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Impact of feeding low and average birthweight pigs on a weight basis post-weaning on growth performance and body composition

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ABSTRACT

This study aimed to investigate the effectiveness of employing a targeted nutritional regime until slaughter to maintain performance in animals recording high weaning weights. Low birthweight (Low BW; <1 kg) and average birthweight (*Av* BW; 1.3kg-1.7 kg) pigs were reared on sows exhibiting a high lactation feed intake and, as a result, weaning weights were 7.9 kg and 8.9 kg respectively. Pens containing either Low BW or *Av* BW animals were then offered either a 'standard' (STAND) or 'feed-to-weight' (FTW) regime from weaning until slaughter. The STAND regime was reflective of commercial production, where diet transitions were implemented after pre-determined feed levels or time intervals had been reached. In contrast, diet transitions in the FTW regime were carried out when target pen average weights of 12 kg, 18 kg, 22 kg, 45 kg and 75 kg respectively were met. Animal growth, feeding performance and body composition were monitored from weaning until slaughter. As expected, *Av* BW pigs were heavier than Low BW animals throughout ($P<0.001$), recording a superior average daily gain (ADG) ($P<0.01$) and average daily feed intake (ADFI) ($P<0.001$) at each stage of growth. This resulted in *Av* BW animals recording a greater carcass weight ($P<0.001$) and kill-out percentage ($P<0.01$). DEXA scan analysis showed Low BW animals to exhibit a greater percentage fat ($P<0.001$) and lower percentage lean ($P<0.01$) content at week 4 and 10 of age, however birthweight had no effect on these parameters at week 21 ($P>0.05$). Feeding regime did not affect age or weight at diet transition for *Av* BW animals for most transitions ($P>0.05$). However Low BW animals offered the FTW regime were significantly older and heavier than those offered the STAND regime at each transition ($P<0.05$). The FTW regime increased animal ADG and ADFI compared to STAND pigs from weeks 4 to 10 of age ($P<0.05$), whilst providing a greater average daily intake of energy and lysine from week 4 to 10 ($P<0.05$) and week 10 to 17 ($P<0.05$). This facilitated a greater liveweight in FTW animals from 7 weeks of age through to slaughter ($P<0.05$). Feeding regime had no effect on kill-out percentage or back-fat depth ($P>0.05$). Furthermore, DEXA scan results showed total or percentage lean and fat did not differ for FTW or STAND pigs at 10 or 21 weeks of age ($P>0.05$). In conclusion, feeding Low BW animals on a 'feed to weight' basis improved nutrient intake and animal liveweight, likely due to a greater time allowance for digestive development between diet transitions. As such, this approach should be considered for commercial adoption.

1. Introduction

Increasing litter size within modern pig production has led to an increase in the prevalence of low birthweight piglets, mainly due to intra-uterine growth retardation (Antonides et al., 2015). These compromised piglets have a negative impact on herd performance through increased mortality, as well as impaired growth performance and carcass quality (Beaulieu et al., 2010; Gondret et al., 2006).

The impaired growth of low birthweight pigs has been linked to impaired digestive development. For example, the immature gut of compromised pigs exhibits a decreased height of duodenal mucosae and reduced enzyme secretion (Michelis et al., 2013; Alvarenga et al., 2012). The physiological consequence of this underdeveloped digestive system is a reduced digestive capacity which can hinder adaptation to post-weaning diets by limiting pig feed intake and nutrient utilisation (Morise et al., 2007). As low birthweight pigs follow a different trajectory for growth and development compared to average birthweight littermates, they may need to be fed differently in order to facilitate

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maximum growth. As pigs progress through the nursery, growing and finishing stages of production, they transition onto new diets at each stage, with the complexity and digestibility of each diet becoming sequentially reduced as animals get older. Commercially, diet change occurs on the basis of time or quantity rather than animal weight and physiology and as such diet changes are tailored for the 'average pig'. Hence low birthweight animals are often not sufficiently physiologically developed at the time of each diet transition to fully utilise the nutrients provided in the feed.

Studies have shown that offering growing pigs higher specification diets for a longer period will improve performance (Apple et al., 2004; Magowan et al., 2011b), with growth benefits and economic returns most pronounced in low birthweight animals (Collins et al., 2017). Indeed Douglas et al. (2014b) found a significant improvement in average daily gain from day 28 to day 70 ($P < 0.019$) when a greater allocation of higher specification starter diet was offered to low wean weight pigs (average weaning weight of 7.1 kg at day 28). However the majority of documented studies only allocate a higher specification diet during one stage of post-weaning production and do not continue to monitor performance to quantify subsequent growth as animals progress to slaughter. It is also important to determine the carcass composition of any improved weight gain, since compromised animals are often associated with inferior carcass composition which represents less economic value (Rehfeldt et al., 2008; Gondret et al., 2005).

The objective of this study was to determine if the performance of low and average birthweight animals is improved when diet transition is carried out on a weight basis between weaning and slaughter compared to animals following the standard production practice of changing diets at pre-determined intervals. Furthermore, the effect of birthweight and feeding regime on body composition at various stages throughout the growing and finishing periods was determined. It was hypothesised that low birthweight animals fed on a weight basis will have an improved growth rate and carcass composition in comparison to control groups.

2. Materials and methods

This study was conducted at the Agri-Food and Biosciences Institute (AFBI), Hillsborough, Northern Ireland. The work was carried out under Project Licence Number PPL2851 in accordance with the Animals (Scientific Procedures) Act 1986 (The Parliament of the United Kingdom, 1986).

2.1. Establishment of piglets pre-trial

A total of 616 crossbred piglets (Duroc x (Large White x Landrace)) were selected from 83 sows at birth over 11 time replicates. Within this cohort, 308 low birthweight (Low BW; <1 kg) piglets and 308 average birthweight (*Av* BW; 1.3kg-1.7 kg) piglets were selected. At farrowing, 4 sows per time replicate were selected as foster mothers. A minimum period of 24 h was allowed for animals to consume sufficient colostrum from their birth mother prior to fostering. Cross fostering was completed within 36 h of farrowing to establish two experimental litters comprising 14 Low BW piglets and two experimental litters comprising 14 *Av* BW piglets per time replicate, with each litter assigned to a foster mother. As such all piglets were reared on a total of 44 foster sows, which ranged from parity 2 to 4. Weight, parity and body condition of foster sows was balanced across Low BW and *Av* BW litters. Fostered litters were designed such that no litter contained any more than three siblings and no piglets were reared by their birth mother. Litters were also balanced for sex. Only viable animals which had demonstrated effective suckling of their birth mother were considered for selection.

During lactation, foster sows were offered a commercial lactation diet (DE = 14.5 MJ/kg, CP = 17.4%, Lys = 1.2%) twice daily using a wet and dry feeder. Each sow was offered 3 kg of the lactation diet on the day of farrowing, after which their allocation was increased by 0.5 kg/day until a maximum of 11 kg of feed per day was offered. No creep feed was offered to piglets during lactation. Each litter was vaccinated for *Mycoplasma hypopneumoniae* and Porcine circovirus 2 (Ingelvac MycoFLEX® and Ingelvac CircoFLEX® respectively, Boehringer Ingelheim Ld., Bracknell, UK) on the day prior to weaning. All piglets were weaned at 28 ± 1 days of age.

Table 1
Dietary formulations.

	Starter 1	Starter 2	Link	Grower	Finish 1	Finish 2
DE (MJ/kg)	16.5	15.8	15.5	15.0	14.2	13.8
CP (%)	22.5	22.0	20.5	17.5	16.0	15.0
Total Lysine (%)	1.70	1.60	1.50	1.20	1.15	1.05
Oils and Fats (%)	8.50	8.30	7.00	5.50	3.50	3.25
Crude Fibre (%)	2.5	3.5	2.5	3.0	3.5	4.0
Composition						
Cooked Oats	✓	✓				
Cooked Extruded Soya	✓					
Cooked Wheat	✓		✓	✓	✓	✓
Cooked Barley	✓		✓	✓	✓	✓
Maize			✓	✓	✓	✓
Hi-Q DDGS					✓	✓
Fine Limestone			✓	✓	✓	✓
Rapeseed				✓	✓	✓
Whey Powder	✓	✓	✓			
Full Fat Soya		✓				
Hipro soya			✓	✓	✓	✓
Skim Milk Powder		✓				
Milk Albumin	✓	✓				
Fishmeal	✓	✓				
Dextrose	✓	✓				
Coconut oil	✓	✓				
Calcium Carbonate		✓				
Lactose	✓					
Calcium Formate	✓					
Palm Oil	✓	✓				
Soya Oil	✓	✓	✓	✓	✓	✓
DCP	✓	✓	✓	✓	✓	✓
Lysine	✓		✓			
Threonine	✓					
Salt			✓	✓	✓	✓
Methionine	✓	✓	✓			
E567 Clinoptolite	✓					
Valine	✓					
Tryptophan	✓		✓			
(Pro) Phorce						
Min/Vit Mix	✓	✓	✓	✓	✓	✓

The starter diets were commercially manufactured by Devenish Nutrition Ltd (Belfast, N. I), and the link, grower and finisher feed by Thompsons (Belfast, N.I.). The exact formulation of diets cannot be disclosed due to commercial confidence, but a tick represents the presence of the material in the diet.

At weaning, 20 piglets (10 boars and 10 gilts) were selected from the two Low BW litters, with reduction of numbers still satisfying previous calculations for sample size requirements. The range of body weight values removed was such that there was a minimal difference between the mean and standard deviation of bodyweight of this group and the two original litters. These pigs were then assigned to two pens of 10 animals, ensuring that mean weight, standard deviation of bodyweight and sex remained balanced. Surplus animals were removed from trial. This was repeated for the two *Av* BW litters. Hence a total of 440 animals were placed on trial at day 28 ± 1 and animals remained in the same pen groups until slaughter.

2.2. Treatments and dietary regimes

All post-weaning diets employed are displayed in Table 1. The trial represented a 2 × 2 factorial arrangement where pen groups of either Low BW or *Av* BW pigs were offered either a 'standard' (STAND) regime or a 'feed-to-weight' (FTW) regime in the post-weaning period to slaughter. Under the STAND dietary regime, pens of pigs were offered (ad lib) 30 kg of Starter Diet 1 followed by 60 kg of Starter Diet 2 and then 70 kg of a Link ration. When this allocation of Link ration had been consumed, pigs were changed onto a Grower ration which was fed ad-lib until day 85 ± 1. The STAND regime pens were then offered Finish Diet 1 until day 120 ± 1 at which point they were offered Finish Diet 2 until slaughter at day 160 ± 1.

The principle used in the post-weaning FTW regime was to feed animals (ad lib) according to average pen bodyweight. Diet changes were from Starter Diet 1 to Starter Diet 2, to Link, to Grower, to Finish Diet 1 and then Finish Diet 2. In FTW pens these dietary transitions were undertaken when pen average weight reached 12 kg, 18 kg, 22 kg, 45 kg and 75 kg respectively. Animals remained on the Finish 2 diet until slaughter at day 160 ± 1.

2.3. Housing

All trial pigs were moved to nursery accommodation at 28 ± 1 days of age and remained there until day 69 ± 1. In this nursery accommodation, pigs were housed in groups of ten on plastic slatted pens (0.38 m^2 per pig). Temperature was initially maintained at 28 °C but was reduced to 18 °C in daily increments of 0.5 °C. Pigs were offered feed via a small circular hopper (Rotecna, Spain), with one hopper per 10 pigs. This was available for the first week post weaning to encourage feed intake. Thereafter in the nursery accommodation, pigs were offered feed in a 'dry multi-space feeder' (Etra Feeders, Northern Ireland) with a feeder trough space allowance of 6.6 cm per pig. At day 69 ± 1 pigs were transferred in their pen groups to finishing accommodation where they were housed on fully slatted concrete floors (0.61m^2/pig). Animals had access to feed and water via a 'wet and dry' single space feeder (Estra Feeders, Northern Ireland) with one feeder per pen of 10 pigs. An additional water nipple was available outside the feeder.

2.4. Animal management

Following weaning, one pen of Low BW animals and one pen of *Av* BW animals were assigned to the FTW feeding regime throughout the nursery and finishing stage. The remaining pen of Low BW and *Av* BW animals were offered the STAND feeding regime for the duration of the trial to act as a control. On day 160 ± 1 animals were assigned a unique slap number and sent to the abattoir for slaughter.

2.5. Measurements

In nursery accommodation all pigs were individually weighed at 5, 7 and 10 weeks of age. Total pen feed intake was recorded from 4 to 5, 5 to 7 and 7 to 10 weeks of age. In finishing accommodation, all animals were individually weighed at 12, 15 and 17 weeks of age. Animals were also weighed at day 160 ± 1, prior to slaughter. Total pen feed intake was recorded from 10 to 12, 12 to 15, 15 to 17 and 17 to 23 weeks of age. All animals in both STAND and FTW pens were weighed individually at each dietary change and total pen feed intake was also recorded at each dietary change. All fallen animals had a death date and death weight recorded. Animals were fasted from the evening of the day prior to slaughter. On the morning of slaughter, a backfat measurement was recorded at the P_2 position (65 mm from the midline at the level of the last rib) for each animal using an ultrasonic scanner (Pig Scan-A-Mode backfat scanner, SFK Technology, Denmark). The carcass weight of each animal was also recorded in the abattoir, which was used in combination with the liveweight value to calculate individual kill out percentage.

2.6. Body composition

A sub-sample of 80 pigs over two time replicates were used to monitor the progression of animal body composition as animals grew from 4, to 10 to 21 weeks of age and to establish how this differed with birthweight and / or feeding regime. As such, 20 pigs per treatment group were assessed. All pigs underwent the same management as that described above except that at 4, 10 and 21 weeks of age the pigs were sedated and scanned using a Dual-energy X-Ray absorptiometry (DEXA) scanner. At the time of scanning, the individual animal was transferred to an empty 'sedation pen'. Two separate intramuscular injections, one containing 0.5 ml/10 kg Stresnil (Elanco Ltd, Basingstoke, UK) and a second containing 2 ml/10 kg Ketamidor (Chanelle Pharma Ltd, Galway, Ireland), were administered to the neck of the animal. When the required level of sedation had been achieved, each animal was transported to the DEXA scanner and underwent a whole-body composition scan. Following the scan, each animal was transported to a 'recovery pen', equipped with rubber matting, for a minimum of 4 h. After complete recovery, the animal was reintroduced into its original pen and group of animals, where it continued to be monitored for a further 4 h to ensure no adverse effects.

Carcass composition was assessed by DEXA using a Stratos DR device equipped with the Stratos DR (v4.0.7.0 11–16–2016) software package, both from the same company (Mi Healthcare, Knowsley, United Kingdom). Images were analysed in accordance with methodologies from Kipper et al. (2018). For each scanned subject, the DEXA device reported the total bone mineral density (BMD) and bone mineral composition (BMC). The total mass and percentage of bone, tissue, lean and fat was also calculated.

2.7. Statistical analysis

A linear mixed model was employed to analyse pig performance at an individual and pen level where applicable. Birthweight and feeding regime were fitted as fixed effects, with the first order interaction forming four treatment groups. Replicate and foster mother were incorporated as a random effect. For parameters of body weight, relative growth, carcass characteristics, ADG, ADFI, FCR, as well as weight and age at diet transition, the experimental unit was the pen of pigs. For body composition analysis, the experimental unit was the individual pig. Relative growth for a given time period was calculated as the difference between the final weight and initial weight divided by the initial weight. Average daily intake of energy and lysine was calculated using ADFI and formulated values for each diet. Conversion efficiency of energy and lysine was calculated as intake of energy or lysine divided by weight gain during the period of interest. Recommended daily intake of energy and lysine was calculated using equations from Whittemore et al. (2003). Significance was defined as $P<0.05$, with tendencies defined as $P<0.1$. All statistical analysis was carried out using Genstat 16th Edition (Lawes Agricultural Trust, Rothamsted Experimental Station).

3. Results

3.1. Animal growth performance

No significant interactions between birthweight and feeding regime were recorded for parameters of animal weight, carcass characteristics or morbidity / mortality (Table 2) ($P>0.05$), or for animal growth and feeding performance (Table 3). The average weight of Low BW pigs was significantly less than that of *Av* BW pigs at each stage of production ($P<0.001$) (Table 2). Animals of Low BW recorded a lower carcass weight ($P<0.001$) and kill out percentage ($P<0.01$) compared to *Av* BW pigs, but their back-fat depth was similar ($P>0.05$). Low BW pigs exhibited significantly poorer ADG compared to those of *Av* BW at all stages throughout the trial ($P<0.01$ respectively) (Table 3). Although birthweight had no overall effect on animal relative growth between 4 and 10 weeks of age ($P>0.05$), animals in Low BW pens recorded a greater relative growth between week 10 and 17 ($P<0.001$). Whilst birthweight had no significant effect on the relative growth of animals between 17 and 23 weeks of age ($P>0.05$), the cumulative effect was

Table 2
Effect of birthweight and feeding regime on animal weight and carcass characteristics.

	Low BW[a] STAND[c]	*Av* BW[b] FTW[d]	STAND[c]	P-Value FTW[d]	SEM	Birthweight	Regime	Birthweight x Regime
Pen average weight (kg)								
Week 4	7.9	7.9	8.9	9.0	0.13	<0.001	0.353	0.661
Week 5	8.3	8.4	9.6	9.7	0.13	<0.001	0.228	0.877
Week 7	13.5	13.9	15.6	16.4	0.22	<0.001	0.002	0.304
Week 10	25.5	26.6	29.1	29.7	0.39	<0.001	0.005	0.365
Week 12	36.8	38.6	41.1	43.0	0.80	<0.001	0.005	0.635
Week 15	54.1	57.1	60.4	62.5	0.83	<0.001	<0.001	0.420
Week 17	69.1	71.7	76.7	76.8	0.86	<0.001	0.029	0.053
Week 23	113.1	114.9	122.6	124.5	1.20	<0.001	0.033	0.936
Post-weaning morbidity / mortality (%)	9.6	6.1	3.5	7.9	2.83	0.437	0.911	0.092
Carcass weight (kg)	90.8	92.0	98.4	100.0	1.01	<0.001	0.041	0.843
Kill out%	80.3	80.1	81.4	82.0	0.69	0.004	0.688	0.445
Back-fat depth (mm)	10.1	10.4	10.0	10.1	0.22	0.227	0.396	0.534

[a] Low BW = Low birthweight pigs (<1 kg).
[b] Average birthweight pigs (1.3–1.7 kg).
[c] Diet transition carried out on basis of pre-determined quantity or time period as follow - 30 kg/pen Starter Diet 1, 60 kg/pen Starter Diet 2, 70 kg/pen Link, Grower until 12 weeks of age, Finish 1 until 17 weeks of age, Finish 2 until slaughter.
[d] Feed-to-weight = Diet transition carried out when pen average weight meets target threshold as follows: Starter Diet 1 – Starter Diet 2 @12 kg, Starter Diet 2 – Link @ 18 kg, Link – Grower @ 22 kg, Grower – Finish 1 @45 kg, Finish 1 – Finish 2 @ 75 kg.

that Low BW pigs expressed a superior overall relative growth compared to *Av* BW pigs during week 10 to 23 (3.45 kg/kg vs 3.22 kg/kg; SEM = 0.067; $P<0.001$). The ADFI recorded by pigs in Low BW pens was significantly lower than that of pigs in *Av* BW pens at each stage of production ($P<0.001$ respectively) (Table 3). The FCR expressed by Low BW did not differ to that of *Av* BW pigs between 4 and 10 weeks of age ($P>0.05$). Pens containing Low BW animals recorded a significantly superior FCR between 10 and 17 weeks of age ($P<0.05$). However FCR did not differ between Low BW and *Av* BW pigs between 17 and 23 weeks of age ($P>0.05$) or for the cumulative period from week 10 to 23 (2.31 vs 2.32; SEM = 0.022; $P>0.05$).

Although feeding regime had no significant effect on pig average weight at 5 weeks of age ($P>0.05$) (Table 2), pigs in pens offered the FTW feeding regime recorded a significantly greater liveweight than those offered the STAND regime at week 7 ($P<0.01$), 10 ($P<0.01$), 12 ($P<0.01$), 15 ($P<0.001$), 17 ($P<0.05$) and 23 ($P<0.05$) as well as a greater carcass weight ($P<0.05$). Animal morbidity / mortality, kill out percentage or back-fat depth did not differ significantly between pigs which were offered the FTW or STAND feeding regimes ($P>0.05$ respectively). Pigs offered the FTW feeding regime recorded a significantly greater ADG than those offered the STAND regime between 4 and 10 weeks of age ($P<0.05$) (Table 3). However, feeding regime had no effect on animal ADG during any of the time periods recorded from 10 weeks of age through to slaughter ($P>0.05$ respectively). Relative growth was superior for pigs offered the FTW regime during 4 to 10 weeks of age ($P<0.05$). However feeding regime had no effect on relative growth between 10 and 17 weeks of age ($P>0.05$) or between 17 and 23 weeks of age ($P>0.05$). Animals offered the FTW feeding regime exhibited a higher ADFI compared to those on the STAND regime between 4 and 10 weeks of age ($P<0.05$). Despite pens of pigs offered the FTW regime tending to record a greater ADFI when compared to STAND animals between 10 and 17 weeks of age ($P<0.1$), ADFI did not differ between FTW and STAND pens between week 17 and 23 ($P>0.05$). Finally, FCR was not affected by feeding regime during 4 to

Table 3
Effect of birthweight and feeding regime on relative growth, average daily gain, average daily feed intake and feed conversion ratio.

	Low BW[a] STAND[c]	FTW[d]	*Av* BW[b] STAND[c]	FTW[d]	SEM	P-Value Birthweight	Regime	Birthweight x Regime
Pig average daily gain (g/day)								
Week 4–10	421	443	476	488	9.7	<0.001	0.017	0.443
Week 10–17	903	921	952	950	18.9	0.007	0.570	0.437
Week 17–23	1097	1081	1149	1187	25.9	<0.001	0.569	0.153
Pig relative growth (kg/kg)								
Week 4–10	2.27	2.37	2.28	2.36	0.057	0.932	0.014	0.773
Week 10–17	1.74	1.72	1.62	1.58	0.033	<0.001	0.183	0.649
Week 17–23	0.63	0.60	0.61	0.62	0.021	0.125	0.203	0.557
Pig average daily feed intake (g/day)								
Week 4–10	594	626	674	688	12.7	<0.001	0.015	0.306
Week 10–17	1778	1824	1870	1928	36.9	<0.001	0.053	0.824
Week 17–23	2884	2840	2997	3105	64.5	<0.001	0.501	0.106
Feed conversion ratio								
Week 4–10	1.38	1.38	1.38	1.39	0.015	0.556	0.911	0.844
Week 10–17	1.97	1.98	1.98	2.05	0.027	0.042	0.024	0.100
Week 17–23	2.65	2.65	2.69	2.62	0.055	0.919	0.350	0.381

[a] Low BW = Low birthweight pigs (<1 kg).
[b] Average birthweight pigs (1.3–1.7 kg).
[c] Diet transition carried out on basis of pre-determined quantity or time period as follow - 30 kg/pen Starter Diet 1, 60 kg/pen Starter Diet 2, 70 kg/pen Link, Grower until 12 weeks of age, Finish 1 until 17 weeks of age, Finish 2 until slaughter.
[d] Feed-to-weight = Diet transition carried out when pen average weight meets target threshold as follows: Starter Diet 1 – Starter Diet 2 @12 kg, Starter Diet 2 – Link @ 18 kg, Link – Grower @ 22 kg, Grower – Finish 1 @45 kg, Finish 1 – Finish 2 @ 75 kg.

Table 4
Effect of birthweight and feeding regime on pig intake and conversion efficiency of energy and protein.

	Low BW[a]	*Av* BW[b]		P-Value				
	STAND[c]	FTW[d]	STAND[c]	FTW[d]	SEM	Birthweight	Regime	Birthweight x Regime
Pig average daily energy intake (MJ)								
Week 4–10	9.2	9.8	10.4	10.6	0.19	<0.001	0.012	0.207
Week 10–17	25.6	26.4	26.9	27.8	0.52	0.001	0.023	0.990
Week 17–23	40.0	39.3	41.3	42.9	0.91	<0.001	0.554	0.084
Pig recommended daily energy intake (MJ)*								
Week 4–10	13.6	13.9	14.8	15.0	–	–	–	–
Week 10–17	27.8	28.3	29.4	29.5	–	–	–	–
Week 17–23	37.4	37.7	38.5	38.6	–	–	–	–
Energy conversion efficiency								
Week 4–10	21.9	22.0	21.9	21.8	0.27	0.485	0.841	0.528
Week 10–17	28.2	28.7	28.2	29.3	0.42	0.337	0.011	0.359
Week 17–23	36.5	36.4	36.0	36.3	0.95	0.649	0.819	0.788
Pig average daily lysine intake (g)								
Week 4–10	8.5	9.1	9.5	9.6	0.16	<0.001	0.004	0.051
Week 10–17	20.6	21.3	21.7	22.3	0.42	0.002	0.038	0.922
Week 17–23	30.5	30.0	31.4	32.7	0.70	<0.001	0.439	0.108
Pig recommended average daily lysine intake (g)*								
Week 4–10	11.1	11.3	12.1	12.2	–	–	–	–
Week 10–17	19.9	20.3	20.9	21.0	–	–	–	–
Week 17–23	24.5	24.6	24.8	24.8	–	–	–	–
Lysine conversion efficiency								
Week 4–10	20.3	20.6	20.0	19.7	0.28	0.005	0.948	0.191
Week 10–17	22.8	23.1	22.8	23.6	0.33	0.391	0.021	0.424
Week 17–23	27.8	27.9	27.4	27.7	0.72	0.574	0.691	0.879

* Whittemore et al. (2003).
[a] Low BW = Low birthweight pigs (<1 kg).
[b] Average BW = Average birthweight pigs (1.3–1.7 kg).
[c] Standard = Diet transition carried out on basis of pre-determined quantity or time period as follow - 30 kg/pen Starter Diet 1, 60 kg/pen Starter Diet 2, 70 kg/pen Link, Grower until 12 weeks of age, Finish 1 until 17 weeks of age, Finish 2 until slaughter.
[d] Feed-to-weight = Diet transition carried out when pen average weight meets target threshold as follows: Starter Diet 1 – Starter Diet 2 @12 kg, Starter Diet 2 – Link @ 18 kg, Link – Grower @ 22 kg, Grower – Finish 1 @45 kg, Finish 1 – Finish 2 @ 75 kg.

10 ($P>0.05$) or 17 to 23 weeks of age ($P>0.05$), but was superior for STAND animals between week 10 and 17 ($P<0.05$).

3.2. Intake and conversion efficiency of energy and lysine

There was no significant interaction between birthweight and feeding regime when analysing the average daily intake or conversion efficiency of energy or lysine throughout the trial period ($P>0.05$ respectively) (Table 4). The average daily intake of energy and lysine for pigs in *Av* BW pens was significantly greater than that of pigs in Low BW pens at each stage of production ($P<0.01$ respectively). However energy conversion efficiency was not affected by birthweight at any stage of the trial ($P>0.05$ respectively). Although pigs in *Av* BW pens recorded a superior lysine conversion efficiency between 4 and 10 weeks of age ($P<0.01$), birthweight had no effect on lysine conversion efficiency during any period from week 10 through to slaughter ($P>0.05$ respectively).

Pigs offered the FTW regime recorded a greater average daily energy intake and average daily lysine intake between 4 and 10 weeks of age ($P<0.05$ and $P<0.01$ respectively) and weeks 10 to 17 ($P<0.05$ respectively). However feeding regime had no effect on the average daily intake of energy or lysine from 17 to 23 weeks of age ($P>0.05$). The conversion efficiency of both energy and lysine was significantly superior for pens of pigs offered the STAND regime between 10 and 17 weeks of age ($P<0.05$ respectively). However feeding regime had no significant effect on the conversion efficiency of energy or lysine during any other time period studied in the trial ($P>0.05$).

3.3. Animal dietary transitions

Significant interactions between birthweight and feeding regime were recorded for average weight and average age of pens of pigs at each diet transition in this study ($P<0.01$ respectively) (Table 5). The implication of these interactions were such that pen average weight at each dietary transition did not differ significantly when the FTW feeding regime was offered to either Low BW and *Av* BW pens of pigs ($P>0.05$ respectively). However, when the STAND regime was offered, Low BW pens recorded a significantly lower average weight than *Av* BW pigs at each transition ($P<0.05$ respectively). Moreover, Low BW pigs offered the STAND regime were significantly lighter than Low BW animals offered the FTW regime at each transition ($P<0.05$ respectively). In general, age at each diet transition was similar for *Av* BW pigs regardless of feeding regime ($P>0.05$). However, for Low BW pigs, age was significantly greater at each diet transition for animals offered the FTW regime compared to those offered the STAND regime ($P<0.01$).

3.4. Co-efficient of variation of animal weights

A significant interaction between birthweight and feeding regime was recorded when assessing the co-efficient of variation (CoV) for animal weights at 10 and 12 weeks of age ($P<0.05$ respectively) (Table 6). In both instances, when the FTW regime was offered to *Av* BW pigs, the CoV was higher than that when the STAND regime was offered. The reverse was true for the Low BW pigs, such that the CoV was lower for animals offered the FTW compared with those offered the STAND regime. However no interaction existed for the CoV at any other stage of production ($P>0.05$ respectively). Whilst the CoV for Low BW animals was greater at 4 ($P<0.01$) and 5 weeks of age ($P<0.01$) compared with *Av* BW pigs, birthweight had no effect on the co-efficient of variation of animal weight during any period from week 7 through to slaughter ($P>0.05$ respectively). Feeding regime had no significant effect on the co-efficient of variation of animal weights at any stage of the trial ($P>0.05$).

Table 5
Effect of birthweight and feeding regime on animal average weight and age at each diet transition as well as time offered each diet.

	Low BW[a] STAND[c]	*Av* BW[b] FTW[d]	STAND[c]	P-Value FTW[d]	SEM	Birthweight	Regime	Birthweight x Regime
Pen average weight at diet transition (kg)								
Starter Diet 1 – Starter Diet 2	10.77[a]	12.02[b]	11.96[b]	12.1[b]	0.137	<0.001	<0.001	<0.001
Starter Diet 2 - Link	15.96[a]	18.07[c]	17.02[b]	18.19[c]	0.158	<0.001	<0.001	<0.001
Link – Grower	20.5[a]	22.09[b]	21.78[b]	21.94[b]	0.164	<0.001	<0.001	<0.001
Grower - Finish 1	37.08[a]	45.46[c]	40.55[b]	45.3[c]	0.602	<0.001	<0.001	<0.001
Finish 1 - Finish 2	69.46[a]	75.81[b]	74.79[b]	74.96[b]	1.258	0.017	<0.001	<0.001
Age at diet transition (days)								
Starter Diet 1 – Starter Diet 2	43.27[b]	45.73[c]	42.18[a]	42.09[a]	0.532	<0.001	0.004	0.002
Starter Diet 2 - Link	54.16[b]	56.43[c]	52.19[a]	52.61[a]	0.420	<0.001	<0.001	0.004
Link - Grower	62.42[b]	63.69[c]	60.23[a]	59.42[a]	0.475	<0.001	0.483	0.004
Grower - Finish 1	84.94[a]	92.12[c]	85.02[a]	87.67[b]	0.701	<0.001	<0.001	<0.001
Finish 1 - Finish 2	119.9[a]	123.7[b]	119.8[a]	118.3[a]	0.927	<0.001	0.085	<0.001
Time offered each diet (days)								
Starter Diet 1	13.27[b]	15.73[c]	12.18[a]	12.09[a]	0.532	<0.001	0.004	0.002
Starter Diet 2	10.91	10.73	10.00	10.55	0.380	0.049	0.503	0.184
Link	8.27	7.24	8.00	6.82	0.369	0.171	<0.001	0.73
Grower	22.55[a]	28.45[c]	24.82[b]	28.27[c]	0.644	0.027	<0.001	0.01
Finish 1	34.92	31.56	34.80	30.65	0.636	0.241	<0.001	0.386
Finish 2	40.15[b]	36.33[a]	40.17[b]	41.69[b]	0.927	<0.001	0.085	<0.001

[a] Low BW = Low birthweight pigs (<1 kg).
[b] Average BW = Average birthweight pigs (1.3–1.7 kg).
[c] Standard = Diet transition carried out on basis of pre-determined quantity or time period as follow - 30 kg/pen Starter Diet 1, 60 kg/pen Starter Diet 2, 70 kg/pen Link, Grower until 12 weeks of age, Finish 1 until 17 weeks of age, Finish 2 until slaughter.
[d] Feed-to-weight = Diet transition carried out when pen average weight meets target threshold as follows: Starter Diet 1 – Starter Diet 2 @12 kg, Starter Diet 2 – Link @ 18 kg, Link – Grower @ 22 kg, Grower – Finish 1 @45 kg, Finish 1 – Finish 2 @ 75 kg.

3.5. Animal body composition

No significant interactions were evident for any of the body composition parameters evaluated at 10 or 21 weeks of age ($P>0.05$ respectively) (Table 7). The bone mineral density of Low BW animals was significantly lower than that of *Av* BW pigs at 4 ($P<0.001$) and 10 weeks of age ($P<0.001$), however no significant difference was observed at week 21 ($P>0.05$). The bone mineral composition of Low BW pigs was lower than that recorded for *Av* BW pigs at 4 ($P<0.001$), 10 ($P<0.001$) and 21 weeks of age ($P<0.01$). Pigs in the Low BW grouping exhibited a lower level of total fat content compared to *Av* BW pigs at 4 ($P<0.01$) and 10 weeks of age ($P<0.05$), however no significant difference was apparent at week 21 ($P>0.05$). The quantity of total lean and total tissue recorded in Low BW pigs was significantly lower than that of *Av* BW animals at 4, 10 and 21 weeks of age ($P<0.01$ respectively). Animals of Low BW exhibited a reduced percentage bone and percentage lean compared to heavier animals at 4 ($P<0.001$ respectively) and 10 weeks of age ($P<0.05$ and $P<0.01$ respectively), however birthweight had no effect at week 21 ($P>0.05$). Conversely, Low BW animals recorded a greater percentage fat than *Av* BW pigs at 4 ($P<0.001$) and 10 weeks of age ($P<0.001$), with no difference being apparent at week 21 ($P>0.05$). Feeding regime had no significant effect on bone mineral density, bone mineral composition or animal total or percentage fat and lean at any stage of the study ($P>0.05$ respectively).

4. Discussion

It is accepted within literature that the growth trajectory of Low BW animals differs to that of *Av* BW counterparts (Fix et al., 2010). As nutrition is one of the key drivers of growth, it plays a crucial role in influencing the growth trajectory of Low BW animals. However, the increased prevalence of Low BW animals within commercial pig production has significantly complicated dietary management. The current study was designed to determine if the growth of Low BW and *Av* BW pigs could be improved when all dietary transitions from weaning to slaughter were carried out on a weight basis. This was compared to the

Table 6
Effect of birthweight and feeding regime on co-efficient of variation of animal weight.

	Low BW[a] STAND[c]	FTW[d]	*Av* BW[b] STAND[c]	FTW[d]	SEM	P-Value Birthweight	Regime	Birthweight x Regime
Co-efficient of variation								
Week 4	0.11	0.09	0.008	0.006	–	–		
Week 5	0.12	0.11	0.10	0.09	0.009	0.002	0.771	0.792
Week 7	0.13	0.12	0.10	0.12	0.010	0.197	0.904	0.09
Week 10	0.13[b]	0.12[ab]	0.10[a]	0.13[b]	0.012	0.179	0.313	0.024
Week 12	0.13[b]	0.11[a]	0.11[ab]	0.13[b]	0.014	0.943	0.633	0.03
Week 15	0.13	0.11	0.11	0.12	0.013	0.553	0.395	0.14
Week 17	0.12	0.11	0.10	0.11	0.010	0.290	0.989	0.12
Week 23	0.10	0.09	0.08	0.09	0.014	0.301	0.921	0.492

[a] Low BW = Low birthweight pigs (<1 kg).
[b] Average BW = Average birthweight pigs (1.3–1.7 kg).
[c] Standard = Diet transition carried out on basis of pre-determined quantity or time period as follow - 30 kg/pen Starter Diet 1, 60 kg/pen Starter Diet 2, 70 kg/pen Link, Grower until 12 weeks of age, Finish 1 until 17 weeks of age, Finish 2 until slaughter.
[d] Feed-to-weight = Diet transition carried out when pen average weight meets target threshold as follows: Starter Diet 1 – Starter Diet 2 @12 kg, Starter Diet 2 – Link @ 18 kg, Link – Grower @ 22 kg, Grower – Finish 1 @45 kg, Finish 1 – Finish 2 @ 75 kg.

Table 7
Effect of birthweight and feeding regime on pig body composition at 4, 10 and 21 weeks of age.

	Low BW[a] STAND[c]	FTW[d]	*Av* BW[b] STAND[c]	FTW[d]	SEM	P-Value Birthweight	Regime	Birthweight x Regime
Bone mineral density								
Week 4	0.51	0.58	0.004	<0.001	–	–		
Week 10	0.70	0.73	0.75	0.76	0.015	<0.001	0.054	0.323
Week 21	0.97	0.98	0.98	0.99	0.011	0.161	0.222	0.433
Bone mineral composition								
Week 4	193	236	6.6	<0.001	–	–		
Week 10	624	651	706	733	29.6	<0.001	0.198	0.998
Week 21	2116	2124	2223	2252	59.8	0.007	0.659	0.811
Total fat (kg)								
Week 4	2.44	2.70	0.093	0.005	–	–		
Week 10	6.68	6.74	7.19	7.18	0.332	0.046	0.903	0.887
Week 21	26.59	25.74	26.67	26.70	1.401	0.599	0.668	0.655
Total lean (kg)								
Week 4	4.48	5.33	0.144	<0.001	–	–		
Week 10	16.58	17.02	18.36	19.33	0.834	<0.001	0.235	0.657
Week 21	76.29	75.95	79.99	82.20	2.440	0.005	0.563	0.462
Total tissue (kg)								
Week 4	6.91	7.97	0.230	<0.001	–	–		
Week 10	21.82	23.77	25.89	26.51	1.369	<0.001	0.189	0.496
Week 21	102.88	101.68	108.25	108.90	3.403	0.009	0.920	0.701
Bone%								
Week 4	2.72	2.87	0.020	<0.001	–	–		
Week 10	2.62	2.68	2.71	2.69	0.031	0.027	0.389	0.069
Week 21	2.02	2.06	2.01	2.03	0.024	0.293	0.128	0.645
Lean%								
Week 4	63.09	64.62	0.354	<0.001	–	–		
Week 10	69.40	69.70	70.41	70.93	0.483	0.001	0.244	0.763
Week 21	72.84	73.21	73.69	73.97	0.819	0.253	0.577	0.938
Fat%								
Week 4	34.19	32.52	0.355	<0.001	–	–		
Week 10	27.98	27.64	26.88	26.37	0.499	<0.001	0.236	0.830
Week 21	25.11	24.71	24.29	23.99	0.680	0.172	0.552	0.925

[a] Low BW = Low birthweight pigs (<1 kg).
[b] Average BW = Average birthweight pigs (1.3–1.7 kg).
[c] Standard = Diet transition carried out on basis of pre-determined quantity or time period as follow - 30 kg/pen Starter Diet 1, 60 kg/pen Starter Diet 2, 70 kg/pen Link, Grower until 12 weeks of age, Finish 1 until 17 weeks of age, Finish 2 until slaughter.
[d] Feed-to-weight = Diet transition carried out when pen average weight meets target threshold as follows: Starter Diet 1 – Starter Diet 2 @12 kg, Starter Diet 2 – Link @ 18 kg, Link – Grower @ 22 kg, Grower – Finish 1 @45 kg, Finish 1 – Finish 2 @ 75 kg .

performance of animals following a standard regime reflective of commercial production. It was hypothesised that the 'feed-to-weight' regime would better match the lysine and energy requirements of animals, with any performance benefits arising being more pronounced in Low BW pigs.

4.1. Effect of birthweight and feeding regime on dietary transitions, growth and feed intake

It was expected that differences in both age and liveweight at each dietary transition would be more pronounced when comparing Low BW animals offered either the FTW or STAND regime than when comparing *Av* BW pigs offered either the FTW or STAND regime and results are in agreement with this premise. Indeed the weight of the Low BW pigs offered the FTW regime actually matched that of the *Av* BW pigs following the STAND regime at many diet changes.

Low BW animals recorded a poorer ADFI, and as such a lower daily intake of energy and lysine, compared to *Av* BW pigs throughout the trial. Whilst a struggle to adapt to post-weaning diets is common for all weight categories of pigs, it is often most evident amongst low birthweight animals (Collins et al., 2017). This is supported by findings from the current study in that the deficit in ADFI of Low BW pigs compared to *Av* BW pigs was similar between 4 and 10 weeks of age and 10 and 17 weeks of age (71 g/day vs 98 g/day), despite the smaller size and feed intake of animals in the former period. This may be due to impaired structure and function of the gastro-intestinal tract, which is common amongst Low BW pigs (Pluske et al., 2005). Indeed a lower weight: length ratio and reduced concentration of IGF-1 receptors in the small intestine can restrict their digestive capacity and hence feed intake immediately post-weaning (Michelis et al., 2013). However during the finishing period the poorer feed intake of Low BW pigs recorded in the current study is in contrast to literature, which has shown birthweight to have no effect on feed intake later in production (Douglas et al., 2014b; Gondret et al., 2005). This may be due to the lighter birthweight of compromised pigs employed in the current study, compared to that of previous literature (<1 kg vs <1.2 kg). Indeed a greater level of uterine restriction experienced by highly compromised pigs has been shown to restrict digestive capacity throughout lifetime, with Alvarenga et al. (2012), reporting a reduced mucosal height in Low BW pigs at 150 days of age.

The lighter weight and reduced ADG of Low BW animals compared to *Av* BW litter mates was evident throughout the trial and is in agreement with literature (Douglas et al., 2014a). Indeed an average weight differential of 1.0 kg at weaning diverged to 9.6 kg at slaughter. Whilst this is a greater divergence than that reported in previous studies comparing Low BW and *Av* BW pigs at an equivalent slaughter age (7.7 kg, Douglas et al., 2014a; 6.1 kg, Beaulieu et al., 2010), it is similar to the 9 kg reported in more recent work (Hawe et al., 2020). Impaired post-natal growth of Low BW pigs has been attributed to a diverse range of factors. Whilst the reduced feed intake of Low BW pigs described above will have contributed to this reduced liveweight, it is the inferior muscle fibre network associated with these animals which is cited as the greatest contributor to their long term restricted growth. Indeed Rehfeldt and Kuhn (2006) quantified Low BW pigs to have 50,000 fewer total fibres at birth than *Av* BW pigs (290,000 vs 340,000), with post-natal muscle growth largely determined by hypertrophy of muscle fibres present at birth (Douglas et al., 2014b). It is interesting to note that this study is in agreement with Poore et al. (2004), showing that the relative growth of Low BW pigs was similar to *Av* BW animals. The lack of difference in FCR between Low BW and *Av* BW pigs supports a growing body of literature showing feeding efficiency does not differ between animals exhibiting a low birthweight and / or weaning weight compared to heavier animals, as a reduced ADG is offset by a lower ADFI (Collins et al., 2017; Magowan et al., 2011b; Nissen and Oksbjerg, 2011).

The greater ADFI in FTW pigs immediately post-weaning concurs with findings from Wellock (2009) which showed animals fed a high quality diet recorded a greater ADFI than those offered a low quality diet in the 14 days following weaning (347 g/day vs 309 g/day). Furthermore, a partial consequence of the strict weight boundaries for diet change amongst FTW animals was that these animals were offered the higher specification diets with a greater nutrient density for longer. The above factors help explain the greater intake of energy and lysine amongst FTW pigs compared to STAND pigs. Indeed the FTW feeding regime better matched the recommended daily energy intake of animals, as suggested by Whittemore et al. (2003), than that of the STAND regime from 4 to 10 and 10–17 weeks of age. Furthermore, FTW animals were closer than STAND animals to matching their recommended daily lysine intake from 4 to 10 weeks of age.

As hypothesised, animals allocated to the FTW feeding regime were significantly heavier than those on the STAND regime from 7 weeks of age through to slaughter, recording a greater growth rate during the nursery period and a greater carcass weight. Previous studies have attributed the improved ADG in animals offered a superior post-weaning feeding regime to an improved FCR (Muns and Magowan, 2018; Lawlor et al., 2002; Magowan et al., 2011ab). It was therefore unexpected that feeding regime in the current study had no effect on FCR, except between 10 and 17 weeks of age, where STAND animals converted feed more efficiently than FTW pigs. It is possible this lack of improvement was due to a smaller divergence in allocation of starter diets between FTW and STAND groups in the current study compared to previous work. For example, starter diets employed by Magowan et al. (2011b) were of similar composition to those employed in the current study, but a greater divergence in allocation was employed in the former study. It is possible that the inferior FCR of FTW animals compared to STAND pigs between 10 and 17 weeks of age can also be explained by comparing their intake of lysine and energy to that recommended in Whittemore (2003). Whilst neither feeding category consumed their recommended energy requirements during this period, both FTW and STAND pigs exceeded their recommended lysine intake. However FTW animals exceeded this requirement by 2% more than STAND animals. Liu et al. (2015) showed that feeding the optimal CP for a given population (15.8%), rather than NRC guidelines (17.7%), significantly improved FCR in Landrace pigs during the growing stage (2.33 vs 2.43). Hence the increased intake of lysine by FTW pigs during 10 to 17 weeks of age, in an attempt to meet energy requirements, could have resulted in a poorer FCR. From the above it can be concluded that the improved weight recorded for *Av* BW pigs offered the FTW regime compared to those offered the STAND regime was due to their superior feed intake as well as lysine and energy consumption. Similarly it is evident that Low BW animals offered the FTW regime also benefited from improved nutrient intake compared to those on the STAND regime. This was reflected by energy consumption from 4 to 10 weeks of age, where Low BW pigs offered the FTW regime were over 3% closer to satisfying their energy requirements than STAND pigs. This is a pertinent finding, especially during the immediate post-weaning period where animals typically struggle to achieve their required feed intakes (Tokach et al., 2003) which is recognised as a growth limiting factor in compromised pigs (Gondret et al., 2005). However it is also possible that consuming the highest specification Starter Diet 1 for longer, as well as being older and more mature at each dietary transition, may have facilitated improved digestive development and improved growth performance amongst Low BW animals offered the FTW regime. Indeed Huting et al. (2017) suggested an increased supply of essential nutrients such as threonine and tryptophan, which may have been more readily available to the Low BW pigs offered the FTW regime, can help negate the higher intestinal epithelial cell turnover and reduced appetite in compromised pigs.

Whilst previous work has shown that offering a higher specification or increased allowance of post-weaning diets conferred growth benefits in the immediate post-weaning period, these were no longer evident at slaughter (Douglas et al., 2014b; Wolter et al., 2002). However the findings of the current study are promising in that the FTW dietary regime continued to support the superior animal liveweight for both Low BW and *Av* BW animals through to slaughter.

4.2. Animal body composition and carcass characteristics

The greater carcass weight of *Av* BW pigs at slaughter compared to those of Low BW was expected due to their greater liveweight. This is in agreement with the findings of Rehfeldt et al. (2008) which showed Low BW animals to record a reduced carcass weight when compared to their heavier littermates (85.1 kg vs 88.1 kg). The greater kill-out percentage recorded by *Av* BW pigs concurs with the work by Makaukii et al. (2000) who found heavier animals to record a significantly increased kill-out percentage. This was attributed to the organs of the carcass accounting for a greater proportion of total deadweight in lighter animals. Birthweight had no effect on the backfat recorded at slaughter in the current study, despite the Low BW animals being 9.6 kg lighter at slaughter. This is supported by Rehfeldt et al. (2008), who attributed similar findings to the smaller number yet greater size of myofibrils in compromised pigs. The greater quantity of total tissue and lean content for *Av* BW pigs compared to those of Low BW throughout the trial, as well as a greater total fat content for *Av* BW pigs at 4 and 10 weeks of age, supports findings from Gondret et al. (2005). Additionally, the higher percentage lean content and lower percentage fat content expressed by *Av* BW pigs at 4 and 10 weeks of age may be explained by the inferior muscle fibre network and increased lipid deposition associated with low birthweight animals (Rehfeldth and Kuhn, 2006; Douglas et al., 2014b; Pardo et al., 2013). Whilst Low BW pigs continued to record a numerically lower percentage lean content and numerically greater percentage fat content to *Av* BW pigs at 21 weeks of age, the lack of significant difference was unexpected and in contrast to literature (Bee, 2004; Collins et al., 2017). The more extensive variation within the data set as animals grew heavier meant a greater difference was required for significance to be observed, as explained by Wellock et al. (2009). For both Low BW and *Av* BW pigs, percentage lean content increased progressively by a similar extent from 4, to 10, to 21 weeks of age and percentage fat content decreased progressively to a similar extent from 4, to 10, to 21 weeks of age. This is a unique finding as no studies known to the authors have compared the change in body composition of Low BW and *Av* BW pigs over time by serially scanning a single animal population.

Feeding regime had no effect on kill-out percentage in this study. This is in agreement with work by Skinner et al. (2014) which found no difference in this parameter when commercial slaughter weight pigs were offered different starter regime allowances in the six weeks following weaning. Although Wolter and Ellis (2001) found that providing additional nutrients to piglets via a milk supplement in the two weeks following weaning decreased the levels of back-fat at slaughter by 1.5 mm compared to animals fed conventionally ($P < 0.05$), the current study found no differences in back-fat levels between animals offered the two feeding regimes. Similarly, feeding regime had no effect on either the total or percentage content of tissue, lean or fat at any stage of the trial period for the animal subset which underwent DEXA scanning. This concurs with findings from Lawlor et al. (2002) showing that starter diet allowance in the four weeks following weaning had no effect on any carcass characteristics at slaughter. Furthermore Dalla Bona et al. (2016) showed that altering the dietary allowance of pigs from weaning to a liveweight of 145 kg at slaughter had no significant effect on carcass lean percentage. This is a significant finding as it suggests, despite an inferior capacity for lean growth in compromised pigs compared to normal birthweight counterparts (Rehfeldt and Kuhn, 2006), both birthweight categories in this study had the capacity to convert the additional nutrient and energy intake provided by the FTW regime to a greater liveweight, yet record an equivalent percentage lean content to pigs fed the STAND regime. Whilst this is an important finding, it should be interpreted cautiously as body composition analysis was based on a dataset employing only a subset of the total experimental animals.

5. Conclusion

This study has shown that careful management of post-weaning nutrition can markedly increase the liveweight of all animals. Furthermore, low birthweight pigs have the physiological capacity to improve their growth performance when offered a feeding regime tailored to their weight and stage of development. This improved the growth of low birthweight animals relative to their weaning weight during the nursery stage and reduced the weight differential at slaughter compared to average birthweight pigs fed a standard ration by almost 2 kg, with no detrimental effect on carcass composition. This represents an opportunity commercially to maximise the slaughter weight of all animals, improving output and profitability at farm level.

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The authors declare there are no conflicts of interest.

CRediT authorship contribution statement

Samuel James Hawe: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Writing - original draft. **Nigel Scollan:** Supervision. **Alan Gordon:** Formal analysis. **Ramon Muns:** Conceptualization, Data curation, Software, Methodology. **Elizabeth Magowan:** Conceptualization, Methodology, Supervision, Validation, Writing - review & editing.

Declaration of Competing Interest

The authors declare there are no conflicts of interest.

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