THE EARLY WEANING OF PIGS

VI. THE EFFECTS OF EARLY WEANING AND OF VARIOUS GROWTH CURVES BEFORE 50 LB. LIVE WEIGHT UPON SUBSEQUENT PERFORMANCE AND CARCASS QUALITY

By I. A. M. LUCAS, A. F. C. CALDER* and H. SMITH†

Rowett Research Institute, Bucksburn, Aberdeen

(With Five Text-figures)

Although the early-weaned pigs in one previous experiment in this series were kept to bacon weight there was no comparable sow-reared group with which to compare their growth or their carcass qualities (Smith & Lucas, 1957*b*). The desirability of making such a comparison was emphasized by another experiment which suggested that pigs weaned at 8 lb. had poorer food conversion efficiencies from 25 to 40 lb. than others weaned at 20 lb. (Smith & Lucas, 1957*a*). Unfortunately, the effects of weaning weight upon performance from 40 lb. onwards was not then investigated.

Another closely related problem, but distinct from early weaning *per se*, is the effect of variations in the growth curve early in life upon subsequent performance and carcass conformation. This is important because there is some controversy about the rates of growth which are to be desired for young pigs. Opinion in the United Kingdom has been influenced strongly by McMeekan's (1940*a*, *b*, *c*) experiments in which very slow growth up to about 40 lb. followed by rapid growth to bacon weight caused increased deposition of subcutaneous fat. Conversely, rapid early growth favoured muscle development and led to a higher proportion of lean meat in the carcasses.

The objects of the present experiment were: (1) to compare the performances of early-weaned pigs with sow-reared pigs when both grow rapidly up to 50 lb. live weight, and (2) to compare the performances of early weaned pigs kept to three different growth curves before 50 lb. live weight by varying their feed intakes.

EXPERIMENTAL METHOD

Treatments. A within-litter comparison was made between the effects of the following treatments before 50 lb. live weight.

Treatment 1, in which pigs were weaned from their dams at 56 days old and then fed dry meal *ad lib.* until they each weighed 50 lb.

Treatment 2, in which pigs were weaned at about 10 days old and fed dry meal *ad lib.* until they each weighed 50 lb.

Treatment 3, in which pigs were weaned at about 10 days old and fed a restricted twice-daily allowance of dry meal until they reached 30 lb. at about 56 days old. From 30 to 50 lb. live weight they were fed dry meal *ad lib.*

Treatment 4, in which pigs were weaned at about 10 days old and fed a restricted twice-daily allowance of dry meal until they reached 50 lb. at about 90 days old.

The restricted meal allowances in treatments 3 and 4 did not follow a fixed scale, but the adjustments in amount fed depended upon whether the piglets were growing faster or slower than was necessary to achieve the weights for age given above.

From 50 to 200 lb. all pigs were kept to a standard high plane of feeding.

Pigs. Nine litters each of at least four males and four females were used. At 10–13 days old all males were castrated and the pigs in each litter were allocated at random, one barrow (castrated male) and one gilt going to each treatment. Piglets on treatments 2–4 were weaned and the remaining pair, together with others not required for the experiment, were left with the sow. The sow-reared pigs were thus given every opportunity to obtain liberal intakes of sow's milk and creep feed and to reach high weights at 56 days old.

The litters were all out of Wessex Saddleback sows by either a Large White or Landrace boar. All were in good health at the start of the experiment.

Housing. The housing allowed all weaned pigs to be fed individually throughout the experiment.

Treatment 1 pigs were reared by their dams in wooden ark huts with runs which were either drawn up on to an area of concrete or moved over a grass field.

* Present address: Eastern Counties Farmers, 86, Princes Street, Ipswich.

† Present address: Cyanamid Products, Ltd., Bush House, Aldwych, London.

Pigs on treatments 2, 3 and 4 were housed up to 25 lb. live weight in individual cages kept in a room with an initial air temperature of 80° F. This temperature was allowed to fall to 65–70° F. at 14–21 days after weaning. From 25–50 lb. the pigs were kept in individual huts with small outdoor runs. The cages and huts and the management of the early-weaned pigs were the same as in previous experiments (Smith & Lucas, 1956, 1957*b*).

From 50 to 200 lb. all pigs were kept in groups in well-insulated pens with outdoor runs, but they were fed individually in separate compartments.

Diets. The diets fed are shown in Table 1.

Sow-reared pigs had access to diet A fed in a

Table 1. *Compositions and chemical analyses of the diets fed to the pigs*

Composition	Creep-fed, diet A (%)	8–25 lb. live weight, diet B (%)	25–50 lb. live weight, diet C (%)	50–100 lb. live weight, diet D (%)	100–200 lb. live weight, diet E (%)
	Diets fed over different live-weight ranges				
Ground barley	25·9	—	31·0	60·0	62·5
Ground maize	15·5	—	—	—	—
Ground oats	7·8	—	—	10·0	10·0
Rolled oat groats	—	22·0	42·0	—	—
Wheat milling offals					
Medium grade	10·4	—	—	17·25	17·25
Finest grade	—	—	10·0	—	—
Sugar (sucrose)	—	10·0	—	—	—
Roller-dried skim milk	12·8	42·0	3·5	—	—
White fish meal	7·8	15·0	10·0	7·5	3·0
Extracted decorticated groundnut meal	—	—	—	3·5	5·0
Extracted soyabean meal	2·6	—	—	—	—
Dried yeast (75% unextracted)	—	5·0	—	—	—
Dates	14·8	—	—	—	—
Cod-liver oil	—	2·0	1·0	—	—
Salt (NaCl)	0·5	0·5	0·5	0·5	0·5
Ground limestone	—	—	—	0·5	1·0
Steamed bone flour	1·4	—	—	—	—
Mineral-vitamin-antibiotic supplements*	0·5	3·5	2·0	0·75	0·75
Analyses on air-dry basis					
(1) Determined values (%)					
Dry matter	—	93·1	88·9	85·7	85·7
Crude protein	—	29·3	17·1	15·8	13·6
Crude fibre	—	0·3	2·0	4·6	4·1
Crude fat	—	3·9	4·1	2·3	2·2
Ash	—	7·8	4·3	4·7	3·9
Calcium	—	1·7	0·8	0·9	0·7
Phosphorus	—	1·1	0·7	0·6	0·5
(2) Calculated values† (mg./lb.)					
Thiamine	—	3·2	1·5	2·9	2·9
Riboflavin	—	5·8	2·2	2·1	2·0
Nicotinic acid	—	19·7	17·0	34·3	36·1
Pantothenic acid	—	9·3	5·9	4·8	5·2
Pyridoxine	—	2·1	1·0	2·7	2·8
(3) Supplements added					
Vitamin A (i.u./lb.)	2270	7200	3600	2270	2270
Vitamin D (i.u./lb.)	454	1800	900	454	454
Chlortetracycline (mg./lb.)	—	79·2	18·0	8·2	8·2
Procaine penicillin (mg./lb.)	—	32·0	—	—	—

* The supplement for diet A was 0·5 lb. Adisco (Isaac Spencer and Co., Aberdeen), which contains 1000 i.u. vitamin A and 200 i.u. vitamin D/g.

The supplement for diet B consisted of 2·2 lb. Aurofac 2A (Cyanamid of Great Britain Ltd.) containing 3·6 g. chlortetracycline hydrochloride/lb.; 0·2 lb. penicillin concentrate (Glaxo Laboratories Ltd.) containing 16·0 g. procaine benzylpenicillin/lb.; 1·0 lb. trace mineral mixture and 0·1 lb. maize starch. The trace mineral mixture contained $FeSO_4.7H_2O$ 18·10 g.; $MgSO_4.7H_2O$ 22·90 g.; $CuSO_4.5H_2O$ 2·67 g.; $MnSO_4.4H_2O$ 7·40 g.; $ZnSO_4.7H_2O$ 1·97 g.; KIO 0·076 g.; $CoSO_4.7H_2O$ 0·428 g.; maize starch 200·456 g.; ground flaked maize 200·0 g.

The supplement for diet C consisted of 0·5 lb. Aurofac 2A; 1·0 lb. trace mineral mixture as above and 0·5 lb. vitamin supplement containing 100 mg. riboflavin, 100 mg. calcium-D-pantothenate and maize starch.

The supplements for diets D and E consisted of 0·5 lb. Adisco + B_2 (Isaac Spencer and Co., Aberdeen) containing vitamins A and D at levels given above plus 0·5 mg. riboflavin/g.; 0·23 lb. Aurofac 2A and 0·02 lb zinc carbonate.

† Calculated on the basis of figures tabulated by Lucas & Calder (1956) and Smith & Lucas (1956).

creep and early-weaned pigs were fed the 29% protein diet B until they weighed 25 lb., when they were changed over to the 17% protein diet C. From 50 to 100 lb. and 100 to 200 lb. all pigs were given the 16% protein diet D and the 14% protein diet E, respectively. Changes from one diet to another were made as the individual pigs reached the specified weights.

Feeding. Before 50 lb. live weight the diets were given dry, with water available *ad lib.* from separate troughs. From 50 to 200 lb. live weight the pigs were fed twice daily; the meal being given with about twice its weight of water poured over it. In addition water was available *ad lib.* from automatic drinking bowls.

From 50 to 200 lb. all pigs were fed to the scale based on live weight which is shown in Table 2. As diets D and E contained 67·5% total digestible nutrients, this scale represented a 'very high' plane of feeding according to the definition we use (Lucas & Calder, 1956). Feed allowances were adjusted according to the scale once each week after the pigs were weighed.

Slaughter of pigs and carcass quality measurements. Each pig was slaughtered when it weighed about 200 lb., the weight being taken after 15 hr. starvation. Killing-out percentages were calculated from this weight and the dead weight, which is the weight within 1 hr. of killing of the bled carcass from which the hair, heart, lungs, liver, intestines and spleen have been removed and which has had subtracted from it a standard weight to allow for shrinkage after chilling.

Measurements of length between the junction of the first rib and sternum and the anterior edge of the symphysis pubis, of maximum shoulder fat, minimum back fat, average rump fat and thickness of streak (Lucas & Calder, 1956, 1957) were made on the carcasses after they had been chilled for 24 hr. after slaughter. The carcasses were then trimmed for the production of Wiltshire sides, cured by brine injection and immersion in brine tanks for 5 days and then drained for 3 days. At this stage the weights of the sides were taken and these expressed as proportions of the dead weights have been quoted as 'dressing percentages'. The carcasses were then cut into 'fores', 'middles' and 'hams' (Lucas & Calder, 1956), which were weighed separately. Cuts were made at the level of the last rib and tracings and photographs were taken of the bacon rashers at this point. From the tracings the areas and shape indices (length ÷ depth) of the 'eye' muscles were taken, together with two measurements of thickness of fat over the 'eye' muscles (Smith & Lucas, 1957*b*). Samples of fat from $\frac{3}{4}$ in. thick rashers cut at the level of the last rib were also taken for iodine value determinations.

Records. From 8 to 50 lb. live weight each early-weaned pig was weighed every third day and its food consumption for each 3-day period was recorded. From 50 to 200 lb. live weight all pigs were weighed once each week and their daily feed intakes were recorded.

RESULTS

As we have a limited number of cages for young weaned pigs it was decided that the litters should be put on experiment two at a time. When each pair of litters was moved from the cages to the small huts the cages were cleaned and another pair of litters was started. The first pigs were put on experiment in April 1956 and the last were slaughtered at bacon weight in August 1957.

In this experiment, as in two other trials which were carried out at about the same time (Lucas, Calder & Smith, 1959), there was a high incidence of certain disorders in some litters. Several piglets died of 'bowel oedema' at about 20 days old and others were affected by a scour which was difficult to cure. In one litter the pigs grew well until they reached about 150 lb. live weight, but then developed the signs of 'secondary breakdown' with presumed virus pneumonia.

When more than one pig in one litter were affected by a disorder at any stage of the experi-

Table 2. *Feeding scale followed from 50–200 lb. live weight*

Live wt. of pig (lb.)	Meal/day (lb.)	Live wt. of pig (lb.)	Meal/day (lb.)	Live wt. of pig (lb.)	Meal/day (lb.)	Live wt. of pig (lb.)	Meal/day (lb.)
49–51	2·9	88–90	4·3	127–129	5·7	166–168	7·1
52–54	3·0	91–93	4·4	130–132	5·8	169–171	7·2
55–57	3·1	94–96	4·6	133–135	5·9	172–174	7·3
58–60	3·2	97–99	4·7	136–138	6·1	175–177	7·4
61–63	3·3	100–102	4·8	139–141	6·2	178–180	7·5
64–66	3·4	103–105	4·9	142–144	6·3	181–183	7·6
67–69	3·6	106–108	5·0	145–147	6·4	184–186	7·7
70–72	3·7	109–111	5·1	148–150	6·5	187–189	7·9
73–75	3·8	112–114	5·2	151–153	6·6	190–192	8·0
76–78	3·9	115–117	5·3	154–156	6·7	193–195	8·1
79–81	4·0	118–120	5·4	157–159	6·8	196–198	8·2
82–84	4·1	121–123	5·5	160–162	6·9	199–201	8·3
85–87	4·2	124–126	5·6	163–165	7·0	202–204	8·4

ment the entire litter was discarded and replaced by another. The results from single abnormal animals were omitted in the statistical analyses of the data and missing values were fitted.

One pig from a litter retained in the experiment died of 'bowel oedema' at 29 days old and the results from another pig in another litter were discarded because of pyrexia of unknown origin, low appetite and slow growth from 116 to 130 days of age. In addition to these two missing values, four carcasses were not recovered for measurement after curing. Thus six missing values had to be fitted in data for area and shape of 'eye' muscle, fat over 'eye' muscle, carcass proportions and iodine values.

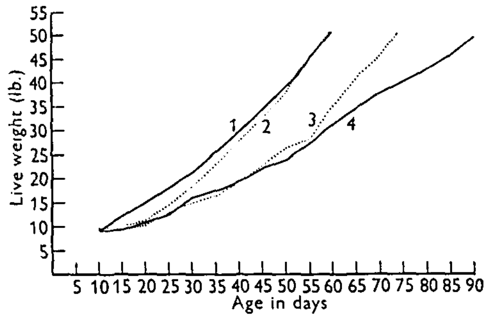

Fig. 1. Average growth curves of the pigs from the start of the experiment to about 51 lb. live weight. (1) Sow reared. (2) Early weaned—unrestricted. (3) Early weaned—restricted to 30 lb. live weight. (4) Early weaned—restricted to 50 lb. live weight.

Performance up to 51 lb. live weight

The growth curves in Fig. 1 show that the experimental plan was followed closely.

Treatment 1 pigs ate considerable amounts of creep feed, grew rapidly and reached 51 lb. at an average of 3–5 days after being weaned at 56 days old. Treatment 2 pigs had the type of growth curve which is typical of early weaning. After a check period, during which they gained only about 2 lb. in 10 days, they grew rapidly and reached 51 lb. at very nearly the same age as sow-reared animals.

Pigs on treatment 3 weighed an average of 29·5 lb. at 56 days old and after they were changed to *ad lib.* feeding they grew rapidly to 51 lb. The mean growth curve of treatment 4 pigs followed that for treatment 3 up to 30 lb., but as the animals continued on restricted feeding they did not weigh 50 lb. until they were 90 days old.

The mean daily feed intakes of the early-weaned pigs (Table 3) show how severe the feed restriction had to be in order to keep to the growth curves required in treatments 3 and 4. There were no significant differences between treatments or sexes,

Table 3. *Average daily feed intakes per pig from weaning to 45 lb. live weight*

	Treatment					
	2 Early weaned, unrestricted		3 Early weaned, restricted to 30 lb. live wt.		4 Early weaned, restricted to 50 lb. live wt.	
Days after weaning	Approx. live wt. (lb.)	Daily feed intake (lb.)	Approx. live wt. (lb.)	Daily feed intake (lb.)	Approx. live wt. (lb.)	Daily feed intake (lb.)
0–3	10	0·5	10	0·4	10	0·4
4–6	10	0·7	10	0·6	10	0·6
7–9	11	0·8	10	0·6	10	0·8
10–12	12	1·0	11	0·8	11	0·8
13–15	14	1·1	12	0·8	12	0·7
16–18	16	1·4	14	0·8	14	0·9
19–21	19	1·7	15	0·8	16	0·7
22–24	22	1·7	16	1·0	17	0·9
25–27	24	2·1	17	0·9	18	0·9
28–30	27	2·1	19	0·9	19	0·9
31–33	30	2·4	21	1·0	21	1·0
34–36	33	2·4	23	1·1	23	1·1
37–39	36	2·6	25	1·1	24	1·0
40–42	40	3·0	27	1·1	25	1·1
43–45	45	3·3	28	1·3	27	1·3
46–48	—	—	32	2·4	30	1·2
49–51	—	—	36	2·6	32	1·3
52–54	—	—	39	2·5	34	1·4
55–57	—	—	43	2·7	36	1·3
58–60	—	—	—	—	38	1·3
61–63	—	—	—	—	39	1·4
64–66	—	—	—	—	41	1·6
67–69	—	—	—	—	42	2·2
70–72	—	—	—	—	44	2·4

however, in feed conversion efficiency from 9 to 51 lb. (Table 4).

In appearance, the early-weaned pigs fed *ad lib.* lost their bloom during the check period following weaning, but this was regained when the pigs reached 20–30 lb. live weight. The pigs on restricted feed intakes, however, lost their bloom and did not regain it until they were changed over to high-scale feeding. At 30 lb. (treatments 3 and 4) and 50 lb. (treatment 4) these pigs looked very hairy, white and 'pinched' although they remained active and apparently healthy.

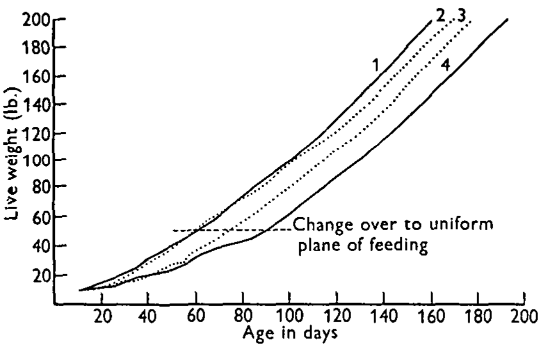

Fig. 2. Average growth curves of the pigs from start of the experiment to slaughter. (1) Sow reared. (2) Early weaned—unrestricted. (3) Early weaned—restricted to 30 lb. live weight. (4) Early weaned—restricted to 50 lb. live weight.

Performance from 51 *to* 205 *lb. live weight*

Although all pigs were kept to the same very high plane of feeding after they reached 51 lb. live weight, there were significant effects of treatments upon both growth rate and feed conversion efficiency from 51 to 102 lb. ($P < 0{\cdot}01$) and 102–205 lb. ($P < 0{\cdot}01$). When these measurements were made for the entire period, 51–205 lb. live weight, the levels of statistical significance were very high at $P < 0{\cdot}001$.

The most notable feature of the results (Table 4 and Fig. 2) is that early-weaned pigs fed *ad lib.* grew 7–8 % more slowly from 51 to 205 lb. and had 7–9 % poorer food conversion efficiencies than sow-reared pigs which had been about the same weight as themselves at 59 days old. In comparison to the sow-reared animals the early-weaned pigs were 8 days older at slaughter and had each eaten an average of 40 lb. more feed between 51 and 205 lb. live weight.

The effect of restricting the feed consumptions and growth rates of early-weaned pigs between 9 and 30 lb. or 9 and 51 lb. live weight (treatments 2 *v.* 3 *v.* 4) was to improve their growth rates and feed conversion efficiencies from 51 to 205 lb. towards those of sow-reared animals. Restriction only up to 30 lb. gave later performance figures about midway between the *ad lib.* early-weaned and sow-reared groups. Restriction from 9 to 51 lb., when compared with the sow-reared group, caused growth and feed conversion efficiency to be

Table 4. *Growth rates and food conversion efficiencies of the pigs*

	Treatment					
	1 Sow reared	2 Early weaned, unrestricted	3 Early weaned, restricted to 30 lb. live wt.	4 Early weaned, restricted to 50 lb. live wt.	S.E. of means	Level of significance (%)
Av. live wt. (lb.)						
At start of experiment	9·4	9·4	9·2	9·4	—	—
At changeover to diet D	51·4	51·2	51·1	50·1	—	—
At slaughter	204·9	204·4	204·5	204·8	—	—
Av. ages (days)						
At weaning	56·0	10·8	10·8	10·8	—	—
At changeover to diet D	59·5	58·9	73·3	89·8	(S.D. ±3·9)*	—
At slaughter	164·1	171·4	181·6	195·2	±1·50	0·1
Av. live wt. gain/day (lb.)						
51–102 lb. live wt.	1·20	1·11	1·17	1·25	±0·03	1
102–205 lb. live wt.	1·66	1·55	1·61	1·61	±0·02	1
51–205 lb. live wt.	1·47	1·37	1·43	1·47	±0·02	0·1
Av. food consumed/lb. live wt. gain						
9–51 lb. live wt.	—	2·11	2·07	2·20	±0·05	N.S.
51–102 lb. live wt.	3·03	3·30	3·16	2·92	±0·07	1
102–205 lb. live wt.	3·70	3·95	3·86	3·87	±0·05	1
51–205 lb. live wt.	3·48	3·74	3·63	3·55	±0·04	0·1

* S.D. is given here to indicate the scatter of individuals around the treatment means.

4% better from 51 to 102 lb. but 3–5% poorer from 102 to 205 lb. Calculations of rates of gain from about 60 to 102 lb. showed that the high growth rates of these treatment 4 pigs from 51 to 102 lb. was not an artifact due to a sudden increase in gut 'fill' when the feeding scale was increased at 51 lb. live weight.

In this experiment there were highly significant differences between litters in all measures of growth rate and feed conversion efficiency. Sex had no significant effects from 51 to 102 lb., but from 102 to 205 lb. gilts grew 6% faster and had 7% better food conversion efficiencies than the barrows ($P < 0{\cdot}001$). There was no significant treatment × sex interaction.

Killing-out percentages and carcass quality measurements

In comparison to sow-reared pigs, the early-weaned animals fed *ad lib.* up to 51 lb. had more fat over the shoulder, rump and 'eye' muscle, together with smaller 'eye' muscles and thicker streaks. They also had higher killing-out percentages and fats of lower iodine values, but the statistical significance of these latter effects only reached the 10% level.

In contrast, there were no significant differences in carcass measurements between sow-reared pigs and those early-weaned pigs whose feed intakes and growth rates had been restricted up to 30 or 50 lb. live weight. The effect of these restrictions on early-weaned pigs (treatments 2 *v.* 3 *v.* 4) had been to reduce fat thicknesses and increase the area of 'eye' muscle. There were also tendencies towards increases in iodine values of the fats and a reduction in thickness of streak.

No treatment had any significant effect upon the length of carcass, dressing percentage, shape index of the 'eye' muscle or proportions of fore, middle and ham.

There were highly significant litter and sex effects on a number of carcass measurements, but by virtue of the design of the experiment these did not affect the estimation of treatment effects. In comparison to gilts, barrows had greater fat measurements and killing-out percentages, but thinner streaks. They were also shorter, had smaller hams and areas of 'eye' muscle and 'eye' muscles of longer shape in cross-section. Means and levels of significance for these effects are given in Appendix Table 1. There was no sex × treatment interaction.

The treatment and sex effects upon bacon rashers cut at the level of the last rib are illustrated in Figs. 3 and 4. There is no indication from these figures that the treatments affected any characters which were not measured. For example, the presence of undesirable dips in the top lines of the 'eye' muscles was not influenced either by early weaning *per se* or by the variations imposed in the shape of the growth curves before 51 lb. live weight.

DISCUSSION

One of the most interesting aspects of this experiment was the difference in growth rate and carcass quality of sow-reared pigs and early-weaned pigs fed *ad lib.* up to 51 lb. live weight. The slower growth of the early-weaned animals, while on an identical plane of feeding from 51 to 205 lb., was consistent with the deposition of a greater amount of body fat, which has a higher energy value per unit of weight than other tissues. The explanation of this emphasis on the deposition of body fat cannot be derived from the present experiment, but there are two main possibilities.

(1) It is evident from Fig. 1 that although both treatments 1 and 2 pigs reached 51 lb. at the same

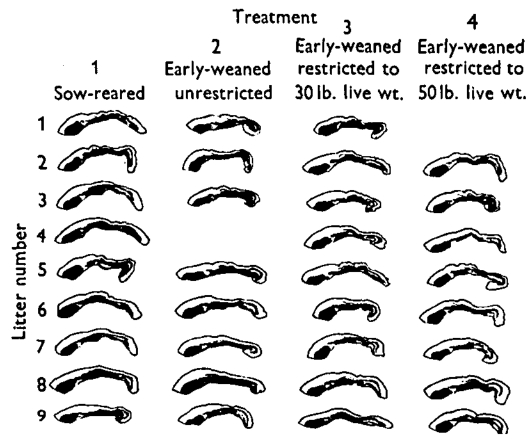

Fig. 3. Bacon rashers cut from the carcasses of the barrows at the level of the last rib.

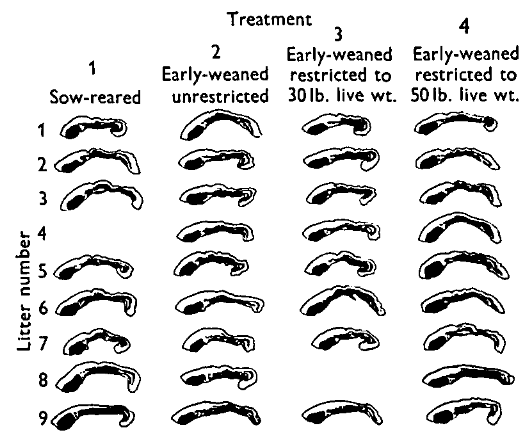

Fig. 4. Bacon rashers cut from the carcasses of the gilts at the level of the last rib.

Table 5. *Average killing-out and dressing percentages and carcass quality measurements of the pigs*

	Treatment					
	1 Sow reared	2 Early weaned, unrestricted	3 Early weaned, restricted to 30 lb. live wt.	4 Early weaned, restricted to 50 lb. live wt.	S.E. of means	Level of significance (%)
Killing-out (%)	74·8	75·5	75·1	75·8	±0·29	10
Dressing (%)	80·0	80·5	80·2	79·7	±0·26	N.S.
Length of carcass (cm.)	79·2	78·5	78·4	78·6	±0·33	N.S.
Max. shoulder fat (cm.)	4·4	4·7	4·5	4·4	±0·07	1
Min. back fat (cm.)	2·2	2·3	2·1	2·1	±0·07	N.S.
Av. rump fat (cm.)	3·0	3·4	3·1	3·0	±0·08	0·1
Fat (1) over 'eye' muscle (cm.)	2·1	2·4	2·1	2·2	±0·06	0·1
Fat (2) over 'eye' muscle (cm.)	3·1	3·3	3·1	3·2	±0·08	10
Iodine value (inner back fat)	62·1	60·7	61·6	61·5	±0·37	10
Iodine value (outer back fat)	67·1	65·9	67·1	66·1	±0·40	10
Area of 'eye' muscle ($cm.^2$)	27·8	25·4	27·1	27·3	±0·53	5
Shape index (length ÷ depth) of 'eye' muscle	2·2	2·2	2·2	2·2	±0·06	N.S.
Thickness of streak (cm.)	3·6	3·8	3·7	3·7	±0·06	5
Fore (%)	27·8	27·5	27·8	27·4	±0·25	N.S.
Middle (%)	46·0	46·8	46·0	46·5	±0·33	N.S.
Ham (%)	26·2	25·7	26·2	26·1	±0·21	N.S.

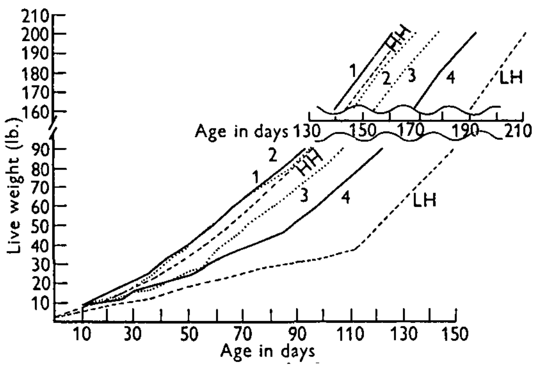

Fig. 5. A comparison of growth curves of the pigs in the present experiment with the 'HH' and 'LH' growth curves tested by McMeekan. (1) Sow reared. (2) Early weaned—unrestricted. (3) Early weaned—restricted to 30 lb. live weight. (4) Early weaned—restricted to 50 lb. live weight. HH, McMeekan's 'High-High' pigs. LH, McMeekan's 'Low-High' pigs.

average age their growth curves up to that weight had not been identical. Thus a growth check from 10 to 20 days of age, followed by a rapid rate of gain, might have had a lasting effect upon the differential rates of growth of various body tissues.

(2) The diets fed to the early-weaned pigs were adequate for rapid live-weight gain following the check period after weaning. Nevertheless, there may have been deficiencies or imbalances of nutrients which affected the type of growth taking place. If this was so, the deficiencies or imbalances could have been masked when rates of gain were slow due to restricted intakes of dietary energy in treatments 3 and 4.

Another important aspect of this experiment was that, when the three early-weaning treatments were compared, restrictions of feed intakes and rates of gain up to 51 lb. improved carcass qualities and rates of gain and food conversion efficiencies from 51 to 205 lb.

The improvements in rates of gain when the plane of feeding was fixed were consistent with the deposition of less body fat and more muscle. They were also in general agreement with the results from Coey's (1954) statistical study which showed that slow growth up to 70 lb. was followed by fast growth in pigs fed *ad lib.* from 70 to 210 lb. The changes in carcass quality were confusing—especially when considered in relation to McMeekan's (1940*a*, *b*, *c*) observation that slow early growth followed by rapid growth to bacon weight ('LH' growth curve) led to the production of fat carcasses. It must be noted, however, that there is no strict analogy between McMeekan's experiment and the comparison of our three early-weaning treatments. Whereas the relevant aspect of McMeekan's comparison was of slow *v.* rapid growth early in life, our comparison has become one of slow growth early in life *v.* either (1) the effect of a short check period followed by rapid growth, or (2) growth on a deficient or imbalanced diet. The problem of explaining the differences in carcass conformation between our early-weaning treatments therefore hinges upon the true cause of fat carcasses with *ad lib.* feeding up to 51 lb. live weight.

The comparison of treatments 3 and 4 (early weaned, restricted) with treatment 1 (sow reared) probably provides a closer analogy to McMeekan's experiment because (1) there was no check in the growth of the fastest growing treatment 1 animals, and (2) if there was a deficiency in the diet for the

https://doi.org/10.1017/S0021859600030987 Published online by Cambridge University Press

early-weaned pigs it was probably masked when energy intakes were severely curtailed (see discussion above). This comparison, however, did not support the observation that the 'LH' type of growth curve leads to the production of fat carcasses—although it may be of importance that the differences between growth curves in our experiment were not as wide and extreme as those tested by McMeekan (Fig. 5).

More information is clearly required in the influence of both early weaning and early rate of growth upon subsequent performance and carcass quality.

SUMMARY

The experiment involved nine litters, each containing four male and female pairs of pigs. At about 10 days of age the four pairs within each litter were randomized one to each of the following treatments. (1) Pigs left with their dams, weaned at 56 days old and then fed *ad lib.* until they each weighed 50 lb. (2) Pigs weaned at 10 days old and fed *ad lib.* until they each weighed 50 lb. (3) Pigs weaned at 10 days old, given restricted feed allowances so that they weighed 30 lb. at 56 days old, then fed *ad lib.* until they each weighed 50 lb. (4) Pigs weaned at 10 days old and given restricted feed allowances so that they weighed 30 lb. at 56 days old and 50 lb. at 90 days old. Between 50 lb. and slaughter at 205 lb. all pigs were kept to the same very high plane of feeding, which was based on live weight. All pigs were individually fed from weaning onwards.

Sow-reared and early-weaned pigs fed *ad lib.* both reached 51 lb. at an average of 59 days of age, but their growth curves before that weight differed because the early-weaned group had a 10-day check period after weaning. Early-weaned pigs on treatments 3 and 4 reached 51 lb. at averages of 73 and 90 days of age, respectively.

The severe feed restrictions required to limit the growth rates of pigs on treatments 3 and 4 had no effect on food conversion efficiencies from 9 to 51 lb. live weight.

Early-weaned pigs fed *ad lib.* up to 51 lb. grew 7–8 % more slowly and had 7–9 % poorer food conversion efficiencies than sow-reared pigs from 51 to 205 lb. live weight. They also gave poorer quality carcasses, with greater fat measurements, smaller areas of 'eye' muscle and thicker streaks.

Compared to early weaning with *ad lib.* feeding up to 51 lb. live weight, the effects of restricting growth rates up to 30 and 50 lb. were to improve rates of gain from 51 to 205 lb. by 4 and 7 %, respectively, and to improve food conversion efficiencies over the same period by 3 and 5 %, respectively. In addition, the carcasses from both 'restricted' treatments had smaller fat measurements and larger areas of 'eye' muscle.

There were no significant differences in carcass quality measurements between the sow-reared pigs and those early-weaned pigs whose growth rates had been restricted up to 30 or 50 lb. live weight.

The differences between this experiment and the well-known studies of McMeekan have been discussed with particular emphasis on the lack of confirmation of the adverse effects on carcass quality of the 'LH' type of growth curve found by McMeekan.

We wish to thank the following members of staff of the Rowett Research Institute for their help and co-operation in this experiment: Mr I. McDonald, for the statistical analysis of the data; Mr I. Robb, for the photographic work required; Miss M. Youngson, for the chemical analyses of the rations and iodine-value determinations on the body fats, and Mr I. Phillip for the care of the animals.

We also greatly appreciate the assistance given by Messrs Lawson and Sons (Bacon Curers) of Dyce who allowed us to cut and measure the carcasses.

REFERENCES

COEY, W. E. (1954). *Agric. Progr.* **29**, 60.

LUCAS, I. A. M. & CALDER, A. F. C. (1956). *J. Agric. Sci.* **47**, 287.

LUCAS, I. A. M. & CALDER, A. F. C. (1957). *J. Agric. Sci.* **49**, 184.

LUCAS, I. A. M., CALDER, A. F. C. & SMITH, H. (1959). *J. Agric. Sci.* **53**, 125.

MCMEEKAN, C. P. (1940*a*). *J. Agric. Sci.* **30**, 276.

MCMEEKAN, C. P. (1940*b*). *J. Agric. Sci.* **30**, 387.

MCMEEKAN, C. P. (1940*c*). *J. Agric. Sci.* **30**, 511.

SMITH, H. & LUCAS, I. A. M. (1956). *J. Agric. Sci.* **48**, 220.

SMITH, H. & LUCAS, I. A. M. (1957*a*). *J. Agric. Sci.* **49**, 405.

SMITH, H. & LUCAS, I. A. M. (1957*b*). *J. Agric. Sci.* **49**, 409.

Appendix Table 1. *The effect of sex on carcass measurements of the pigs*

	Barrows	Gilts	Level of significance (%)
Killing-out (%)	75·6	75·0	5
Dressing (%)	80·2	80·0	N.S.
Length of carcass (cm.)	78·3	79·0	5
Max. shoulder fat (cm.)	4·6	4·4	0·1
Min. back fat (cm.)	2·3	2·1	5
Av. rump fat (cm.)	3·2	3·0	1
Fat (1) over 'eye' muscle (cm.)	2·3	2·1	0·1
Fat (2) over 'eye' muscle (cm.)	3·4	2·9	0·1
Iodine value (inner back fat)	61·3	61·6	N.S.
Iodine value (outer back fat)	66·5	66·6	N.S.
Area of 'eye' muscle (cm.^{2})	25·8	27·9	0·1
Shape index (length ÷ depth) of 'eye' muscle	2·2	2·1	5
Thickness of streak (cm.)	3·6	3·8	0·1
Fore (%)	27·8	27·5	N.S.
Middle (%)	46·6	46·0	10
Ham (%)	25·6	26·5	0·1

(*Received* 13 *December* 1958)