STUDIES ON GROWTH RATES IN PIGS AND THE EFFECT OF BIRTH WEIGHT

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Summary

The purpose of this study was to assess some environmental and management factors that affect growth performance on commercial pig units. In experiment 1, a survey was carried out on 22 pig units of known growth performance in south-west Ireland to compare management factors between those showing poor and good growth rates. Low growth rate appears to be due to the cumulative effect of a combination of factors.

Experiment 2 was conducted to determine the effects of providing an additional feeder on performance of weaned piglets. No benefits were recorded. Feed consumed from the additional feeder was a replacement for feed that otherwise would have been consumed from the control hopper feeder.

Experiment 3 was designed to determine if pig performance and efficiency of growth were affected by weight at birth and at weaning. Lightweight pigs showed inferior growth performance up to the finisher period. Although they compensated some of the inferior growth towards the time of slaughter, they never reached the weights of the heavy birth-weight animals. Males were either significantly heavier or tended to be heavier than females throughout. There was no significant difference between the sexes in the number of days to slaughter. Light and heavy pigs did not differ in the levels of IGF-1 in their blood plasma; however lightweight pigs had significantly lower IgG pre-weaning.

Experiment 4 aimed to determine whether piglet birth weight influenced growth performance, plasma IGF-1 concentrations and muscle fibre characteristics at day 42 of life. At slaughter (Day 42) light birth weight pigs were significantly ($P < 0.001$) lighter. Plasma IGF-1 concentration was lower by 28% ($P=0.06$) in light pigs. Muscle fibre cross sectional area and total fibre number were not significantly different between groups. This study should be repeated with bigger numbers.

Introduction

Pigs on commercial production units grow on average 20 to 30% slower than pigs housed individually in either research facilities or boar testing centres. The reduced growth rate of commercial pigs appears to be associated with a lower feed intake. There are many reasons for the low intakes including, animal constraints, environmental limitations and/or nutritional factors. Commercial units generally have more pigs/building, less air space/pig, less floor space/pig and more pigs/pen.

Reproductive performance (litter size, pigs per sow per year) greatly influences the profitability of commercial swine production. However, bigger litters tend to have lower and more variable individual weights. The higher the piglet birth weight and weaning weight, the greater its potential for growth through to slaughter. As a general rule, each 0.1kg increase in birth weight results in a 0.2kg increase in weaning weight and each 0.1kg increase in weaning weight results in an extra 0.5kg body weight at slaughter.

Numerous authors have examined conditions affecting growth rate of pigs and there is a strong suggestion that the factors shown to reduce performance of pigs raised under commercial conditions increase the stress levels of the animals. The effect of several stressors appears to be additive and the removal of any one of these stressors can improve performance.

Experiment 1. Factors that affect the performance of pigs from weaning to slaughter on Irish commercial units

Introduction

Growth rates on Irish farms are lower than in some other European countries (Table 4.1.). It must be considered that the European countries are rearing castrates and to heavier slaughter weights, therefore, these figures may over-estimate the Irish performance.

Table 3.1. Growth performance in some of the Pig Producing EU countries

Country	Weight Range Kg		Weaner		Finisher	
	Weaning	Slaughter	ADG	FCR	ADG	FCR
Ireland	6.9	94.1	434	1.79	743	2.73
UK	7.2	96.1	462	1.77	627	2.74
Denmark	7.0	102.0	415	1.63	831	2.70
France	7.8	113.8	452	1.68	766	2.91
Netherlands	8.0	115.8	327	1.67	762	2.67

Fowler (2004).

Table 3.2 shows growth rates in Ireland since 2000.

Table 3.2: Summary of physical performance in Ireland 2000, 2002 and 2003 (finishing pigs c 35 to 90kg).

Year	ADG (g/day)	FCE	Slaughter weight (kg)
2000	723	2.68	90.0
2002	749	2.70	93.5
2003	743	2.73	94.1

Fowler (2004).

Objectives

A survey of production parameters of group housed weaner, grower and finisher pigs was carried out to identify differences between farms suffering from poor growth rates (= LOW) in relation to their better performing counterparts (= HIGH). The investigation involved 22 commercial farms with a sow population of 14,000 (about 7.5 per cent of the Irish sow population). All were clients of Teagasc Pig Service who maintaining herd records on PIGSYS (Table 3.3).

Materials and methods

Each farm was visited twice during 2004 and a proportion of pens were monitored. The number of pens surveyed varied from c. 1 in 5 on small units to 1 in 10 on large units.

Table 3.3. Production performance on surveyed farms 2003

			Weaner				**Finisher**	
Farm.		**ADFI**	**ADG**	**FCE**		**ADFI**	**ADG**	**FCE**
1		794	507	1.57		1816	711	2.55
2		652	340	1.92		2023	757	2.67
3		857	445	1.93		2001	695	2.88
4		734	410	1.79		2105	716	2.94
5		858	461	1.86		2177	678	3.21
6		777	454	1.71		2160	712	3.03
7		616	406	1.52		1834	645	2.84
8		N/A	N/A	N/A		N/A	N/A	N/A
9		707	344	2.06		1501	497	3.02
10		N/A	N/A	N/A		N/A	N/A	N/A
11		863	495	1.74		1801	787	2.29
12		707	426	1.67		1772	658	2.69
13		809	365	2.22		1997	847	2.36
14		584	400	1.46		1266	597	2.12
15		785	467	1.68		2106	835	2.52
16		1089	561	1.94		2358	720	3.27
17		876	495	1.77		2009	763	2.63
18		742	465	1.59		1855	719	2.58
19		780	481	1.58		2030	758	2.67

20		968	503	1.85		2220	765	2.9
21		614	401	1.53		1933	753	2.57
22		845	489	1.73		2005	787	2.55

Farm details

All 22 farms were integrated units:

- 2 used wet feeding systems for weaner and finisher pigs
- 10 used dry feeding systems for weaner and finisher pigs
- 10 used wet/dry feed systems (i.e. single space feeders with drinker in the feed trough.
- 5 used wet feeding for the finishing pigs but dry feed for weaners
- 3 provided dry feed to the weaners in addition to wet feed.

Some farms used more than one feed system.

Data collected

- Number of pigs / pen / Pen area of floor.
- Slatted area %   / slat quality / condition and dimensions.
- Feeder type / Feed availability.
- Drinker type / Flow rate/min.
- Temperature recorded / temperature and ventilation control system.

Water flow rate was calculated as the length of time taken to fill a one-litre canister.

Welfare and behaviour

- Presence of manipulable materials.
- Incidence of vices / fighting.
- Pig posture – Lying / eating / activity behaviours.
- Pig variability / condition.

Statistical analysis

Statistical analysis was by the methods of SAS Inc., Cary, NC using pen and farm means as the variables.

Results and discussion

Staffing was a serious issue on some units and although staff numbers were not recorded at the time of survey, on subsequent consideration, it was considered that (at least on some farms) staff shortage could be a contributing factor to low growth rates. Many farms had a combination of feeding systems, housing layouts and management strategies, making it difficult to make meaningful statistical comparisons. Results are shown in Table 3.4.

Weaner stage 1

- In weaner stage 1, units categorised as HIGH had similar group size and floor space per pig to those categorised as LOW (P>0.05). They also had similar feeder space per pig and numbers of pigs per drinker.
- Water flow rate (flow rate per minute multiplied by number of drinkers divided by number of pigs) was significantly higher (P<0.05) in HIGH herds. One of the first symptoms of an inadequate water supply is a reduction in feed intake.
- Only two of the 22 units had wet feed in this stage. Lawlor *et al.* (2002) showed that wastage on wet feeding systems for weaned pigs was very high.
- Overall HIGH herds tended to have a numerically more favourable number of pigs per drinker and more feeder space per pig even if these differences were not statistically significant.

Weaner stage 2

- HIGH and LOW herds had similar group size and floor space per pig (P>0.05).
- HIGH herds had more feeder space per pig for dry feeding (P<0.01) and tended to allow more feeder space for wet fed pigs (P=0.09).
- Number of pigs per drinker was similar in the two categories of farm (P>0.05) while the difference in flow rate per pig favoured the LOW herds.

- Overall as in weaner stage 1, the HIGH herds tended to have a more favourable number of pigs per drinker and floor space per pig even if not statistically significant.

Finisher

- Group size and floor space per finisher pig was similar in the HIGH and LOW groups (P>0.05).
- Dry fed finisher pigs had more space in the HIGH herds (P<0.01). Wet fed pigs also had more feeder space but the difference was not significant (P>0.05).

- While the number of pigs per nipple was lower in HIGH herds, water flow rate per pig was higher in LOW herds. Neither difference was significant.

Table 3.4. Group size and space allowances on farms with good and poor growth rates

	HIGH	LOW	s.e.	F-test
Weaner 1				
Group size	28.1	28.2	3.8	NS
Floor area per pig	0.25	0.24	0.013	NS
Feeder space (dry feed), cm	13.4	12.7	0.68	NS
Feeder space (wet feed), cm	17.0	12.4	Note [1]	-
Pigs per drinker (dry feeding only)	13.6	15.4	3.2	NS
Water flow rate, ml/pig/min	104	65	12	*
Weaner 2				
Group size	23.3	23	2.4	NS
Floor area per pig	0.46	0.42	0.047	NS
Feeder space (dry feed), cm	18.3	15.3	0.55	**
Feeder space (wet feed), cm	21.5	17.9	0.9	P= 0.09
Pigs per drinker (dry feeding only)	14.6	15.4	2.2	NS
Water flow rate, ml/pig/min	84	94	14	NS
Finisher				
Group size	19.6	19	2.1	NS
Floor area per pig	0.76	0.77	0.06	NS
Feeder space (dry feed), cm	26.3	19.1	3.9	**
Feeder space (wet feed), cm	24.4	22.8	1.1	NS
Pigs per drinker	13.4	17.0	1.5	NS
Water flow rate, ml/pig/min	90	120	18	NS

[1]*2 observations only no statistical analysis*

Proportion of pens with adequate space

- There was no difference in stocking rate between HIGH and LOW farms when farm means were compared. When all observations were examined the percentage of pens which allowed adequate space was different only in the case of weaner 2 with 94% of pens in HIGH farms allowing over 0.3m^2 per pig where as only 72% did so on LOW farms (Table 3.5). In the finisher stage only 72% of pens in each category allowed 0.65m^2 per pig. While transfer weights (weaner 1 to weaner 2 and weaner 2 to finisher) were not recorded these figures indicate significant crowding in all stages on both HIGH and LOW farms.

Table 3.5. Percentage of pens in each stage and category allowing more floor space than the threshold value shown

Pig category	**Threshold (m^2)**	**HIGH**	**LOW**
Weaner 1	0.2	66	65
Weaner 2	0.3	94	76
Finisher	0.65	72	72

Feed availability

- Feed availability was scored from 1 = trough clean or empty to 5 = very wasteful. Mean scores are shown in Table 3.6. The percentage of pens where troughs were classed as clean or empty is shown in Table 3.7. The high proportion of very clean feeders in stage 1 pigs may indicate a concern over wastage of expensive creep/starter and link feeds.

Table 3.6. Feed availability scores[1] for each category and stage

Stage	**HIGH**	**LOW**
Weaner 1	2.4	2.6
Weaner 2	2.7	2.7
Finisher	2.7	2.5

[1] A higher value indicates more feed in the trough

- Staff shortages and failure to adjust feeders regularly may be important. Nelssen et al (1999) suggested ‘aggressive’ feeder management to remedy wastage, build-up of stale feed and feeder clogging. This involved regulating the quantity of feed in the feed pan intensively. In the first few days after weaning 50% of the feeder base was covered. This was then reduced to less than 25%.

Implementation of this system saw an improvement in average daily gain and feed efficiency.

Table 3.7. Percentage troughs classed as clean or empty for each category and stage

Stage	HIGH	LOW
Weaner 1	58	53
Weaner 2	35	44
Finisher	41	55

Vices

- LOW farms had a greater percentage of pens showing presence of tail (or other) biting (Table 3.8). This was especially true in first stage pigs.

Table 3.8. Percent of pens in each category and stage showing signs of biting (%)

Stage	HIGH	LOW
Weaner 1	1	13
Weaner 2	10	17
Finisher	7	10

Use of manipulable materials

HIGH farms tended to use manipulable materials to a much greater extent than did LOW farms (Table 3.9). Barren housing conditions may hamper the development of normal behavioural patterns, affecting their welfare and ultimately performance.

Table 3.9. Percent of pens in each category and stage having manipulable material or object (%)

Stage	HIGH	LOW
Weaner 1	8	1
Weaner 2	25	9
Finisher	18	8

Pig evenness

Within-pen variability was scored visually as fair (i.e. pigs variable in size/weight) or good (i.e. pigs even in weight). The percentage of pens judged as "variable" was higher on the LOW farms (Table 3.10). This could be due to failure to grade pigs at entry to the stage.

Table 3.10. Percent of groups in each category and stage showing signs of variability (%)

Stage	HIGH	LOW
Weaner 1	15	37
Weaner 2	16	30
Finisher	12	19

Body condition of pigs was scored as "fair, poor or worse" and "good" (Table 3.11) and LOW farms were more likely to have pigs appearing in poor condition i.e. thin pigs relative to the rest of the group.

Table 3.11. Percent of groups in each category and stage showing signs of poor condition (%)

Stage	HIGH	LOW
Weaner 1	7	13
Weaner 2	9	13
Finisher	4	6

Pig Activity

Pig activity (lying, resting, active, playing) was similar on HIGH and LOW farms in each stage of growth.

Environmental conditions

Temperature control was usually by sensor (thermostat or speed controller) but some units had only manual control (Table 3.12) LOW farms were more reliant on manual environmental control.

Table 3.12. Percent of groups in each category and stage with manual environmental control (%)

Stage	HIGH	LOW
Weaner 1	5	17
Weaner 2	15	28
Finisher	28	28

Slat quality

Flooring slats were scored on state of repair/wear (poor quality = broken, damaged, worn) and results are as follows (Table 3.13). The incidence of poor quality flooring was higher in LOW farms, however in general the slat quality was excellent especially in the first and second stage weaners accommodation.

Table 3.13. Percent of groups in each category and stage with poor quality slats (%)

Stage	HIGH	LOW
Weaner 1	0	2
Weaner 2	0	6
Finisher	4	2

Conclusion

While there were no obvious differences between high and low farms, high growth rate farms (HIGH) tended to have more favourable conditions (under several different criteria) for pig growth than low growth rate farms (LOW). Low growth rate appears to be due to the cumulative effect of a combination of factors and an in-depth study of individual farms is needed to identify and rectify the factors involved.

Experiment 2: Effect of an additional feeder on the intakes and performance of 7kg weaned pigs.

Introduction

Reduced feed intake contributes to the post-weaning growth check and feeders designed or adjusted to minimize wastage may not be the most accessible in design. Intake may be reduced whilst the young pig becomes familiar with feeder operation. Allowing young pigs to eat in a synchronous manner as they do prior to weaning, may stimulate intake.

Smith *et al.* (2001) suggested that ample, unrestricted space for weaned piglets was very important and showed that younger pigs spent more time eating than older pigs. A longer feeding time per pig means that fewer piglets have access to each feeding space, the number of spaces may therefore affect of feed intake. Beattie *et al.* (1999) found no advantage in growth performance when weaned pigs were provided with additional feed in a highly accessible trough. SSWD (single space wet/dry) feeders were used and pigs were only allowed access to the additional feeder for 5 days.

Objectives

The objectives of this experiment were:

- To assess feed intake and growth performance of weaned pigs in an *ad-libitum* feed system when given access to an additional feeder in the first 21 days post-weaning.

- To analyse piglet behaviour in relation to dominance/subordination differences that may impair growth in the immediate post-weaning period.

Materials and Methods

Animals

Four hundred and eighty pigs weaned at 26-28 days of age in 16 single sex groups of 15 (average BW: 7.00 ± 2.85 kg) were used. Groups were assigned at random to the extra feeder (2 feeders) or just one feeder as normal (1 feeder). Thus each of the 2 treatments contained 8 groups.

Housing and Management

Pigs were housed for the 28 day trial period in partially slatted pens 2.7m x 1.3m (0.25 m^2/pig). Temperature was maintained at 28°C in the first week and reduced by 2°C per week to 22°C in the fourth week. Temperature was controlled by a STIENEN PCS 8400 controller (Steinen BV, Nederweert, Netherlands). Additional heat was provided by steel floor pads through which hot water was circulated (Nooyen Roosters B.V., Deurne, The Netherlands).

Feeding

The starter diet *Easi-Start* (Devenish Nutrition Ltd., 96 Duncrue St. Belfast) was fed for 11 days post-weaning. The link diet *Vital* (Devenish Nutrition Ltd., 96 Duncrue St. Belfast), was fed to day 28. Both were fed *ad libitum*. Declared nutrient composition of both diets is shown in Appendix Table 1. Care was taken to avoid feed wastage and to maintain feed freshness. Water was available *ad-libitum* from nipple-in-bowl drinkers (BALP La Buvette, Charleville Nord, France).

The standard feeder (feeder A) was a multi-space hopper 77cm in length with 5 eating spaces. The feeding space was 15cm in depth. The additional ‘Turkey’ feeders [Rotecna Maxi Hopper Pan T Hook, Agramunt (Lleida) Spain] were 32cm in diameter at the base and of a similar design (merely larger) to the feeders in which creep was fed pre-weaning.

Statistical Analysis

Data were statistically analysed using the MEANS, and PROC GLM procedures of SAS [Statistical Analysis System (SAS) Institute Inc., Cary, N. Carolina, USA].

Results

Pig performance

No effect of treatment or sex was found in bodyweight (BW) at any period between weaning and the end of the trial (P>0.05) (Table 4.1). There were no significant differences in ADG, ADFI or FCE (P>0.05) (Table 4.2).

Table 4.1. Effect of treatment (1 feeder or 2 feeders) and sex (male or female) on BW of pigs

Weight (Kg)	**1 feeder**	**2 feeders**	**SE**	**P Value**
Weaning (Day 28)	6.97	7.02	0.55	NS
Day 33	7.43	7.50	0.52	NS
Day 40	9.68	9.72	0.55	NS
Day 47	12.2	12.3	0.65	NS
Day 54	15.4	15.6	0.74	NS
Weight (Kg)	**Female**	**Male**	**SE**	**P Value**
Weaning (Day 28)	6.77	7.22	0.55	NS
Day 54	15.2	15.7	0.74	NS

Table 4.2. Effect of treatment on ADG, ADFI and FCR for two diet periods

	1 feeder	2 feeders	SE	P-Value
Starter				
ADG	226	225	19.5	NS
ADFI	235	237	14.1	NS
FCR	1.05	1.07	0.06	NS
Link				
ADG	405	419	23.5	NS
ADFI	547	582	26.0	NS
FCR	1.35	1.39	0.05	NS
Overall period				
ADG	323	329	13.3	NS
ADFI	402	421	17.1	NS
FCR	1.25	1.28	0.02	NS

Pigs ate significantly more of both diets from feeder A than from feeder B (Table 4.3). When access to two feeders was given to the pigs, they split their feedings between the feeders. There were no significant differences between the sexes in the amount consumed from either feeder (P>0.05).

Table 4.3. Quantities of feed consumed between treatments

Diet consumed (Kg)	***Treatment***			
	1 feeder	**2 feeders**	**SE**	**P-value**
Starter (Feeder A)	42.28	27.10	4.79	**
Starter (Feeder B)	0.00	15.23	3.34	N/A[1]
Link (Feeder A)	113.44	105.81	7.32	NS
Link (Feeder B)	0.00	13.21	6.04	N/A[1]

N/A[1] Not applicable, no P-value calculated as only one feeder present.

Pig Behaviour

Pigs given access to an additional feeder had a significantly higher number of feeding events on day 3 but not on other days (P<0.05 - Figure 4.1).

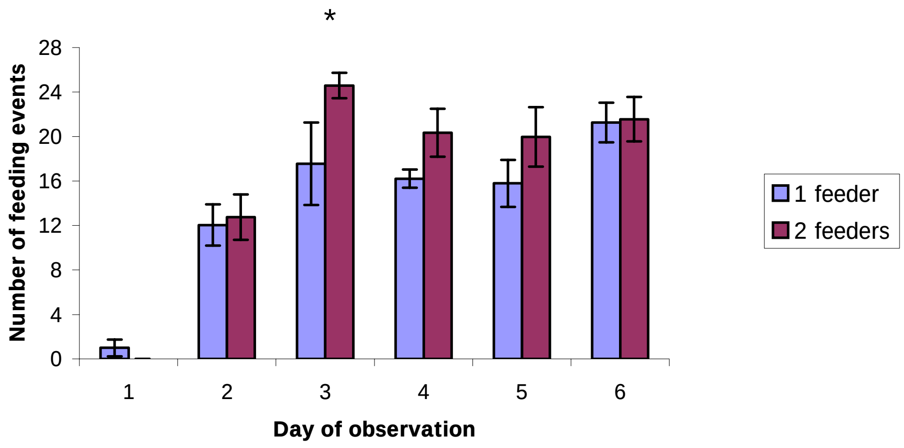

Figure 4.1: Total number of feeding events recorded over the observational period.

Discussion

There was no increase in average daily gain nor average daily feed intake from providing an additional feeder. Beattie *et al.*, (1999) found modest increases in apparent feed intake immediately post-weaning. In the weaner 1 stage of both this trial, and that of Beattie *et al.*, (1999) feed intake averaged circa 330 g/day.

The number of feeding events was highest on the third day of observations (day 5 post weaning). On this day the greatest number of displacements was also recorded, although it was not significantly different between the two treatments. Morrow and Walker (1994) and Nielsen *et al.* (1995) showed diurnal patterns of feeding activity with two peaks, a smaller one before and a larger one after midday. Walker (1991) suggested that in a competitive situation these peaks in demand for the feeder become less distinct.

With more feeding events and feeder displacements, there were also more fights. O'Connell *et al.* (2002) reported that there was less aggressive behaviour amongst weaned pigs when multi space hoppers were used. It may be that the greater number of feeding spaces reduced competition and stimulated pigs to feed together as they did before weaning.

Pigs ate more of both the starter and the link diets from the five-space hopper (feeder A) than they did from the turkey feeder (feeder B). O'Connell et al. (2002) compared five different feeder types for weaned pigs and reported that 'dry' multi-space feeders gave optimum performance immediately post-weaning. Pigs ate 44% more of the starter diet from feeder A, but this increased up to 88% more of the link feed. There was no difference in the total quantity of feed consumed.

The stocking rate allocated to the animals in this experiment was generous ($0.25m^2$), the recommendation for pigs of this weight (10-20kg) being $0.18m^2$ (DAF, 2002). It is possible that under more stringent stocking densities, the additional feeder in the present trial might have been more effective. Feeder space (15cm/pig) in the current work was in accordance with recommendations (DAF, 2002).

Conclusion

No benefits was found to providing an additional feeder (additional feeding spaces). Pigs tended to pick one or other of the feeders and continue to feed from this one.

Experiment 3: Growth rates of pigs (post-weaning and up to slaughter) relative to their birth and weaning weights

Introduction

It has been shown, that the higher the birth weight and weaning weight of the piglet, the greater its potential for growth to slaughter. Parity, genotype and nutrition affect birth weight; litter size and position in the uterine horn have also been cited as possible causes of variation (King *et al*., 1999). Kavanagh (1994) demonstrated that lighter pigs at weaning have lower growth rates post-weaning and are slower to reach a common slaughter weight.

Neonatal pigs are dependent on ingestion and absorption of colostral immunoglobulins. Colostrum also provides highly digestible proteins and growth factors, that enhance growth rate and protein accretion (Pluske, 2001). Intestinal absorption of immunoglobulins normally ceases by 24-36 hours after birth (Pluske and Dong, 1998) and therefore it is important that smaller pigs in the litter consume adequate colostrum soon after birth.

Objectives

The objectives of this experiment were:

- To assess the growth performance of pigs to slaughter in an *ad-libitum* feed system in relation to their weight' at birth and at weaning.
- To measure blood levels of insulin-like growth factor-1 (IGF-1) during nursing and after weaning, as well as levels of immunoglobulin G (IgG) during the nursing period and to ascertain whether levels of these hormones are lower in lighter pigs.

Materials and Methods

Procedure

This experiment used 72 crossbred pigs from the Moorepark herd. They were weaned at 27/28 days of age, weighed and tagged. Pigs (3 males and 3 females from each sow) were chosen based on lowest (LW; 1.2 – 1.6kg), mid (MW; 1.5-1.9kg) and top (HW; 2.1-1.7kg) birth weights. Each pig was housed in an individual pen and fed a commercial starter diet (*Startrite 88*, Nutec Feeds, Monread Ind. Est., Naas Co. Kildare) for 11 days post weaning, then a commercial link diet (*Vigour,* Nutec Feeds, Monread Ind. Est., Naas Co. Kildare) until 32 days post weaning.

Table 5.1: Pig weights at birth and weaning for the two groups combined

	Females, no	**Males, no**	**Birth wt. (kg)**	**Weaning wt. (kg)**
			Mean (SD)	Mean (SD)
LW	12	12	1.36 (0.25)	7.92 (1.34)
MW	12	12	1.63 (0.20)	8.51 (1.47)
HW	12	12	1.93 (0.24)	9.58 (1.29)

From day 60 to day 75, pigs were fed the weaner diet (Appendix Tables 5.3, 5.4 and 5.5). From day 75 to slaughter pigs were penned in groups of 12 and were fed the finisher diet (Tables 5.3, 5.4 and 5.5). Both feeds were pelleted (5mm) and fed *ad-libitum*.

Blood collection

Pigs were blood-sampled at 6d and 20d of age for analysis of IGF-1 and IgG and again 5d and 20d post weaning.

Feeding

Pigs were fed twice daily at 0830, and 1600 hours during the first week. Thereafter pigs were checked twice daily and fed *ad-libitum* with care taken to avoid wastage.

Individual feeding up to day 75 was from hopper type feeder's 30cm in length. After day 75, feeding was from hopper style 7 space feeders 155cm in length. Water was available *ad-libitum* from nipple-in-bowl drinkers (BALP La Buvette, Charleville Nord, France).

Housing and Management

Weaner accommodation

Pigs were individually penned in fully slatted pens (plastic slats, FAROEX, Manitoba, Canada) 1.1m * 0.9m in a room of 24 pens. Temperature control was as in Experiment 2

Finisher accommodation

In the finisher stage pigs were in groups of 12 (6 pigs from each of two litters), in fully slatted pens 4.8m * 2.4m. Temperature control (20 to 22°C) was by a mechanical ventilation system with fan speed and air inlet area regulated by a Steinen PCS Climate Controller, (Steinen BV, Nederweert, Netherlands. Pigs were fed *ad-libitum* in 7 space (1.55m length * 0.33m depth) hoppers. Water was *ad-libitum* from nipple-in-bowl drinkers (BALP La Buvette).

Statistical Analysis

Statistical analysis was by PROC GLM of SAS, (Cary, N. Carolina) and the 'CONTRAST' option was used to compare LW v. MW, LW v. HW and HW v. MW. These pre-planned comparisons were made even if the overall test for differences between means was not significant.

Results

Pig weights are shown in Table 5.2. Treatment means were significantly different ($P<0.001$) at all stages from birth to weaning and post weaning up to day 75. In the finishing period (Day 75 to 111), pig weights were significantly different ($P<0.05$). Pig final weights (> day 111) tended to be different ($P=0.07$).

From day 60, LW pigs were significantly lighter than MW ($P<0.01$) and HW pigs ($P<0.001$). MW pigs were also significantly lighter than HW pigs ($P<0.01$). From Day 60 to day 75, LW pigs were significantly lighter than MW pigs ($P<0.01$) and HW ($P<0.001$) pigs. MW pigs were significantly lighter than HW pigs ($P<0.01$). In the finisher stage, (day 75 to 111), LW pigs were significantly lighter than HW ($P<0.01$) and MW pigs ($P<0.05$). MW pigs were not significantly different in weight to HW pigs.

There was no significant difference in the number of days required to reach slaughter for the three treatment groups. However LW pigs were significantly lighter than MW pigs ($P<0.05$) and HW pigs ($P<0.05$) at the time of slaughter.

At birth female and male animals were not significantly different in weight (Table 3.3). Male pigs tended to be heavier at day 14, ($P=0.09$) day 28 (weaning) ($P=0.06$). Males were significantly heavier than females thereafter, at days 32, 35, 39, 42 and day 47. There was no significant difference between the weights of the sexes at day 60 or day 75. Males tended to be significantly heavier at day 111 ($P<0.05$), but not at the final weighing and the number of days taken to reach slaughter was not significantly different.

Table 5.2. Pig weights from birth to slaughter according to birth weight category

	Birth weight category			F-test				
Weights	LW	MW	HW	SE	Overall	LW v MW	LW v HW	MW v HW
Birth	1.3	1.6	2 2.0	0.03	***	***	***	***
Day 14	3.9	4.8	5.7	0.22	***	**	***	*
Day 28	7.5	8.7	9.8	0.27	***	**	***	**
Day 39	9.8	11.9	13.3	0.30	***	***	***	**
Day 50	15.0	17.1	19.1	0.43	***	**	***	**
Day 60[1]	21.2	23.7	26.2	0.76	**	*	**	*
Day 75	33.2	36.7	40.8	1.08	***	*	***	**
Day 111	49.4	56.2	59.6	2.02	*	*	**	NS
Final weight	79.0	87.4	89.7	2.66	0.07	*	*	NS
Days to slaughter	152.8	152.7	151.3	1.69	NS	NS	NS	NS

[1]48 of the 72 pigs were monitored in the finishing stage.

*In this and subsequent tables *= P<0.05, ** = P<0.01, ***P<0.001. If P < 0.10 and >0.05, the value is shown.*

Table 5.3. Effect of sex on weights from birth to slaughter

	Sex		F-test	
	F	M	SE	F-test
Birth	1.63	1.65	0.023	NS
Day 14	4.57	5.01	0.178	0.09
Day 28	8.37	8.98	0.223	0.06
Day 39	11.13	12.15	0.244	**
Day 60	23.02	24.41	0.618	NS
Day 111	52.52	57.60	1.651	*
Final weight	83.30	87.45	2.170	NS
Days to slaughter	153.6	151.0	1.376	NS

Average Daily gain

Average daily gains from birth to slaughter as affected by **birth weight category** are shown in Table 5.4. There was a significant difference between the treatments (P<0.05) from d0 to 14 and also from d14 to 28 (P<0.01).

There was a significant difference (P<0.01) between categories in weight gain during the immediate period after weaning i.e. day 28-32. Although there was a slight tendency for the treatments to differ (P=0.07) between d32 and 35, there were no overall significant differences between treatments at days 35 to 39. Means were significantly different in the periods day 42-47 (P<0.05), and tended to differ in the periods day 50 to 54 (P=0.08) and 54 to 60 (P=0.07). However no significant differences were seen in the periods day 47 to 50, 60 to 75, 75 to 111 or 111 to slaughter.

Treatment means were significantly different (P<0.01) in the periods from weaning to day 50 and weaning to day 75. There were no significant differences in average daily gains overall from weaning to slaughter or from day 75 to slaughter.

Table 5.4. Average daily gains according to birth weight category

	Birth wt. category				**Treat.**	**F-test**		
	LW	**MW**	**HW**	**SE**	P-Value	**LW v MW**	**LW v HW**	**MW v HW**
Day 0-14	188	228	259	14.5	*	0.07	*	NS
Day 0-28	232	262	287	9.8	**	0.05	**	0.10
Day 28-50	340	379	425	13.6	**	0.06	**	0.02
Day 28-75	543	579	649	19.0	**	NS	**	*
Day 75-slau	606	647	641	32.5	NS	NS	NS	NS
Day 28-slau	575	625	644	24.1	NS	NS	0.10	NS

(LW<1.5kg, MW<2.0kg, HW>2.0kg)

The effect of sex on ADG is shown in Table 5.5. From Days 0 to 14 and 14 to 28 male pig daily gains tended to be higher (P=0.08 and P=0.09 respectively). From birth to weaning (suckling period), males tended to gain more (P=0.06). Males again grew significantly faster in the periods from day 32 to 35 (P<0.01) and day 39 to 42 (P=0.08). Overall from weaning to day 50, there was a tendency for males to grow faster (P=0.10). From day 35 to 39 and after the day 42 period there were no significant differences.

Table 5.5. Effect of sex on average daily gain

	Sex		F-test	
	F	M	SE	F-test
Day 0-14	210	240	11.8	0.08
Day 0-28	249	272	8.0	0.06
Day 28-50	369	394	11.1	0.10
Day 28-75	579	602	15.6	NS
Day 75-slau	610	653	26.5	NS
Day 28-slau	595	634	19.9	NS

Average daily gains from birth to slaughter as affected by **weaning weight category** are shown in Table 5.6. There were no significant differences until the period from day 39 to 42 (P<0.05). There were significant differences during the periods from day 42 to 47 (P=0.07), 47 to 50 (P<0.07) and 60 to 75 (P<0.001). From day 75 to 111, from day 111 to slaughter and overall from day 75 to slaughter, there were no significant differences. However from weaning at day 28 to day 75, overall weight gains of the three categories were significantly different (P<0.05). Also there was a significant difference in gain from weaning to slaughter (P=0.05).

Table 5.6. Average daily gains according to weaning weight category

	Weaning-wt. category					F-test		
ADG	**LW**	**MW**	**HW**	**SE**	**Overall**	**LW v MW**	**LW v HW**	**MW v HW**
Day 28-32	80	129	90	22.9	NS	NS	NS	NS
Day 28-75	549	570	647	18.7	**	NS	**	**
Day 75-slau	599	623	678	31.6	NS	NS	NS	NS
Day 28-slau	576	601	668	22.8	*	NS	*	*

(LW<7.8kg, MW<9.7kg, HW>9.7kg)

From day 28 to 75, i.e. weaning to the change to the finisher diet, HW pigs gained significantly more than LW pigs (P<0.01) or MW pigs (P<0.05). From weaning to slaughter this pattern was also seen with HW pigs gaining significantly more than LW (P<0.05) and MW pigs (P<0.05). No significant differences were seen for average daily gain between day 75 and slaughter.

Daily feed intake

Daily feed intakes are shown in Table 5.7. Intakes were not significantly different from weaning to day 47. A significant difference was noted from day 50 to 54 (P <0.01). MW pigs ate significantly less (P<0.01) than HW pigs from day 47 to 50 and tended to eat less in the day 50 to 54 period (P=0.07). LW pigs tended to eat less than MW pigs (P=0.08) and ate significantly (P<0.01) less than HW pigs in the period day 50 to 54. However the differences became less after the animals moved onto the weaner diet at day 60.

Table 5.7. Daily feed intake according to birth weight category

	Birth wt. Cat.				**F-Test**			
	LW	**MW**	**HW**	**SE**	**Overall**	**LW v MW**	**LW v HW**	**MW v HW**
Feed per day								
Day 28-32	171	205	218	17.0	NS	NS	NS	NS
Day 32-35	331	399	387	28.9	NS	NS	NS	NS
Day 35-39	333	344	375	22.2	NS	NS	NS	NS
Day 39-42	377	410	413	27.5	NS	NS	NS	NS
Day 42-47	416	414	460	23.2	NS	NS	NS	NS
Day 47-50	831	800	926	40.0	0.10	NS	NS	*
Day 50-54	834	934	1030	35.9	*	0.08	**	0.07
Day 54-60	1710	1840	1979	95.5	NS	NS	NS	NS

(LW<1.5kg, MW<2.0kg, HW>2.0kg)

No significant differences between males and females in daily feed were observed over any time period. There were no significant differences between weight categories in feed conversion efficiency (Table 5.8) and there were no significant differences between males and females.

Table 5.8. Feed conversion efficiency according to birth weight category

					F-Test			
FCE	**LW**	**MW**	**HW**	**SE**	**Overall**	**LW v MW**	**LW v HW**	**MW v HW**
Day 28-32	0.88	1.85	2.68	0.524	NS	NS	0.07	NS
Day 32-35	1.03	1.97	1.80	0.431	NS	NS	NS	NS
Day 35-39	1.09	0.90	0.94	0.105	NS	NS	NS	NS
Day 39-42	1.60	1.67	1.53	0.206	NS	NS	NS	NS
Day 42-47	0.92	0.86	0.76	0.060	NS	NS	NS	NS
sDay 47-50	1.25	1.49	1.55	0.113	NS	NS	NS	NS
Day 50-54	1.50	1.45	1.39	0.117	NS	NS	NS	NS

Day 54-60	1.86	2.09	1.17	0.433	NS	NS	NS	NS

(LW<1.5kg, MW<2.0kg, HW>2.0kg)

Levels of Insulin-like growth factor 1 (IGF-1) and immunoglobulin G (IgG) are presented in Table 5.9. No significant differences were observed at any of the 4 samplings. Overall means only are presented for IGF (4 sample points) and IGG (2 sample points).

Table 5.9. Plasma IGF-1 and IgG levels according to birth weight category, ng/ml

	.	**Birth wt. Cat**				**F-Test**			
		LW	**MW**	**HW**	**SE**	**Overall**	**LW v MW**	**LW v HW**	**MW v HW**
IGF	**(Average)**	173	190	172	17.8	NS	NS	NS	NS
IGG	**(Average)**	17.7	22.2	26.7	1.66	**	*	**	0.07

LW<1.5kg, MW<2.0kg HW>2.0kg

There was an overall significant difference in the level of IgG (P<0.01). MW piglets tended to have lower levels than HW on day 6 (P=0.100 and also on day 20 (P=0.09).

Group means for IGF-1 based on **weight at weaning** are shown in Table 5.10. HW pigs tended to have higher IGF-1 on day 33 of age but the difference was less at day 47.

Table 5.10. Plasma IGF-1 and IgG levels according to weaning weight category

		Weaning weight category				**F-Test**			
		LW	**MW**	**HW**	**SE**	**Overall**	**LW v MW**	**LW v HW**	**MW v HW**
IGF-1	**Day 33**	89	123	145	18.4	NS	NS	0.07	NS
IGF-1	**Day 47**	233	259	275	37.3	NS	NS	NS	NS

(LW<7.8kg, MW<9.7kg, HW>9.7kg).

Discussion

Light birth weight piglets remained lighter than either of the other categories. The pigs of a medium birth weight compensated their early weight deficit in comparison to the heaviest piglets by day 111.

Feed intakes during the nursing period were not recorded in the course of this work, however it can be assumed that as the HW pigs gained more than the LW piglets at every stage up to day 32, their intake of milk was higher. Low birth weight piglets are at a competitive disadvantage to larger pigs when the two groups are reared together. Differences in performance due to the lighter piglets inability to compete may confound differences due to birth weight.

Average daily gains up to slaughter did not differ consistently amongst the weight categories. Although lightweight piglets never gained at a rate equivalent to that of the heaviest birth weight groups (>900g/d), they grew at an increasing rate.

Strong positive relationships have been observed between growth rate and the concentrations in blood of IGF-1 in young boars (Owen et al., 1993). However, at the four points at which pigs were blood sampled, the concentration of IGF-1 in plasma was not significantly different; neither piglet birth weight nor sex made any difference to the levels. Taylor *et al*. (1992) stated that concentrations of IGF-1 as well as cholesterol, protein and fat deposition were higher for pigs given a high, as opposed to a low feeding level.

The predominant immunoglobulin isotype in colostrum is IgG and it also constitutes the major isotype in sow serum (Gaskins and Kelley, 1995).   High birth weight pigs had a higher level of IgG in their plasma at day 6 than LW piglets, perhaps due to a higher level of colostrum being ingested. At day 20 this effect was still present but the concentration of IgG was considerably lower. IgG concentration decreases quickly and IgA becomes the major immunoglobulin in sow milk (Gaskins and Kelley, 1995).

Conclusion

Weaning is characterised by a period of low voluntary feed intake and this is coupled with the sudden withdrawal of specialised components contained in sows' milk that afford a degree of protection to the young pig. The relationship between IGF-1 concentration and growth rate in this study was weak.

Experiment 4: Influence of piglet birth weight and feed intake post-weaning on growth, muscle histological traits and plasma growth hormone levels (IGF-1) post weaning.

Introduction

The number of piglets born alive in France has increased from less than 10.9 per litter to 12.2 in the years 1992- 2001 (Pellois, 2002). This selection for increased prolificacy has led to an increase in within litter variability in birth weight (Tribout et. al., 2003).

Fibre number is the most important determinant of muscle mass. In the pig, muscle fibre hyperplasia (increase in the number of cells) is completed during gestation with fibre number remaining fixed from birth (Dwyer and Stickland, 1991). Post-natal growth potential of the muscle is limited to hypertrophy (increase in the size of cells). Relative to heavy piglets, light piglets at birth are handicapped in three ways, (1) they have fewer muscle fibres at birth (and thus a lower growth potential), (2) a lower ingestion capacity (in absolute value) and (3) less growth hormone (IGF-1).

The objective of this study was to evaluate post-weaning, the effects of weaning weight and feed intake on growth, nitrogen retention, rates of circulating IGF-1 and after slaughter, area and number of muscle fibres and potential for protein synthesis.

Materials and Methods

Procedure

This experiment was conducted at the experimental farm of INRA (35590 St. Gilles, France).

Individual piglet body weight was measured within the first 24 hours. At weaning, (28 days), a triplet of pigs was chosen within each litter (n=6), this triplet consisted of 2 piglets that were heavy at birth and weaning and one piglet that was light at birth and weaning.

Piglets within each triplet were assigned to one of three experimental groups, which were as follows.

- LL: lightweight piglets that were fed ad libitum (LL group).
- HL: heavyweight piglets that were pair-fed with the LL piglets.

- HH: heavyweight piglets that were fed ad libitum

Table 6.1: Pig weights at birth and weaning for the three experimental groups.

	Birth wt (kg) ±SE	Weaning wt (kg)±SE
LL	1.17 (0.19)[1]	7.68 (0.71)
HL	1.73 (0.30)	10.3 (0.95)
HH	1.79 (0.32)	10.3 (0.77)
F-test	**	**
Overall	1.56 (0.40)	9.43 (1.49)

** = P<0.01

At weaning at 28 days of age, animals were moved to individual metabolism cages allowing separate collection of faeces and urine. The trial lasted 14 days.

Feeding

The starter feed was based on barley, soya (50% CP), milk products, minerals (calcium carobanate, dicalcium phosphate), vitamins, trace elements and was supplemented with amino-acids, phytase and anti-fungal agents. It provided (on as fed basis) 210g CP, 17.1 kJ DE/g (measured value), 14g lysine, 8.4g methionine and cystine, 9.1g threonine and 2.8g tryptophan per kg (estimated values). The diet was given in pelleted form (Ø = 2mm). During the first 5 days (day 28 – 33), corresponding to the period where piglets are learning to eat the dry food, all piglets were fed ad-libitum. From day 6 onwards, the heavy/light (HL) piglet was pair fed with the light/light (LL) piglet of its triplet while the HH piglet was fed *ad-libitum* i.e. the HL piglet received on each day, the same quantity of feed that was consumed by the LL piglet on the previous day.

Measurements

Blood sampling

Blood samples were taken in a supine position by anterior vena cava puncture on days 33, 37 and 42 of age. Plasma was stored at -20ºC until analysis

Slaughter and tissue collection

The piglets were slaughtered by electrical stunning and exsanguination. Three muscles were excised. They were the (1) entire semitendinosus muscle (ST, a mixed muscle with a red oxidative deep fraction and a white glycolytic superficial fraction), (2) the entire rhomboïdeus (RH, slow twitch oxidative) and (3) a sample of the longissumus dorsi (LD) taken at the level of the last rib. ST and RH were weighed and cut in two or three sections. Samples were stored at -80˚C. The entire liver was also collected and weighed.

Analysis

On muscle homogenates protein, DNA and RNA values were determined. The RNA capacity (i.e., RNA:protein ratio) was calculated because it is reported to be proportional to the fractional synthesis rate (Attaix *et al.,* 1988).

Concentrations of insulin-like growth factor-1 (IGF-1) in plasma were determined using a double RIA antibody assay, after acid ethanol extraction (Louveau and Bonneau, 1996).

Statistical analysis

Statistical analysis was by PROC GLM of SAS Inc., Cary, N. Carolina. The CONTRAST option was used to compare treatments HH v HL, HH v LL, HL v LL even where the overall treatment difference was not significant.

Results

Piglet growth

Growth data are shown in Table 5.2. Overall from weaning to day 42, HH pigs ate more (P<0.001), grew faster (P<0.001) and were more efficient P<0.01) than HL and LL.

Table 6.2. Growth performance of pigs

					F-test			
Treatment	**HH**	**HL**	**LL**	**SE**	**Overall**	**HH V HL**	**HH V LL**	**HL V LL**
Weaning wt. kg	10.4	10.3	7.7	0.33	***	NS	***	***
Final weight	15.2	13.0	10.9	0.44	***	**	***	**
<u>Day 28-33</u>								
ADG, g	87	2	91	22.6	*	*	NS	**
Daily feed, g	134	75	112	15.6	*	*	NS	NS
FCE	1.53	N/A[1]	1.23	0.48	NS	NS	NS	NS
<u>Period 28-42</u>								
ADG, g	345	194	227	12.5	***	***	***	0.08
Daily feed, g	351	235	254	11.9	***	***	***	NS

FCE	1.02	1.21	1.12	0.04	**	***	*	*

[1] Mean FCE for treatment 2 was omitted from the analysis since some of the calculated values were either negative or extreme outliers.

Digestibility

Apparent digestibility of energy and nitrogen were similar across treatments (Table 6.3). Metabolizable energy content of the feed averaged 14.4 kJ /g. Nitrogen retained in HL and LL pigs was similar averaging 7.1g/d, which was 35% lower than in HH pigs

Table 6.3. Effect of weaning weight and feed intake on N and energy digestibility and N retention

	Treatments					**F-test**		
	HH	**HL**	**LL**	**SE**	**Overall**	**HH v HL**	**HH v LL**	**HL v LL**
Nitrogen								
Intake, g	17.9	12.3	12.1	0.51	***	***	***	NS
Faecal N, g	2.3	1.5	1.7	0.16	**	**	*	NS
Urinary N , g	3.4	2.7	2.6	0.13	**	**	***	NS
Digestibility, %	86.8	87.7	85.7	0.03	NS	NS	NS	NS
N retained, g/d	1.74	1.15	1.12	0.01	***	***	***	NS
Energy								
Intake, kJ	8645	5904	5840	232	***	***	***	NS
Fecal, kJ	1098	719	791	48	***	***	***	NS
Urinary energy	219	194	165	16	P=0.09	NS	*	NS
Digestibility %	87.3	87.9	86.4	0.50	NS	NS	NS	6%
ME, kJ /g feed	14.5	14.5	14.3	0.01	NS	NS	NS	NS

Carcass characteristics

Characteristics of pigs at slaughter are given in Table 6.4. Treatment means differed significantly for kill out percentage ($P<0.01$). Differences in treatment means for empty carcass weight, liver weight and weight of the semitendinosus muscle were highly significant ($P < 0.001$). HL and LL pigs had similar liver weight that was 28% ($P<0.01$) lower than in HH pigs, whereas ST weight was different between the three groups ($P<0.01$). However, when expressed in g / kg live weight, only treatment means for liver remained significant ($P < 0.01$).   Mean rhomboïdeus muscle weights at slaughter did not differ significantly.

Table 6.4. Live weights, dead weights, liver weights and muscle weights at Day 42 (day of slaughter of trial animals)

	Treatment				F-test			
	HH	HL	LL	SE	Overall	HH V HL	HH V LL	HL V LL
Carcass wt., kg	10.4	9.3	7.3	0.32	***	*	***	***
Kill out %	68.6	71.9	66.9	1.96	**	0.06	NS	*
<u>Liver</u>								
Weight, g	329	244	227	11.2	***	***	***	NS
G/kg live weight	2.38	1.88	2.09	0.09	**	**	*	NS
<u>ST</u>								
Weight, g	60	52	42	1.98	***	*	***	**
G/kg live weight	0.43	0.40	0.39	0.022	NS	NS	NS	NS
<u>RH</u>								
Weight, g	5.5	4.8	4.8	0.35	NS	NS	NS	NS
G/kg live weight	0.04	0.04	0.04	0.003	NS	NS	NS	NS

LD, ST and RH muscle composition

Muscle composition

Longissimus dorsi dry matter percentage was not significantly different between treatments and overall, LD dry matter averaged 27.1 ± 1.37%. Concentrations of DNA, RNA and protein and the protein:RNA ratio in LD were not significantly different among groups (Table 6.5). DNA was significantly higher in RH muscle of the LL pigs than in HH or HL groups. There was also a tendency (P=0.07) for LL pigs to have higher levels of RNA than the HL pigs in this muscle. There were no significant differences between treatments in the RH muscle for protein or the protein:RNA ratio. There were no significant differences between treatments in the ST muscle for levels of DNA, RNA or the protein:RNA ratio. There was, however, a tendency (P = 0.07) for HL pigs to have higher levels of protein in this muscle than the HH or the LL pigs.

Table 6.5: Concentration of DNA, RNA, Protein and the ratio of protein:RNA in the LD, ST and RB muscle samples

	Treatment					F-test		
	HH	HL	LL	SE	Overall	HH V HL	HH V LL	HL V LL
DNA mg/g								
LD	0.75	0.78	0.67	0.079	NS	NS	NS	NS
ST	0.71	0.81	0.79	0.118	NS	NS	NS	NS
RB	0.67	0.79	0.97	0.078	*	NS	*	NS
RNA ug/g								
LD	1055.0	1037.3	1112.8	44.03	NS	NS	NS	NS
ST	882.6	922.7	930.8	48.40	NS	NS	NS	NS
RB	985.3	946.4	1033.9	32.08	NS	NS	NS	0.07
Protein ug/g								
LD	128025	125675	128030	2881.1	NS	NS	NS	NS
ST	118942	125935	118572	2670.6	NS	0.08	NS	0.07
RB	121820	125487	124103	3092.4	NS	NS	NS	NS

LD: longissimus ST:semidentinosus, RB: rhomboïdeus

Muscle fibre histology

Number of muscle fibres counted in the ST and RH muscles are shown in Table 6.6. No significant differences were found between any of the treatments. However, counts were very variable, for example CV of number of muscle fibres in HH pigs was 38%.

Treatment means for the semi-tendinosus cross sectional area were significantly different ($P<0.05$) with HH animals having a significantly greater ST cross sectional area compared to LL ($P<0.05$) animals. Also HL pigs tended to be different to LL animals ($P<0.1$). However, there were no significant differences for ST fibre areas. Treatment means for the cross sectional area of the rhomboïdeus muscle were not significantly different. Means for RH fibre areas were significantly different ($P<0.05$). HL pigs had significantly greater RH fibre areas than both the LL ($P < 0.02$) and the HH ($P=0.05$) pigs.

Plasma Hormone levels

Concentrations of plasma IGF1 measured on d 33, 37 and at slaughter were not significantly different (P> 0.05). Therefore data were pooled (Table 6.6). Differences in treatment means tended towards significance (P<0.06). HH pigs had a higher concentration of plasma IGF-1 than HL (P<0.05) and tended towards significance compared with LL (P<0.06).

Table 6.6: Number of muscle fibres and IGF-1 concentrations

	Treatment				**F-test**			
	HH	**HL**	**LL**	**SE**	**Overall**	**HH V HL**	**HH V LL**	**HL V LL**
ST								
CSA mm^2	82.4	78.2	69.4	3.39	*	NS	*	0.08
No. of fibres ST	702621	584526	668269	101434	NS	NS	NS	NS
Area ST fibre µm^2	0.16	0.14	0.15	0.01	NS	NS	NS	NS
RH								
CSA RB, mm^2	0.40	0.47	0.52	0.062	NS	NS	NS	NS
No. of fibres RH	33493	46221	38840	6715.8	NS	NS	NS	NS
Area RH fibre µm^2	0.11	0.13	0.11	0.004	*	*	NS	**
IGF-1 ng/ml	93.3	61.04	67.02	9.27	0.06	*	0.06	NS

Discussion

Increasing numbers of low birth weight piglets from large litters are a cause for concern because of their lower survival rate and lower subsequent growth rate. Piglets born at lighter weights do not grow as quickly as their heavier counterparts (Powell and Aberle, 1980; Wolter et al., 2002) and level of feeding has been shown to have a marked effect on muscle histology (Lefaucheur et al., 2003).

In the pre-study period (i.e. birth to weaning) HH and HL pigs grew at similar rates (>300 g/d) but LL pigs had lower growth rates (<300 g/d). HH and HL pigs were similar in weight at birth and weaning, suggesting that these animals were able to compete effectively during the nursing period. LL piglets were of a lighter weight at birth and did not show any compensatory growth up to weaning and were therefore lighter at weaning also. This agrees with the results of Kavanagh (1994) who carried out a study on the manipulation of weaning weight by aggressive feeding of a liquid milk-based diet**.** Gondret et. al., (2005) speculated that ADFI (and ultimately growth rate) was reduced in low birth weight piglets only in the suckling and immediate post-weaning period. In this study, feed intake immediately post-weaning was very variable as was growth rate in agreement with the literature data. It is noticeable, that during this period (d 28- D 33) where pigs were fed ad libitum, light pigs consumed more feed (91 vs 50 g/d) than did the heavy ones (HH and HL groups). In pigs raised in groups, Bruininx et al. (2001) reported similar results. Thereafter, as expected, HH pigs consumed more and hence grew faster than LL and HL pigs which consumed similar amounts of feed.

There were no significant differences in IGF-1 expression between the HL and the LL treatments. However there was a clear tendency for the HH piglets to have higher concentrations of IGF-1 than HL and LL pigs. Differences between HH and HL pigs could be explained by the fact that IGF-1 is responsive to nutrient intake (Straus, 1994), with blood IGF-1 levels being closely related to the energy intake and hence growth rate (Dauncey et al., 1994).

In this study the number of muscle fibres in ST muscle is in the range determined by Gondret et al. (2005), whereas it was lower in the RH muscle. The difference is likely due to the sampling location of sections. Assuming that number of muscle fibres is fixed at birth, the results of our study suggest that birth weight has no effect on the number of muscle fibres as illustrated by total fibre number in ST and RH muscles. This is in contrast with data of Handel and Stickland (1987) and Gondret et al. (2005) showing that fiber number is reduced in light piglets at birth. However, in the work of Handel and Stickland (1987), a reduced number of muscle fibres was only observed in piglets weighing 0.78 kg or less which is much lower than the average birth weight of our light piglets (1.2 kg). It suggested that effects of birth weight and feed intake on number of muscle fibre and fibre traits require further investigations.

Experiments 5 and 6. Effect of stocking rate and split-marketing on performance of pigs and pigmeat output

Introduction

Intensive production systems require that inputs and facilities be used in the most efficient manner. Stocking strategy can have a significant effect on the output from pig units. Crowding can result in depressed pig performance while understocking can cause reduced pigmeat output. Alternatively, split-marketing pigs on a number of days (SM) can result in lower within pen variation in pig weight and improved growth rate of pigs remaining behind.

Two experiments were conducted to determine if performance of pigs and pigmeat output per unit area could be improved either by varying the stocking density (by increasing group size) or by engaging in split-marketing.

Materials and methods

In experiment 5 four hundred and three crossbred pigs (progeny of meatline sires out of F1 LW*LR sows) were allotted at random to single sex groups (n=30) of 11, 13 or 15 pigs per pen. All pens were of equal size (11.04 m^2), resulting in three treatments of increasing stocking density: 1.00 pig/m^2, 1.18 pigs/m^2 and 1.36 pigs/m^2. Initial weight of pigs was 36.7 ± 2.0 (mean ± s.d.) kg and all pigs had free access to a standard diet (barley, wheat, soyabean meal, synthetic amino acids, minerals and vitamins; CP 188g/kg, CF 33 g/kg, DE 13.6 MJ/kg, lysine: DE 0.81 g/MJ) until they reached slaughter weight.

In experiment 6 twenty-six single sex groups of 13 or 14 pigs were assigned at random to one of three treatments: entire pen group sold on one day (1D), pen group sold on two days 14 days apart (2D: 40 % on day 1 and 60 % sold on day 2) and pen group sold on three days, each seven days apart (3D: 25 % on day 1, 25 % on day 2 and 50 % on day 3). Initial weight of pigs was 38.8 ± 2.1 (mean ± s.d.) kg. Pigs were fed the same diet as experiment 1, but in a wet mix (3:1 water: feed), three times daily (0.24 at 0800 h, 0.42 at 1400 h and 0.34 at 2000 h). Pigs were slaughtered at 99.4 ± 3.5 and at 90.0 ± 2.3 (mean ± s.d.) kg in experiments 1 and 2, respectively. Backfat and muscle depths were measured 6 cm from the midline of the split carcass midway between the 3rd and 4th last rib using the Hennessy Grading Probe approximately 45 minutes post mortem. Carcass lean meat (LM) was estimated according to the formula: LM (g/kg) $= 534.1 - 7.86*X_1 + 2.66*X_2$ where X_1 and X_2 represent backfat and muscle depths in mm. Performance of pigs (average daily gain (ADG), average daily feed intake, feed conversion ratio (FCR), carcass ADG, carcass FCR, carcass lean, backfat and muscle depth and kill out proportion) and output per unit area (measured as carcass and lean gains per m^2 per year) were calculated for both experiments. Output per year was based on daily output*365*0.9 (for 90 % occupancy rate) in experiment 1 and on cycle length (days from start until the last pig left, plus three days for refilling), in experiment 6.

Statistical analysis

Statistical analysis was by the GLM procedures of SAS Inc., Cary, N. Carolina for a randomised complete block design in both experiments. Single degree of freedom contrasts were used to compare the effects of 11v15 pigs and 13v15 pigs in experiment 1, and initial weight was used as a covariate in experiment 2.

Results

Treatment had no effect on growth rate, feed intake, feed conversion ratio, carcass ADG, carcass FCR, carcass lean, backfat or muscle depths or kill out proportion in either experiment (P>0.05). Treatment did have an effect on pigmeat output for both strategies (Table 7.1). Increasing stocking density caused increases of 34 % (11 to 15 pigs per pen) and 12 % (13 to 15 pigs per pen) in carcass and lean gains per m^2 per year (P<0.001). Split-marketing pen groups on two or three days increased cycle length by 12 to 13 % compared to selling on one day (P<0.001). Although within pen variation in cold weight decreased with increase in number of sale days (P<0.001), both carcass and lean gains per m^2 per year decreased by 12 to 13 % when more than one sale day was involved (P<0.01 for carcass gains and P<0.001 for lean gains). There were no treatment by sex interactions detected in either experiment.

Table 7.1. Effect of stocking strategy on pigmeat output (ls means)

Stocking density					P-value[1]		
	11	13	15	sem	Overall	11v15	13v15
Carcass gain per pig per day, g/day	716	722	704	9.7	0.46	0.42	0.22
Carcass gain per m^2 per year, $kg/m^2/yr$	225	268	301	3.6	***	***	***
Lean gain per m^2 per year, $kg/m^2/yr$	128	153	172	2.0	***	***	***

Split-marketing					
	1D	2D	3D	sem	P-value[1]
Cycle length, days	67.7	75.9	76.7	0.39	***
Carcass gain per m^2 per year, $kg/m^2/yr$	367	328	327	7.0	**
Lean gain per m^2 per year, $kg/m^2/yr$	214	189	189	4.4	***
Variation in cold weight in pen	5.27	3.81	1.74	1.28	***

*[1] ** P<0.01 *** P<0.001*

Conclusions

The manner in which a pen is stocked or in which pigs are marketed did not affect individual pig performance but did have a significant effect on the pigmeat output per unit area. Increasing the stocking density within the range examined here resulted in increased output per pen, but split-marketing had the converse effect of decreasing output. Facilities were used most efficiently at the highest stocking density and by marketing the pen group on a single day.

Overall summary of results

Experiment 1

Experiment 1 was designed to identify a number of different variables that affect growth rate of pigs in commercial units. It must be recognised that additive factors affect voluntary feed intake and growth rate. It was concluded from this survey that low growth rate appears to be due to the cumulative effect of a combination of factors and an in-depth study of individual farms is needed to identify these factors.

Experiment 2

This experiment was carried out to determine the effects of providing an additional feeder on performance of weaned piglets. Pigs given access to an additional feeder had a significantly higher number of feeding events than where one feeder alone was available ($P<0.05$). Numerically there were a greater number of displacements when two feeders were available as opposed to one feeder especially on day three. Pigs ate significantly more of both the starter ($P< 0.01$) and link diet ($P<0.001$) from feeder A as opposed to feeder B.

Experiment 3

This experiment was designed to determine if pig performance, efficiency of growth and growth hormone concentrations in serum were influenced by weight at birth and at weaning. Lightweight pigs (LW) showed inferior growth performance up to the finisher period. They did compensate some of this inferior growth performance towards the time of slaughter, however they never reached the weights of the heavy birth-weight animals (HW). Males were either significantly heavier or tended to be heavier than females throughout the growth period. Light and heavy pigs did not differ in the levels of IGF-1 in their blood plasma; however lightweight pigs did have significantly lower levels of IgG pre-weaning.

Experiment 4

This experiment was designed to evaluate the growth performance of light birth weight piglets relative to heavy birth weight animals. Light birth weight was associated with significantly reduced average daily gain and average daily feed intake. At slaughter (Day 42) light birth weight pigs were significantly ($P < 0.001$) lighter. Plasma IGF-1 concentration was reduced by 28% ($P=0.06$) in LL pigs compared with HH pigs. Fibre mean cross sectional area and total fibre numbers were not significantly different between treatments. There were no significant differences between treatments in the DNA or RNA concentrations of the muscles sampled. The small number of piglets in the study may be a factor affecting the results.

Experiments 5 and 6

The manner in which a pen is stocked or in which pigs are marketed did not affect individual pig performance but had a significant effect on pigmeat output per unit area. Increasing the stocking density within the range examined here resulted in increased output per pen, but split-marketing had the converse effect of decreasing output. Facilities were used most efficiently at the highest stocking density and by marketing the pen group on a single day.

Overall conclusions

When comparing performance between farms, differences in growth rate are explained in large part by differences in feed intake. Diets, feeding systems, farm management practices, environmental conditions and pigs propensity to grow have all been evaluated in some form in this work. Feed intake is the driving force behind growth and must be considered the most important factor. All the experimental data lead to this conclusion.

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Appendix

Appendix Table 1. Declared compositions of commercial diets

	Part A		Part B	
Diet	**Starter**	**Link**	**Starter**	**Link**
Diet no.	**1.1a**	**1.2a**	**1.1b**	**1.2b**
Crude oil % (min)	9.5	7.5	9.0	7.5
Crude protein % (min)	22	21	20	20
Crude fibre % (max)	2.2	3.0	2.5	3.0
Crude ash % (min)	6.5	7.2	6.0	6.0
Lysine % (max)	1.6	1.5	1.6	1.5

Appendix Table 2. Ingredient content of weaner and finisher feeds.

Moorepark	**Weaner**	**Finisher**
Barley	225	364
Wheat	355.4	404
Maize	100	0
Soya Full Fat	100	0
Soya Hi – Pro	180	200
Fat Tallow/Lard	10	10
L-Lysine HCL	4.0	3.0
DL-Methionine	2.0	0.8
L-Threonine	1.5	1.0
Di Cal Phos	5.0	0.0
Limestone Flour	11	13
Salt	3.0	3.0
Vit-Mins	3.0	1.0
Mould curb	0.0	0.0
Phytase 5000 iu/g	0.1	0.1
Total	1000	1000

Phytase: Natuphos - BASF, 5000 FTU/gm equal to 500 FTU per kg finished feed.

Appendix Table 3. Calculated analysis of weaner and finisher diets g/kg

	Weaner	Finisher
Crude Protein	196	178
Lysine	13.1	11.1
Methionine	5	3.6
Meth + Cyst	8.5	6.9
Threonine	8.6	7.4
Tryptophan	2.5	2.3
Dry matter	872	870
DE MJ/kg	14.1	13.7
Fat	43	27
Linoleic (C18:2)	16	8
Crude fibre	36	37
Ash	50	44
Calcium	7.6	7
Phosphorous	5	3.9
Phos dig	3.4	2.5

Appendix Table 4: Vitamin Trace Mineral Inclusion Levels 2005 (per tonne finished diet)

	Starter/weaner	Finisher
Copper sulphate. $7H_20$ g	620	60
Ferrous sulphate monohydrate g	450	120
Manganese oxide g	60	40
Zinc oxide g	150	100
Potassium iodate g	1	0.5
Sodium selenite g	0.6	0.4
Vitamin A miu	6	2
Vitamin D_3 miu	1	0.5
Vitamin E (* 1,000 iu)	100	40
Vitmin K g	4	4
Vitamin B_{12} mg	15	15
Riboflavin g	2	2
Nicotinic acid g	12	12
Pantothenic acid g	10	10
Choline chloride g	250	-
Vitamin B_1 g	2	2
Vitamin B_6 g	3	3
Endox g	60	-
Inclusion levels of minerals, mg/kg		
Copper	155	15
Iron	90	24
Manganese	47	31
Zinc	120	80
Iodine	0.6	0.3
Selenium	0.3	0.2