg on the weekly weigh day. All remaining animals were sold out at 24 weeks of age due to the requirement for the electronic feeders in the following replicates of this experiment. As such, the average weight at sale was not 90 kg, but rather 82.9, 83.8 and 85.9 kg respectively for the light, medium and heavy birth weight animals (P=0.014). Age at sale was significantly greater for the light birth weight pigs (153.3, 151.3 and 149.4 days respectively for the light, medium and heavy birth weight pigs, P<0.001). The number of pigs classified as 'full value' (90 kg live weight by 23 weeks of age) differed between birth weight categories (40.3 %, 55.1 % and 61.5 % of the pigs weaned for the light, medium and heavy birth weight pigs respectively, x^2=18.4, P<0.001). Growth rate was generally low across all treatment groups in the electronic feeders. Considering only the animals that were present in the electronic feeders at 19 weeks of age, 1.2 % of the heavy birth weight pigs died or were removed between 19 weeks of age and sale, while in comparison 3.0 % of the medium birth weight pigs present at 19 weeks of age were not sold and 6.7 % of the light birth weight pigs present at 19 weeks of age were not sold. The animals that were not sold due to being underweight were moved to other facilities until they reached an acceptable sale weight. Unfortunately, the fate of these animals (i.e age at eventual slaughter) could not be tracked.

The impact of birth weight on survival through to sale weight is displayed in Figure 1. While the majority of pigs were sold out between 21 and 23 weeks of age, sale age ranged from 19 to 24 weeks of age. Not surprisingly, there was a greater percentage of heavy birth weight pigs sold out before 21 weeks of age compared to the light or medium birth weight pigs. The light birth weight pigs were more likely to die or be removed from the group for welfare reasons between weaning and the close out of the finisher period (34%) compared to 19.5 % for the medium birth weight pigs and 20 % for the heavy birth weight pigs.

Table 3 - Influence of birth weight category on growth rate, feed intake and feed efficiency of group housed weaner pigs

	Sex		SED	Birth weight			SED	Significance		
	Female	Male	Sex	Light (n=190)	Medium (n=199)	Heavy (n=200)	Birth weight	Sex	Birth weight	Sex x Birth weight
Live weight										
Weaning	7.0	6.9	0.15	6.2	6.9	7.9	0.19	0.40	<0.001	0.24
Day 21 post-weaning	13.3	13.2	0.21	11.9	13.2	14.7	0.25	0.74	<0.001	0.41
Day 40 post weaning	25.0	26.4	0.45	24.1	25.5	27.4	0.55	0.003	<0.001	0.12
0-21 days										
ADG (g/d)	298.4	301.1	7.53	271.5	300.4	327.4	9.23	0.72	<0.001	0.48
ADFI (g/d)	363.2	343.9	9.67	320.2	358.4	382.1	11.85	0.053	<0.001	0.84
FCR (kg/kg)	1.22	1.15	0.027	1.19	1.20	1.17	0.034	0.011	0.57	0.80
21-40 days										
ADG (g/d)	614.3	691.4	20.33	644.9	647.4	666.3	24.90	<0.001	0.61	0.21
ADFI (g/d)	928.9	895.7	26.07	865.5	899.6	971.8	31.93	0.21	0.006	0.71
FCR (kg/kg)	1.52	1.33	0.054	1.37	1.42	1.49	0.065	<0.001	0.18	0.24
0-40 days										
ADG (g/d)	448.6	486.5	10.82	448.8	465.5	488.3	13.25	<0.001	0.016	0.18
ADFI (g/d)	627.5	597.4	15.22	571.9	610.9	654.6	18.64	0.054	<0.001	0.77
FCR (kg/kg)	1.40	1.24	0.035	1.28	1.33	1.35	0.043	<0.001	0.32	0.20

Table 4 - Influence of birth weight category on growth rate, feed intake and feed efficiency during the finisher period

	Sex		SED	Birth weight			SED	Significance		
	Female	Male	Sex	Light (n=147)	Medium (n=175)	Heavy (n=169)	Birth weight	Sex	Birth weight	Sex x Birth weight
Age (days)										
Entry to electronic feeders	95.3	95.3	0.17	95.4	95.2	95.4	0.21	0.95	0.61	0.22
Sale	152.3	150.1	0.57	153.3	151.3	149.4	0.70	<0.001	<0.001	0.88
Sale*	151.7	150.7	0.53	152.9	151.2	149.8	0.64	0.068	<0.001	0.96
Live weight (kg)										
Entry to electronic feeders	45.3	45.6	0.64	42.3	45.3	48.3	0.77	0.64	<0.001	0.55
17 weeks of age	57.9	59.5	0.87	55.4	58.0	62.1	1.06	0.069	<0.001	0.52
19 weeks of age	67.0	71.8	0.99	65.9	69.0	72.4	1.22	<0.001	<0.001	0.58
Sale	82.2	86.6	0.87	82.9	83.8	85.9	1.07	<0.001	0.014	0.29
Average daily gain (kg/d)										
14 – 17 weeks of age	0.539	0.618	0.022	0.575	0.551	0.608	0.027	<0.001	0.095	0.74
14 – 19 weeks of age	0.587	0.715	0.018	0.639	0.639	0.666	0.022	<0.001	0.28	0.57
14 weeks of age – Sale	0.637	0.753	0.015	0.695	0.685	0.703	0.018	<0.001	0.58	0.23
Average daily feed intake (kg/d)										
14 – 17 weeks of age	1.31	1.29	0.034	1.26	1.30	1.34	0.042	0.54	0.22	0.030
14 – 19 weeks of age	1.47	1.55	0.032	1.49	1.48	1.56	0.039	0.006	0.070	0.055
14 weeks of age – Sale	1.65	1.76	0.027	1.69	1.68	1.73	0.033	<0.001	0.23	0.18
Feed conversion ratio (kg/kg)										
14 – 17 weeks of age	2.51	2.18	0.125	2.48	2.44	2.16	0.154	0.007	0.057	0.20
14 – 19 weeks of age	2.74	2.27	0.075	2.51	2.53	2.49	0.092	<0.001	0.86	0.81
14 weeks of age – Sale	2.67	2.40	0.049	2.51	2.53	2.56	0.061	<0.001	0.81	0.50

*Sale weight as covariate

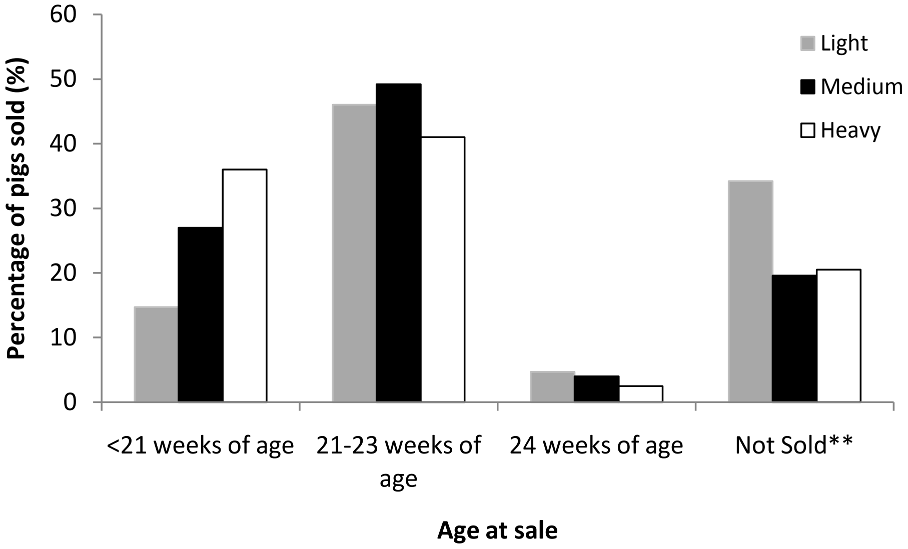

Figure 1 - Influence of birth weight category on the percentage of animals sold by age during the finisher period.
** Not sold refers to animals that died or were removed between weaning and the close out of the finisher period (24 weeks of age). These animals may have eventually been sold at an older age, but unfortunately this could not be tracked.

Further break down of the individual live weight data at entry to the electronic feeders (14 weeks of age) and again at 19 weeks of age shows the distribution of animals that were 'light for age' in each of the birth weight categories (Figure 2). Light for age in this instance has been defined as the percentage of animals from each birth weight category with weights below the lower quartile cut off weight for the entire population. At 14 weeks of age, 35.1 % of the population of light birth weight pigs remained light for age, 26.4 % of the medium birth weight pigs were light for age and 14.2 % of the heavy birth weight pigs were light for age. The percentage of pigs from each of the birth weight categories that remained light for age at 19 weeks of age were similar to the distribution at 14 weeks of age (Figure 2).

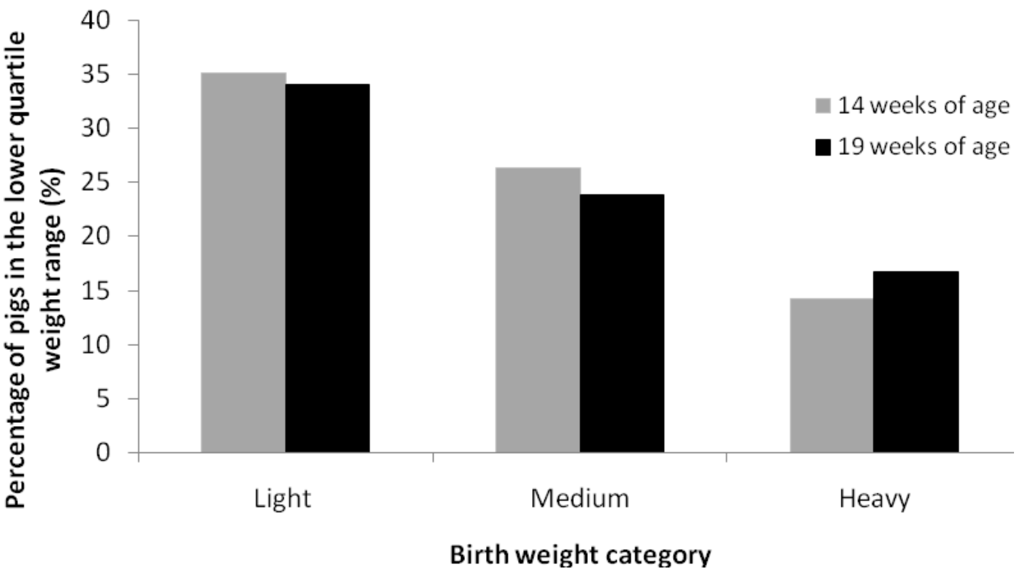

Figure 2 - Percentage of pigs light for age at 14 and 19 weeks of age
Average weight at 14 weeks of age: 45.5 kg, 19 weeks of age: 69.3 kg.

The influence of birth weight category on body composition and carcass characteristics is displayed in Table 5. Including live weight as a covariate in the analyses, the light birth weight animals displayed greater adipose tissue depths (P2 and leg fat) than the heavier birth weight animals at both 17 and 19 weeks of age. Carcass P2 was also significantly greater in the light birth weight animals. At 19 weeks of age, regression analysis using leg fat depth measurements confirms that the light birth weight pigs had significantly more adipose tissue for any given live weight (Figure 3). Similar analysis for carcass P2 indicates that for any given carcass weight, the light birth weight pigs will have approx 0.6 mm of extra P2 back fat depth (Figure 4).

Table 5 - Influence of birth weight category on live weight and body composition during the finisher period

	Sex		SED	Birth weight			SED	Significance		
	F	M	Sex	L	M	H	BW	Sex	BW	Sex x BW
P2 fat depth (mm)										
17 weeks	7.7	7.2	0.11	7.3	7.5	7.6	0.13	<0.001	0.13	0.93
19 weeks	8.3	8.2	0.11	8.1	8.3	8.3	0.13	0.37	0.46	0.73
Sale	9.1	9.1	0.11	9.1	9.1	9.1	0.13	0.84	0.95	0.40
P2 fat depth (mm)*										
17 weeks	7.7	7.2	0.09	7.5	7.5	7.3	0.11	<0.001	0.05	0.56
19 weeks	8.4	8.0	0.08	8.4	8.3	8.1	0.10	<0.001	0.014	0.27
Sale	9.3	8.9	0.08	9.2	9.1	9.0	0.10	<0.001	0.15	0.84
Leg fat depth (mm)										
17 weeks	8.3	7.6	0.13	7.7	8.0	8.1	0.16	<0.001	0.046	0.91
19 weeks	9.1	8.9	0.15	8.9	8.9	9.1	0.18	0.14	0.35	0.72
Sale	10.1	10.0	0.15	10.1	10.0	10.1	0.18	0.86	0.95	0.23

	Sex		SED	Birth weight			SED	Significance		
	F	M	Sex	L	M	H	BW	Sex	BW	Sex x BW
Leg fat depth (mm)*										
17 weeks	8.4	7.5	0.09	8.1	8.0	7.7	0.11	<0.001	0.011	0.48
19 weeks	9.3	8.6	0.11	9.2	8.9	8.8	0.13	<0.001	0.008	0.37
Sale	10.3	9.8	0.12	10.2	10.0	9.9	0.14	<0.001	0.10	0.43
Carcass characteristics										
HSCW (kg)	62.6	64.5	0.72	63.1	62.8	64.6	0.89	0.008	0.079	0.10
Carcass P2 (mm)	7.0	7.0	0.16	7.3	6.9	6.9	0.20	0.73	0.074	0.87
Carcass P2 (mm)**	7.1	6.9	0.15	7.3	6.9	6.7	0.18	0.27	0.001	0.92
Dressing percentage (%)	76.4	74.8	0.30	76.0	75.5	75.4	0.37	<0.001	0.24	0.40

*Live weight included as a covariate in the analyses
**Carcass weight included as a covariate in the analyses

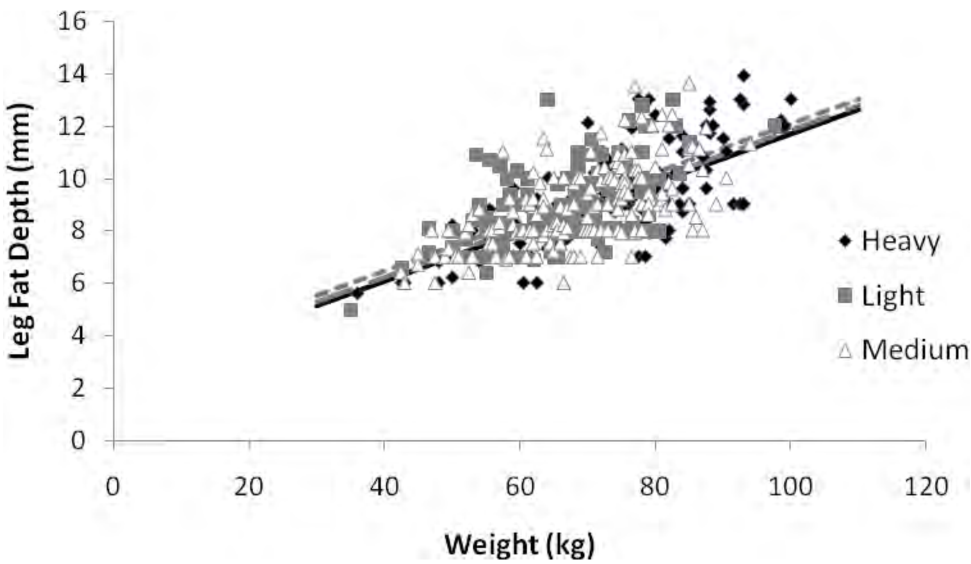

Figure 3 - Influence of birth weight category on leg fat depth at 19 weeks of age (light birth weight: *P*=0.015, medium birth weight *P*=0.34).
Regression equation: Leg fat depth (mm) = 2.373 + 0.09332x (+0.132 medium, +0.362 light). R^2=0.41. The solid black line represents the heavy birth weight pigs, the large dashed grey line the medium birth weight pigs, and the short dashed grey line the light birth weight pigs.

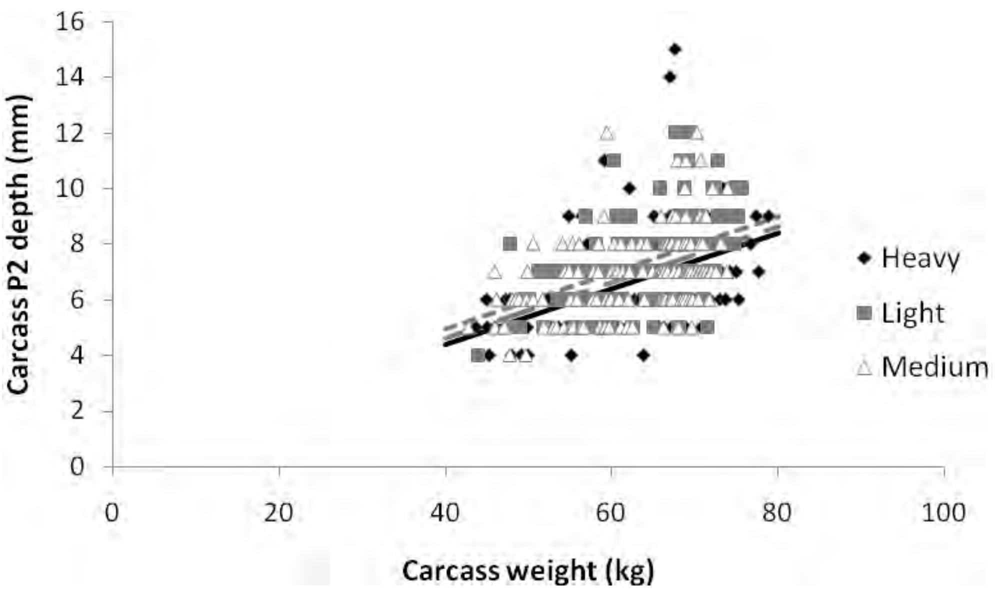

Figure 4 - Influence of birth weight category on carcass P2 depth (light birth weight: *P*=0.002, medium birth weight *P*=0.19).

Regression equation: Carcass P2 depth (mm) = 0.33 + 0.10099x (+0.229 medium, +0.588 light). The solid black line represents the heavy birth weight pigs, the large dashed grey line the medium birth weight pigs, and the short dashed grey line the light birth weight pigs.

Additional analyses was undertaken after classifying pigs within birth weight category as fast or slow growing (based on the average growth rate of that category from birth to slaughter). These analyses provided some further insight into the impact that slow growing pigs have on the population. Feed efficiency from 14 to 19 weeks of age differed substantially between the fast and slow growing population (FCR: 2.29 and 2.70 kg/kg respectively, $P<0.001$, sed 0.073). Interestingly, there was an interaction between birth weight category and growth, as displayed in Figure 5. The magnitude of the difference between the fast and slow growing pigs that were born at heavy weights was much greater than the difference between the fast and slow growing light birth weight pigs (Figure 5).

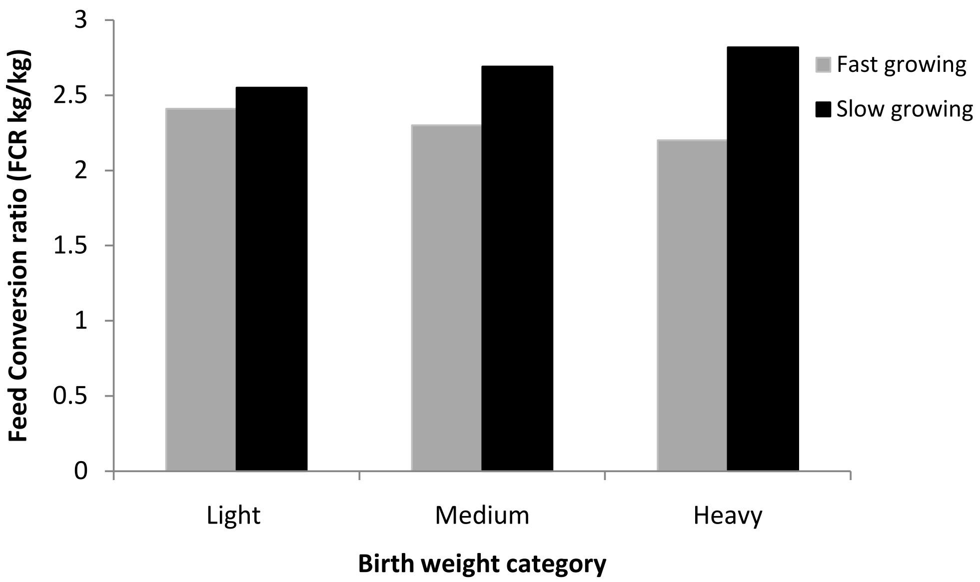

Figure 5 - Influence of birth weight category and growth rate classification on feed efficiency from 14 to 19 weeks of age.

Significance: birth weight P=0.98, growth rate P<0.001, interaction P=0.034.

Pigs that grew slower from birth to slaughter also tended to differ in their body composition at 19 weeks of age compared to their faster growing counterparts. Using live weight at 19 weeks of age as a covariate in the analysis, there was a tendency for the slow growing pigs to have greater P2 back fat depths at this time (8.2 and 8.4 mm for the fast and slow growing pigs respectively, P=0.068, sed 0.13, Figure 6). Similarly, leg fat depth at 19 weeks of age also tended to be greater in the slower growing animals (8.9 and 9.1 mm respectively, P=0.058, sed 0.17).

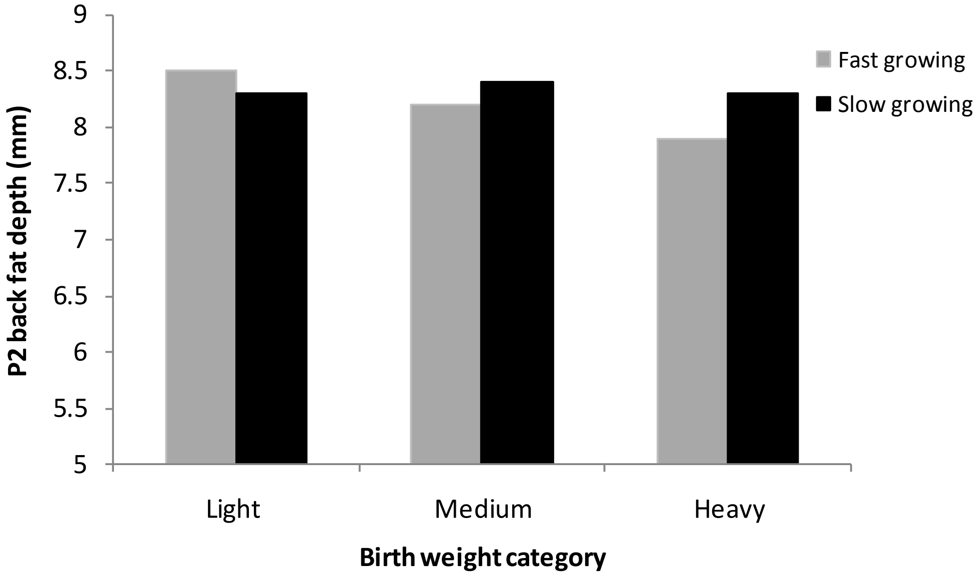

Figure 6 - Influence of birth weight category and growth rate classification on P2 back fat depth at 19 weeks of age.

Significance: birth weight P<0.001, growth rate P=0.068, interaction P=0.36.

The impact of weight at birth on mortalities and removals from weaning through to slaughter is displayed in Tables 6 and 7. During the weaner period there was a greater percentage of deaths and removals from the light birth weight group, although the differences were not significant (x^2=1.51, P=0.47). Similarly, during the grower and finisher phase, there were significantly more deaths and removals from the light birth weight group compared to the medium or heavy birth weight pigs (x^2=6.88, P=0.032).

Table 6 - Influence of birth weight category on deaths and removals during the weaner period (4 to 10 weeks of age)

Birth weight category	Deaths				Removals*					Total deaths, removals (% of population selected at weaning)
	E.coli	Meningitis	Unthrifty	Sudden death**	Unthrifty	Lame	Meningitis	Scours	Unknown	
Light	3	1	1	2	6	1	1	1	4	20/190 (10.5 %)
Medium				2	8			1	3	14/199 (7.0 %)
Heavy	5			2	5	1			4	17/200 (8.5 %)

*Removed from production pens to a sick bay for welfare reasons.

**Cause of death not determined

Table 7 - Influence of birth weight category on deaths and removals during the grower/ finisher period (10 weeks of age to sale)

Birth weight category	Deaths			Removals*				Total deaths, removals (% of population at 10 weeks of age)
	APP	Sudden death#	Destroyed lame	Unthrifty	Lame	Undetermined#	Too small for movement	
Light	5		2	6	1	15	2	29/170 (17.1 %)
Medium	1	2		3	1	10		17/185 (9.2 %)
Heavy	3	2	2	1		8	1	17/183 (9.3 %)

*Removed from production pens to a sick bay for welfare reasons.

Cause of death or removal not determined

4. Application of Research

The outcomes from this investigation confirm that light weight at birth has a clear impact on lifetime growth performance, body composition and survivability through to target sale weights. There have been numerous studies showing the impact of birth weight and/or weaning weight on performance parameters through to slaughter. Recent CRC projects in 2B-103 have shown that pigs weaned heavier remain heavier at every weigh point from weaning through to slaughter. In one such study, the weight difference between the light and heavy weaning weight groups increased from 4.1 kg at weaning to 11.7 kg at the end of the finisher period (22 weeks of age). These results are very similar to Dunshea *et al.* (2003) in which the pigs that were heavy for age at weaning were 13 kg heavier at slaughter than the pigs light for age at weaning. The differences in live weight at weaning were smaller in this present study, 1.7 kg between the light and heavy birth weight pigs, and as such the magnitude of the difference at 19 weeks of age was also reduced compared to these previous investigations. For bigger producers, the ability to segregate animals of different birth or weaning weights and run them as separate groups through to the sale is likely to reduce the variation in weight at the end of the finisher period and aid in minimizing the number of weeks that pigs are marketed from any one group. Given the strong association between birth weight, weaning weight and days to market, strategies to increase birth weight, and/or reduce the variation in birth weight continue to be required.

The difference in age at sale in this present study was somewhat distorted given that 6.7 % of the light birth weight pigs present at 19 weeks of age did not make it to sale by 24 weeks of age (close out). Those animals that were substantially underweight for sale were moved to alternative accommodation at this time. Unfortunately once removed, the fate (including age of eventual slaughter) could not be monitored. The light birth weight pigs were 6.5 kg lighter than the heavy birth weight animals at 19 weeks of age. Assuming that the difference in weight between the birth weight groups did not widen further from 19 weeks of age though to sale, gross calculations suggest that it would take the light birth weight pigs at least eight additional days at a generous growth rate of 0.8 kg/d to attain the same sale weight as the heavy birth weight animals. This is much greater than the 3.9 days difference in sale age observed in this study. Utilising the Pork CRC evaluation model, the eight day difference in sale age equates to a loss of $0.05/kg for the light birth weight population. Assuming that the light birth weight pigs are 30 % of the population, then this would be an overall cost of $0.015/kg. There are also obvious costs associated with the greater mortality/ removal rate of the light birth weight pigs. A total of 49 out of 190 light birth weight pigs (25.8 %) died or were removed for welfare reasons between weaning and sale. This cost of mortality and medical intervention needs to be considered, and management strategies employed. In large scale production systems, the poorest 10-20 % of the population at weaning may be weaned to a separate wean to finish facility, allowing these poorer growers the opportunity to be managed and marketed separately.

In addition to the reduced growth performance and higher mortality/ removal rate, the results of this current investigation have again confirmed that pigs born at light weights have a less desirable carcass composition for selling into the Australian market. The lower carcass weight combined with the higher P2 back fat depth of light birth weight pigs increases the likelihood of these pigs failing to reach the specifications of a premium grade product. Numerous researchers have shown the increased propensity of light birth weight pigs to deposit adipose tissue during postnatal growth compared to those born heavier (Gondret *et al.* 2006; Powell and Aberle 1980). There are recent suggestions that this increased propensity to deposit adipose tissue may be due to a greater prenatal development of adipocytes at the expense of muscle fibres (Karunaratne *et al.* 2005). These authors suggest that under low nutritional conditions *in utero*, the foetus stores fat within muscle fibres so as to have a readily available energy reserve. Under nutritionally adequate postnatal conditions these unfilled adipocytes may begin to fill, resulting in a greater proportion of carcass fat at slaughter in low birth weight pigs. Similar findings have been reported in other animal studies. For example, intrauterine growth restricted rats that were nursed by *ad libitum* fed dams during lactation exhibited rapid catch up growth postnatally, but had a greater percentage of body fat at 9 months of age than those that were not growth restricted *in utero* (Desai *et al.* 2005). Low birth weight lambs have been shown to have a greater percentage of fat at 20 kg compared to their heavier born contemporaries (Greenwood *et al.* 2000), while other researchers have shown that low birth weight lambs can 'catch-up' to the weight of their heavier born contemporaries by 8 weeks of age, however at maturity (2.3 years of age) they tend to have more abdominal fat relative to body weight (Louey *et al.* 2005).

The impact that the light birth weight pigs have on herd feed efficiency is not as clear from this study as it was hoped. During the weaner period, birth weight category did not influence feed efficiency, with the light birth weight pigs consuming less feed and growing slower than the pigs born at heavier weights. From 14 to 17 weeks of age there was a strong tendency for the heavy birth weight pigs to be more efficient than those born at light weights (13 % reduction in FCR, P=0.057). However, when this time period is extended to 19 weeks of age or to sale there were no significant differences in FCR between birth weight categories. If feed efficiency is in fact similar between the light and heavy birth weight pigs during the grower and finisher period, the key issue is still the extended period of time that it takes the light birth weight pigs to reach market weight.

5. Conclusion

The results from this study confirm that pigs born at weights below 1.3 kg display reduced lifetime growth rates, an increased likelihood of illness and/ or mortality and are fatter at slaughter. The challenge for producers is to employ management strategies that cost effectively assist in improving the performance and health status of this group of animals.

6. Limitations/Risks

There were a couple of limitations/ risks from data interpretation in this study.

- The growth performance of animals that were removed from this experiment due to injury or illness could not be tracked through to sale once removed from the trial pens. The impact that these animals have on herd feed efficiency was therefore not measured. There were a greater number of light birth weight pigs that were removed from trial compared to either of the medium or heavy birth weight pigs which should be taken into account when interpreting the data.
- The number of pigs that were removed from the light birth weight group may have been exacerbated due to the artificially large variation in live weights within pens. Many producers would not normally run their very small animals with their healthy, fast growing pigs. The necessary removal of these pigs from the electronic feeder pens for welfare reasons prevented us being able to assess the impact that these animals had on herd FCR.

7. Recommendations

As a result of the outcomes in this study the following recommendations have been made:

- Where possible, light birth weight pigs should be weaned into a separate facility to enable targeted wean to finish management.
- Light birth weight pigs will be fatter for any given carcass weight. Producers should take this into account when determining selling/ marketing strategies for these animals.
- Holding onto slow growing pigs beyond the close out age of the shed may be costly in terms of feed efficiency, increased likelihood of death or illness and fatter carcasses. Producers may consider a final cut off age to reduce the impact that these pigs have on the overall herd performance.

8. References

Desai M, Gayle D, Babu J, Ross MG (2005) Programmed obesity in intrauterine growth-restricted newborns: modulation by newborn nutrition. *American Journal of Physiology- Regulatory, Integrative and Comparative Physiology* 288, R91-R96.

Dunshea FR, Kerton DK, Cranwell PD, Campbell RG, Mullan BP, King RH, Power GN, Pluske JR (2003) Lifetime and post-weaning determinants of performance indices of pigs. *Australian Journal of Agricultural Research* 54, 363-370.

Gondret F, Lefaucheur L, Juin H, Louveau I, Lebret B (2006) Low birth weight is associated with enlarged muscle fiber area and impaired meat tenderness of the longissimus muscle in pigs. *Journal of Animal Science* 84, 93-103.

Greenwood PL, Hunt AS, Hermanson JW, Bell AW (2000) Effects of birth weight and postnatal nutrition on neonatal sheep: II. Skeletal muscle growth and development. *Journal of Animal Science* 78, 50-61.

Karunaratne JF, Ashton CJ, Stickland NC (2005) Fetal programming of fat and collagen in porcine skeletal muscles. *Journal of Anatomy* 207, 763-768.

Louey S, Cock ML, Harding R (2005) Long term consequences of low birthweight on postnatal growth, adiposity and brain weight at maturity in sheep. *journal of Reproduction and Development* 51, 59-68.

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

Powell SE, Aberle ED (1980) Effects of birth weight on growth and carcass composition of swine. *Journal of Animal Science* 50, 860 - 868.