

TITLES AND ABSTRACTS OF PAPERS GIVEN AT THE
60TH MEETING OF THE BRITISH SOCIETY OF ANIMAL PRODUCTION,
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1. DEPOSITION OF FAT IN THE CARCASSES OF LAMBS OUT OF FINNISH LANDRACE
× DORSET HORN EWES AS AFFECTED BY BREED OF SIRE, RATE OF GROWTH,
SLAUGHTER WEIGHTS AND SEX

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Entire male and female lambs by three breeds of sire, Southdown, Suffolk and Cotswold, were compared on two planes of nutrition in a $3 \times 2 \times 2$ factorial experiment. After weaning at about six weeks of age, a 90% barley diet (15% CP) was fed either *ad libitum* or so as to reduce growth rate by one-third. The results describe dissectible fat deposition in the carcasses of 69 lambs serially slaughtered at 40, 50, 60 and 70% of their estimated mature weights (between 27 and 57 kg live weight). The analysis, using multiple regression, was of linear response lines relating weight of fat to carcass weight, allowing the estimation of all important (including interaction) effects on slope and intercept. Of greatest importance were the third-order interactions in slope between sire breed, sex and nutrition: there was no response from the restricted diet except for males by Suffolk and Cotswold sires. The reductions in total fat deposition for these males relative to those fed *ad libitum* were 94 g fat/kg carcass (i.e. 9.4%) ($P < 0.001$) and 77 g fat/kg carcass (i.e. 7.7%) ($P < 0.01$) respectively. The Cotswold sires effected an 8.0% ($P < 0.05$) increase in slope for total fat, explained almost entirely by a 7.8% ($P < 0.01$) increase in slope for subcutaneous fat (all responses are relative to the Southdown crosses.) The general conclusions, assuming an acceptability limit of 28% dissectible fat in the carcass, are that the Southdown is an unsuitable sire; that the Cotswold sires lambs for killing between 29 and 38 kg dependent on sex and rate of growth; and that male Suffolk crosses may be taken to a heavier weight (approximately 45 kg) if growth is restricted.

2. THE RELATIONSHIP OF FATTY TISSUE DEVELOPMENT RELATIVE TO MUSCLE TISSUE
DEVELOPMENT IN LAMBS AS AFFECTED BY FEEDING LEVEL, GENOTYPE AND
MATURITY

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Four levels of energy were fed to 400 castrated male lambs of four genotypes from weaning to 80% of muscle maturity in two trials. Lambs were slaughtered initially and sequentially over the growth period. The carcasses were jointed and each joint separated into fatty, lean and bone tissues. In trial 1 constant amounts of energy were fed daily throughout ($E_1 = 1.6$, $E_2 = 2.05$, $E_3 = 2.4$, $E_4 = 2.7$ Mcal ME/day). South Country Cheviots and Scottish Halfbred lambs were used. In trial 2 four levels of energy above that estimated for body maintenance were fed. Feeding levels were adjusted after each 5 kg body-weight increase. South Country Cheviot and Suffolk × Scottish Halfbred lambs were used. Mean daily energy intakes were $E_1 = 1.6$, $E_2 = 2.1$, $E_3 = 2.6$, $E_4 = 3.1$ Mcal ME/day

for the Cheviot and $E_1 = 1.8$, $E_2 = 2.3$, $E_3 = 2.8$, $E_4 = 3.3$ Mcal ME/day for the Suffolk-cross lambs. The data related the growth of fatty tissue in the carcass, and in each joint, to that of muscle tissue by the use of the allometric relationship. The exponential was increased as rate of muscle growth increased. The estimated amounts of fatty tissue associated with various weights of muscle tissue were derived for each genotype at each energy level. The paper discusses these findings in relation to the application of intensive feeding regimes to lambs of various genotypes when constraints of carcass weight and level of fatness are applied.

3. AN ESTIMATION OF FATNESS IN THE CARCASSES OF MEAT ANIMALS BY MEASUREMENT OF CARCASS PROFILE AREAS

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A morphometric approach to quantifying fatness in the carcasses of meat animals is presented, based on the observation that fattening is accompanied primarily by increases in width measurements of the body. An integrated value of width is achieved by measuring, from photographic material, the dorsal profile area of the intact carcass and adjusting it for length. Carcasses of 30 Hereford steers (mean side weight 117.9 kg, SD 7.6 kg), selected to avoid extremes of fatness, (mean dissectible fat 31.1 kg, SD 4.4 kg), were photographed and appraised visually for fatness by a panel of six judges. The panel average score in combination with side weight was only slightly better than profile area and length (74.2% and 73.2% variation explained respectively) in predicting total dissectible fat. Preliminary results from investigations on the carcasses of a number of British Friesian and (much fatter) Aberdeen Angus steers suggest that the method, and indeed the same prediction equation, applies to the Friesian data with accuracy comparable to that obtained from the Herefords, but the predictions were generally less accurate for the Angus. For all three breeds, prediction from area and length was appreciably better than from side weight alone. Work is being continued on lamb and pig carcasses. It is suggested that this method of fat evaluation, which is both objective and inexpensive, may be used advantageously in many practical situations, particularly when the full value of the carcass must be preserved.

4. INFLUENCE OF DIETARY ENERGY CONCENTRATION ON CARCASS COMPOSITION IN THE *ad libitum* FED BEEF ANIMAL

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The metabolizable energy concentration (M/D) of feeds used in beef production is highly variable ranging from a high M/D value in the case of barley grain to a very low value in the case of barley straw. The effect of a wide range of metabolizable energy concentration on growth and carcass composition was studied in Friesian steers over a weight range of 300 to 450 kg. The animals had been reared under a semi-intensive system up to 300 kg live weight. Sixty-four yearling Friesian steers were allocated within the following experimental design (numbers of animals in brackets). Three slaughter weights: 300 (8), 375 (16) and 450 kg (40); five metabolizable energy concentration: 2.86 (16), 2.42 (8), 2.11 (16), 2.86/2.11 (8) and 2.11/2.86 Mcal ME/kg DM (8). In this paper only results from the 450 kg slaughter weight are discussed. The diets were based on ground barley grain, ground barley straw, soya bean meal, molasses, and a vitamin and mineral supplement. The three diets were of similar nitrogen content (average 13% crude protein) and fed

ad libitum to individually penned animals. Live-weight gain (1.24, 1.32, 0.90, 1.13 and 1.18 \pm 0.07 kg/day) and feed intake (8.71, 9.89, 8.82, 8.83 and 9.65 \pm 0.39 kg DM/day) were significantly different between the five energy concentrations ($P < 0.05$). A half carcass from each animal was minced, sampled and analyzed. The weight of chemical fat (36.3, 33.4, 33, 33.8 and 33.7 \pm 1.74 kg) and protein (20.2, 19.9, 19.1, 19.9 and 19.9 \pm 0.35 kg) was not significantly different between treatments. The key conditions of the experiment were: (1) animals were of a similar breed, age and pre-treatment; (2) age at slaughter varied between 16 and 22 months of age; (3) ground barley straw was the basis of the diet, which ranged from 2.11 to 2.86 Mcal ME/kg DM. Under these conditions it can be concluded that dietary energy concentration has no significant effect on carcass composition.

5. MANAGEMENT AND BEHAVIOURAL FACTORS AFFECTING THE INCIDENCE OF DARK CUTTING BEEF

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An attempt was made to associate pre-slaughter behaviour, management and handling with carcass quality in semi-intensively reared bulls. A group of 60 bulls, 30 Friesians and 30 Hereford \times Friesians, reared at Rosemaund Experimental Husbandry farm was observed for one day per week from October 1973 to February 1974 whilst they were penned during the finishing stage. Activity recording covered the daily behaviour pattern of the group as a whole, the reaction of bulls to routine handling, and the more detailed study of animal interactions. From these observations an arbitrary activity score was drawn up for groups and individual bulls. The results showed it was possible to identify dominant and submissive animals, and hence recognize the dominance order for pens. From February, bulls were drawn out from the groups for slaughter; behavioural observations continued during loading for transport and during lairage, if this occurred. Ultimate (24 hr) pH of the carcasses was taken as this is a proven indicator of dark cutting meat. Bulls which were killed immediately on arrival at the abattoir produced carcasses within the normal pH range. When bulls from different rearing pens were mixed and laired overnight ultimate pH values were all high. Some preliminary telemetric studies of heart rate and electrocardiograph were conducted on a small number of bulls under normal conditions, and also during lairage and the slaughter procedure. Blood samples were taken twice during rearing and also at slaughter, and the levels of cortisol determined. The results of these observations are related to the incidence of dark cutting meat.

6. MUSCLE QUALITY IN COMMERCIAL PIG CARCASSES

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Over an 8-week period pH measurements were taken in the *longissimus dorsi* muscle of 17,145 bacon-weight carcasses at 45 minutes post-mortem (pH₁) in one abattoir. The sex, commercial grade and breed composition of carcasses were recorded, the latter being obtained from producer replies to mailed questionnaires. The overall least squares mean pH₁ was 6.38; 9.7% of carcasses had pH₁ values

below 6.0. Gilt and castrate carcasses had similar mean values, and there was no sex difference in the incidence of pH₁ measurements below 6.0. First grade (A1) carcasses had lower muscle pH₁ measurements (average 6.37) and a higher percentage (10.9%) of values below 6.0 compared with those in the lowest grade (C) (6.39 and 9.4%), although these differences were of little practical significance. Carcasses of homebred pigs had slightly lower mean muscle pH₁ measurements than those from pigs initially purchased as weaners (6.37 v. 6.39) and they also had a higher incidence of pH₁ values below 6.0 (10.6 v. 8.8%). Neither the type of pig (purebred, crossbred or 'hybrid'), nor breed of sire (Large White or Landrace) influenced the mean muscle pH₁ measurements or the percentage of values below 6.0. There was no indication that boars performance tested by the Meat and Livestock Commission or those supplied by breeding companies sired pigs whose muscle quality was inferior to that of pigs from untested boars.

7. THE EFFECT OF ANABOLIC STEROIDS AND PARTIAL CASTRATION ON THE PERFORMANCE OF BEEF CATTLE

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Forty-eight Friesian male calves were offered a diet containing predominantly barley, and at 100 kg live weight were divided into six groups and allocated to one of the following treatments: entire bull (BB); bull implanted at six-weekly intervals (PB); castration at 8 weeks of age (CC); castrate implanted at six-weekly intervals starting at 8 weeks of age (6W); castrate implanted 60 days before slaughter (F60); and partial castrate where the testes were either pushed into the abdominal cavity and retained by stitching the inguinal canal, or held subcutaneously by applying a rubber ring across the top of the scrotum (PC). They were slaughtered at either 430 or 480 kg live weight. The anabolic steroid used was trienbolone acetate in 20 mg pellets, and it was implanted subcutaneously at the base of the ear at a rate of 0.80 mg/kg live weight. Daily live-weight gains (kg) up to 430 kg were BB 1.297, PB 1.192, CC 1.031, 6W 1.079, F60 0.992, PC 1.198 (SE of treatment difference approximately ± 0.065). The growth rate of entire bulls was similar to that of implanted bulls and partial castrates and superior to that of castrates. Implantation at six-weekly intervals or 60 days before slaughter did not affect growth rate. Repeated implantations with trienbolone acetate did not cause epiphyseal closure as shown by measurements made on some long bones. Testicle weights were 470 g (BB), 260 g (PB) and 250 g (PC). Histological examinations made so far on tissue from the body of the testicle and the epididymis from implanted bulls and partial castrates do not show any signs of spermatogenesis.

8. STUDIES ON THE VOLUNTARY INTAKE OF HEATHER (*Calluna vulgaris*) BY SHEEP

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The voluntary intake of heather by sheep is low in comparison with that of other roughages of similar digestibility. It was considered that the relatively high concentrations of phenols and tannins in heather might affect palatability and hence voluntary intake. Two methods were used to study the possible effect of palatability on the voluntary intake of heather by sheep. In method A, 50% of a previously established voluntary intake was given *per* rumen fistula to sheep offered heather *ad libitum*. If total intake exceeded the previously established voluntary

intake it could be concluded that palatability was limiting intake. In method B the heather given *per* rumen fistula had previously been ingested and masticated by oesophageal-fistulated sheep. Five mature Scottish Blackface castrated males (wethers) were used in a simple cross-over design to compare the two methods. The mean voluntary intake of DM (g/day \pm SE) prior to heather being given *per* fistula was 440 ± 41.2 . The mean total DM intake in method A (353 ± 31.2) was significantly lower than in method B (532 ± 31.5) $P < 0.01$. The respective DM digestibilities were 43 ± 1.7 , 39 ± 3.3 and 47 ± 1.1 , the difference between methods being significant ($P < 0.05$). This change in digestibility made it impossible to draw conclusions regarding the effect of palatability on voluntary intake. The effects of mastication and added saliva on intake and digestibility were examined. Calculations indicate that DM intake and digestibility were both positively related to soluble nitrogen intake, suggesting that the differences noted between methods A and B could be explained in terms of the quantity of soluble nitrogen entering the rumen. Measurements of rumen ammonia concentration, cell wall digestibility and mean retention time of undigested food residues support this hypothesis.

9. THE EFFECT OF LEVEL OF RED CLOVER SILAGE IN THE DIET ON THE REPRODUCTIVE PERFORMANCE OF EWES

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Ewes grazing red clover, or fed unwilted silage prepared from red clover, prior to and during mating have been shown to produce fewer lambs than ewes fed non-oestrogenic grasses. Drying and pelleting red clover reduced the level of formononetin in the diet, and the depression in fertility was less when pelleted red clover was fed, compared with silage. It was not known what level of red clover silage or how much formononetin could be ingested before lambing percentage was affected. Red clover was conserved as unwilted silage and also, after drying and grinding, as pellets. Five groups of 20 Border Leicester \times Cheviot ewes were fed a non-oestrogenic grass and red clover silage in the proportions 100 : 0, 75 : 25, 50 : 50, 25 : 75, 0 : 100, and a sixth group was fed red clover pellets. The ewes were fed the diets prior to and during mating. The lambing percentages were 235, 210, 205, 185, 175 and 190% for the six groups respectively. The results indicate that the reproductive rate of ewes is depressed linearly by inclusion of red clover silage in the diet, and that total substitution of the non-oestrogenic grass with red clover silage reduced the lambing performance by 25%. The feeding of red clover silage, and pellets, to ewes prior to and during mating should be avoided.

10. EFFECT OF HERBAGE ALLOWANCE ON THE PERFORMANCE OF GRAZING EWES AND LAMBS IN THE FIRST 12 WEEKS AFTER LAMBING

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The effect of herbage allowance on herbage intake, live weight and lactation performance was measured in an experiment using Scottish Halfbred ewes suckling twin lambs and grazing an S23 perennial ryegrass sward. The herbage allowances were maintained at 25.0, 33.0, 47.4, 73.3 and 120.0 g of herbage DM per kg live weight of animals (ewes plus lambs) per day, by daily fence movements. The mean weights of ewes at 3 days post partum and of lambs after lambing were 82.6 ± 1.44 and 5.2 ± 0.12 kg respectively. In the first month there were no significant

differences between treatments in rate of live-weight loss of ewes, milk yield, or lamb growth rate (means: -416 ± 25 , 1943 ± 53 and $+209 \pm 6$ g/day respectively). In the second and third months ewe live-weight change, milk yield and lamb growth rate were all significantly affected by herbage allowance. In the second month the treatment means (g/day) ranged from -255 ± 52 to -81 ± 57 for ewe live-weight change, from 1155 ± 139 to 1606 ± 206 for milk yield and from $+167 \pm 32$ to $+234 \pm 11$ for lamb growth rate. In the third month the ranges were -71 ± 24 to $+141 \pm 68$; 870 ± 6 to 1209 ± 138 ; and $+136 \pm 27$ to $+228 \pm 16$ g/day respectively. Intakes of herbage by ewes and lambs are discussed.

11. BOAR PERFORMANCE, CARCASS AND MUSCLE QUALITY CHARACTERISTICS IN TWO LINES OF LARGE WHITE PIGS

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Forty young Large White boars were fed *ad libitum* over the live-weight range 27 to 87 kg. Twenty came from a line in which selection had been practised for economy of production and carcass lean content over 7 generations, and 20 were from a genetic control line. Half carcasses of all pigs, and those of an additional 10 boars from each line slaughtered at 27 kg live weight, were physically dissected into their component tissues. Quality determinations were made on six muscles and one loin chop taken from each carcass of the pigs slaughtered at 87 kg live weight. Growth rate did not differ between the lines but selection line boars had lower feed conversion ratios (9%) and their carcasses had a higher percentage of lean tissue (3%) and a lower percentage of fat (4%). Lean deposition/day was not significantly different in the two lines but daily deposition of fat was 17% lower in the selection line. Muscle pH₁ values were similar for each line but all muscles of selection line boars had higher transmission percentages. Although muscles from boars in the selection line were paler in colour than those from the control line only one difference was significant (*psaos major*). Chops from selection line carcasses had higher drip losses but this was attributable to their relatively greater eye-muscle areas. Low correlation coefficients were recorded between muscle quality characteristics and both performance and carcass traits.

12. PILOT PROGENY TEST OF BRITISH FRIESIAN BULLS FOR GROWTH RATE AND FOOD CONVERSION EFFICIENCY

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Fifty-eight British Friesian bulls, comprising nine sire groups were used. Half-sib group size varied from 2 to 10 per sire. Calves procured from the University dairy herd during a calving period of five months were removed from their dams at 2 days of age, weaned at 42 days and fed concentrates and hay in groups until 90 days. The test commenced at 100 days, and from then until 400 days and subsequent slaughter at 480 kg live weight, bulls were fed individually and *ad libitum*. The pelleted complete diet comprised 50% dried grass and 50% barley, with added minerals and vitamins. Live weights and food intakes were recorded

weekly. The mean (\pm SD) 400 day weight was 447.7 ± 35.3 kg and differences between sire groups approached significance only at the 20% level. However, significant differences ($P < 0.05$) between sire groups occurred in growth rate and food conversion efficiency during the period 100 to 200 kg live weight (approximately 100 to 200 days.) Estimates of heritability for performance parameters have been obtained and the results discussed in relation to variation in performance of Friesian bulls for beef.

13. GROWTH AND CARCASS TRAITS IN CROSSBRED OFFSPRING FROM SIX TERMINAL RAM BREEDS

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Six terminal ram breeds (Oxford, Suffolk, Dorset Down, British Oldenburg, Texel and Ile de France, three rams representing each breed) were crossed with two-year-old crossbred ewes for March/April lambing in 1973. The lambs were reared at grass and slaughtered at either 35 or 40 kg live weight. Full carcass dissection was carried out on the left side of each carcass. Data from some 286 lambs were analysed by least squares to adjust for sex, birth and rearing type and other factors. Significant between-breed differences were observed in birth weight, live weight at 8 weeks of age, age at slaughter and muscle, bone and fat content of the carcass. Growth rate to slaughter was highest in Oxford crossbreds and yield of lean meat greatest in Texel crossbreds. Details are presented of growth and carcass characteristics of the various crossbreds.

14. PERFORMANCE OF WELSH MOUNTAIN AND SCOTTISH BLACKFACE EWES AND THEIR CROSSES

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A combined flock of 200 Welsh Mountain and 200 Scottish Blackface ewes was established during the 1960s at Rhydyglafes, Merioneth. Reciprocal crossbred progeny groups were also formed to measure any possible heterosis. All four sub-groups (*viz.* two purebred and two crossbred) were fully established by 1970 and will be recorded over 8–10 years. Preliminary results are available from 360 ewes born in 1970–72, lambing in 1972–74, and having two lambings each on average. Blackface ewes significantly exceeded the performance of the Welsh ewes by 19% in lambs weaned (119 *v.* 100%), 30% in weaning weight (26.7 *v.* 20.5 kg) and 16% in fleece weight (1.46 *v.* 1.26 kg). This advantage was partially offset by the Blackface ewes being 38% heavier (47.1 *v.* 34.1 kg). There were also substantial differences in barrenness, ewe mortality and lamb mortality rates. The crossbred ewes exceeded the average of the two purebreds by about 3% in lambs weaned, lamb weaning weight and in their own bodyweight, but these differences were not significant. While further data are required to establish the economic significance of these results, they seem to show some advantage of Blackface sheep over Welsh, with the crossbreds having an intermediate performance.

15. EFFECT OF DAYLENGTH ON THE GROWTH OF LAMBS

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To investigate the slower growth of ruminants in winter, 72 lambs were kept in two similar rooms with either 16 or 8 hours of artificial light per day. Half were offered a concentrate feed *ad libitum* (AL) the other half being fed according to a scale related to body weight (R). Weight gain in the 16-week period was higher ($P < 0.01$) in animals kept in the longer daylength at both levels of feeding: 16 AL, 28.0 kg; 8 AL, 26.5 kg; 16 R, 19.3 kg; 8 R, 14.8 kg ($SE \pm 0.4$). Daylength had no effect on carcass composition or dressing percentage, whereas AL feeding caused greater fat deposition than did R ($P < 0.01$). Serum prolactin concentrations in samples taken from 24 lambs on 18 occasions during the experiment showed a rise in long daylength ($P < 0.001$) and with AL feeding ($P < 0.01$). These results suggest that long daylength stimulates growth by central mechanisms and not merely by increasing the time available for feeding. Confirmation that the effect can be obtained under other management conditions would prove the potential of extended daylength as a cheap, safe growth stimulant. The investigation is being repeated during the autumn and winter of 1974.

16. THE USE OF BODY CONDITION SCORES AS A MANAGEMENT AID IN COMMERCIAL FLOCKS

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Data from commercial flocks in the Meat and Livestock Commission's Sheep Recording Scheme were used. Data were available from individually identified ewes in 44 flocks and from a further 120 flocks on a flock basis. The overall correlation between condition score at mating and number of lambs born, on an individual ewe basis, was only $+0.14 \pm 0.01$, with a range from -0.55 to ± 0.37 in different flocks. There was however a close relationship between flock mean condition scores and flock mean lambing performance. Flocks in 'good' condition produced 16 more lambs at birth per 100 ewes than those in 'poor' condition. Twenty-seven flocks were scored 6 to 8 weeks prior to mating, and in 12 flocks the ewes in poor condition were separated off and given preferential treatment. These ewes improved in condition so that they had achieved their respective flock mean score by the time of mating, and their subsequent lambing performance did not differ from the overall flock means. In the remaining 15 flocks the poor ewes were not specially treated, and did not improve in condition by mating relative to the other ewes in their flocks. They subsequently gave 2.2 more barren ewes and produced 11.6 fewer live lambs at birth per 100 ewes mated. The practical implications of these results are discussed.

17. A COMPARISON OF TWO PRACTICAL SYSTEMS OF ARTIFICIAL REARING OF LAMBS

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Thirty Suffolk ♂ × (Finnish Landrace ♂ × Scottish Blackface ♀) castrate lambs, in six pens with five lambs per pen, three pens per treatment, were used to compare

two systems of artificial rearing of lambs on a proprietary milk substitute. These systems were: *ad libitum* cold milk substitute replenished once daily for three weeks (AL), and restricted warm milk substitute fed at 0.5 litre/lamb twice daily for four weeks followed by 0.5 litre/lamb once daily for a fifth week (R). The lambs were then fattened on a cereal based diet, fed *ad libitum*, which had been introduced to them when one week old. Six lambs per treatment were slaughtered for carcass appraisal at approximately 36 kg live weight. Daily live-weight gain (DLWG) from birth to weaning was significantly ($P < 0.01$) higher for AL lambs (AL 244, R 177 g, $SE \pm 18$ g) but there followed a post-weaning check in growth so that at seven weeks old there was no significant difference in DLWG (AL 200, R 212 g, $SE \pm 15$ g). From weaning to slaughter DLWG (AL 236, R 249 g, $SE \pm 19$ g) and concentrate intake (AL 120, R 122 kg, $SE \pm 6$ kg) were unaffected by rearing treatment, although significantly ($P < 0.05$) better conversion of concentrate into live-weight gain was given by AL lambs (AL 4.31, R 4.79, $SE \pm 0.17$). There were no significant differences in live-weight components nor in the composition of the dissected 11–13th rib saddle joint, but carcass weight as a percentage of empty body weight was significantly greater for R lambs (AL 49.8, R 53.9%, $SE \pm 1.7\%$).

18. AN INVESTIGATION OF BODY CONDITION IN SUCKLER HERDS

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Following the development of a cow condition scoring technique at the East of Scotland College of Agriculture, the MLC has implemented an on-farm pilot scheme aimed at evaluating the six-point condition scoring technique and its possible use as a management aid. Over 1,000 cows in 27 selected autumn-calving upland suckler herds are being fully recorded from mating in autumn 1973 to weaning of the calves produced in autumn 1975. Cow weights and condition scores have been recorded prior to mating, at turnout in the spring and at weaning of the calves born in the autumn of 1973, together with calf weaning weights. There is a significant linear correlation between condition score and cow weight within breed or type of cow. On average, for an increase of one score unit, live weight increased by 37 kg. This linear regression is similar for the different breed types. Differences between breeds in live weight related to condition score have also been assessed. The pattern of change in score and weight from mating to weaning shows considerable variation among herds, average score at mating being 2.6 (range 1.6–3.6), at turnout 2.2 (1.4–3.0) and at weaning 2.7 (1.7–3.9). Herds with an average score at mating of 2.6 or more showed the more dramatic change in score of -0.5 to turnout and $+0.6$ from turnout to weaning, compared with -0.3 and $+0.4$, respectively, for herds averaging 2.5 or less at mating. The relationship between change in cow score and calf growth has also been examined. Within herds there was considerable variation in score and weight, but in most herds over two-thirds of cows were included within a single point score increment, suggesting that relatively few cows within a herd would normally require special feeding to reduce considerably the variation between cows.

19. THE EFFECT OF THE INTERVAL BETWEEN FARROWING AND GROUPING ON THE INCIDENCE AND TIMING OF OESTRUS IN SOWS DURING LACTATION

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A system of management involving grouping sows, together with their litters, in the presence of a boar, and feeding *ad libitum*, has proved successful in the re-breeding of sows during lactation. In the experiment reported here, the effect of

varying the number of days between farrowing and grouping (10, 15, 20 or 25 days), on the incidence and timing of lactational oestrus was investigated using Cam-borough hybrid sows. All litters were weaned at 42 days of age. The results obtained to date for the percentage of animals exhibiting lactational oestrus, the timing of oestrus in relation to grouping and farrowing (days), and the non-return rate to mating at the lactational oestrus, are as follows: 10 day ($n = 18$), 100%, 11.00 ± 0.59 , 21.05 ± 0.54 , 78%; 15 day ($n = 18$), 100%, 9.33 ± 0.48 , 24.67 ± 0.63 , 89%; 20 day ($n = 11$), 100%, 10.18 ± 1.06 , 30.18 ± 1.20 , 91%; 25 day ($n = 23$) 96%, 7.41 ± 0.36 , 32.73 ± 0.49 , 64%. The interval from grouping to oestrus was significantly shorter for the 25 day than the 10 day ($P = < 0.001$) or the 15 and 20 day ($P = < 0.01$) treatments. Data on the performance of the litters being nursed, subsequent reproductive performance, sow weight changes, and food intakes of sows and piglets are also presented.

20. MEAT AND PIGLET PRODUCTION FROM ONCE-BRED GILTS

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Sixty gilts (LW \times (LR \times LW)) were taken at 10 to 12 weeks of age and grown to reach 81 kg (light group) or 99 kg (heavy group) at first oestrus (245 days). At oestrus gilts from each group were allocated to initial slaughter (I), or to one of four treatments, namely: mated and given 19.5, 25.8 or 32.1 kJ ME/day (termed L, M and H pregnant); or 25.8 kJ/day and not mated (non-pregnant, NP). Results for the first five of six replicates follow. Gilts on all post-oestrous treatments made net gains in body weight, the NP animals growing more ($P < 0.05$) than the non-pregnant treatment (M). All piglets were born alive. Energy intake during pregnancy had no effect on litter size, but did affect birth weight, piglets from H animals being heavier ($P < 0.05$). The heavy group produced larger litters than the light group ($P < 0.05$). L, M, H and NP animals were killed at about 120 to 126 days after oestrus and thus a few days after farrowing in the case of the first three groups. Net live-weight gains were 25, 35, 45, 42 and 16, 28, 41, 34 ± 3.1 kg for the L, M, H and NP treatments of the light and heavy groups respectively. Litter size and piglet weights were, respectively, 6.8, 8.0, 8.4 and 10.4, 10.2, 10.0 ± 1.0 ; and 1.13, 1.08, 1.30 and 0.99, 1.06, 1.25 ± 0.09 kg.

21. THE EFFECT OF LACTATION LENGTH OF THE SOW ON THE SUBSEQUENT EARLY EMBRYONIC DEVELOPMENT

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Forty-five Landrace \times Large White sows were allocated at random to one of three lactation lengths: seven, twenty-one, and forty-two days. All sows were mated on the first and second days of the first post-weaning oestrus. They were subsequently slaughtered at 20 days post coitus, and the reproductive tract removed for examination. There were no significant treatment differences for ovulation rate as determined by corpora lutea count (15.6, 16.8, 16.9; for 7-, 21- and 42-day lactation groups respectively). However, there were significant differences ($P < 0.05$) between the numbers of live embryos at 20 days post coitus (9.2, 11.5, 13.4). No differences were observed between treatments for ovarian weights, uterine weights, embryo crown rump lengths or embryo spacing, although uterine lengths for the seven-day lactation group tended to be shorter than the other two groups. It is

concluded that the reduction in subsequent litter size of the early-weaned sow is a result of increased embryo mortality in the first twenty days of pregnancy, rather than of a reduced ovulation rate at the first post-weaning oestrus.

22. EFFECTS OF PROTEIN AND ENERGY LEVELS IN SEMI-SYNTHETIC DIETS ON PERFORMANCE, CARCASS QUALITY AND PROTEIN UTILIZATION BY GROWING PIGS

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In three metabolic experiments each involving 24 castrated male pigs from 20 to 60 kg live weight the effects of protein and energy intake on utilization of protein were studied, using synthetic diets containing isolated soya protein as the only source of protein. In Experiment 1 four isoenergetic diets containing 8, 10, 13.15 and 16.3% CP were used, and best overall results were obtained with the 13.15% CP diet. Dissection and chemical analysis of the carcass indicated a linear increase in leanness as the dietary CP% increased up to 13.15, but not thereafter. In Experiments 2 and 3, increasing the energy level from 3000 to 4600 kcal DE/kg in isonitrogenous diets (13.15% CP) improved performance but adversely affected the carcass quality. The same energy intake achieved by increasing either the caloric density of the diet, or the amount given, resulted in similar performance and carcass fat content. The N retention values rose with increasing CP intake, and declined with increasing energy intake up to 3800 kcal DE/kg but not thereafter. The values were 15–30% higher when determined by the balance method than by chemical analysis of the carcass. The concentration of urea N in plasma, but not of free amino acid, was found to be a sensitive parameter for measuring protein utilization. The concentration of free amino acid in red blood cells was about 30% of that found in plasma. A large proportion of the free amino acid in the body was found in the muscular tissue.

23. EFFECTS OF DIFFERENT DISTRIBUTIONS OF A FIXED AMOUNT OF DIETARY PROTEIN FOR THE GROWING PIG

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It is usually assumed that the most efficient utilization of dietary protein by the bacon pig is achieved when the concentration of protein in the diet is either constant throughout the growing period or is higher at the beginning than at the end. To examine this assumption, 56 pigs weighing 30 kg, half of which were male castrates and half females, were each given over a period of 84 days a total of 25.2 kg of crude protein (CP) distributed according to one of seven patterns. The growth period was divided into two phases during which each pig ate half of its total feed allocation (180 kg), the concentration of CP in these two phases respectively for the seven treatments being 20–8, 17–11, 15–13, 14–14, 13–15, 11–17, and 8–20%. Pigs were slaughtered immediately after consuming their total allocation. The feed conversions (kg feed/kg gain) of the pigs on the above treatments were, in the same order, 3.12, 3.07, 3.00, 3.04, 2.99, 3.02 and 3.31 ± 0.045 and the dead-weight gains (kg) during the period were 44.2, 46.2, 47.2, 47.0, 47.9, 46.5 and 42.8 ± 0.64 . Differences in specific gravity were trivial and not significant. It is concluded that there is little to be gained by using more than one diet after 30 kg for bacon pigs.

24. THE THREONINE REQUIREMENT OF GROWING PIGS

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In order to determine the threonine requirement of growing pigs, a basal diet, which had previously been shown to be deficient in threonine, was formulated from barley, soya bean meal and white fish meal. The crude protein content of the diet was 12.5% and synthetic amino acids were included to provide levels of lysine, methionine plus cystine, and tryptophan of 0.95, 0.55 and 0.20% of the diet respectively. The basal diet contained 0.48% threonine, and supplements of DL-threonine enabled seven further levels to be supplied, i.e. 0.52, 0.54, 0.56, 0.58, 0.60, 0.62 and 0.66%. The eight diets were fed to 64 crossbred females from 25 to 55 kg live weight. A blood sample was collected from each pig on attaining a live weight of 40 kg. Prediction of a requirement value is subjective since the different measured parameters responded in different ways. Growth performance data appeared the most sensitive, whilst carcass dissection results were variable. Blood urea values indicated a lower dietary requirement for threonine than the growth data, but plasma free amino acids failed to demonstrate an increased utilization of dietary amino acids as the threonine level of the diet was increased. There was no benefit in providing levels of dietary threonine above 0.56%.

25. METHIONINE PLUS CYSTINE REQUIREMENT OF THE GROWING PIG

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Fifty-two British Landrace × (British Landrace × Large White) gilts were fed experimental diets to a modified ARC feeding scale from 25 to 55 kg live weight. Four litter mates from each of thirteen litters were allocated to individual treatments arranged as a balanced incomplete block to permit the removal of variation due to litter effects. The experimental diets were based on barley, yeast protein (Toprina) and tapioca, together with supplements of synthetic amino acids to provide 0.9% lysine and 0.59% threonine in the air-dry diet. Levels of essential amino acids and non-essential nitrogen were such that they were not limiting. A range of thirteen dietary treatments from 0.34% to 0.56% methionine plus cystine in the air-dry material (increments of 0.015% from 0.34% to 0.4%, and of 0.02% from 0.4% to 0.56% methionine plus cystine) was used to obtain response curves for growth, carcass composition estimated from a ham dissection, blood urea, urinary urea and plasma amino acids.

26. THE CHARACTERISTICS PRODUCED BY MECHANICAL PROCESSING OF GRASS JUICE AND PULP

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Ryegrass given 250 kg nitrogen/ha was passed through a 10 hp single-screw press to provide juice and pulp. The press used 6.5 kWh of electricity/1000 kg of grass processed, and handled 1500 or 2000 kg/hr double-chopped or precision-chopped grass respectively. Throughout the growing season the extraction rate of juice averaged 49.9%. The extraction rates of dry matter (DM) and crude protein

(CP) into the juice were 17.5% and 31.5% respectively. The mean composition of the juice was for DM -5.9%, CP -30.3% and for true protein -17.1%. The pulp had an average DM of 27% which was 10 percentage units higher than that of the grass; the CP content of the pulp averaged 15.5% which was 1.6 percentage units lower than that of the grass. Grass processed under dry conditions (D) (i.e. little surface moisture) yielded 44.5% juice; when processed under wet conditions (W) it gave 54.5% juice. The extraction of DM and CP for D was 16.3% and 29.2% and for W, 18.5% and 33.2%. The DM contents of the juice for D and W were 6.9% and 5.2%, and values for CP in the DM were 32.2% and 28.7% respectively. For a grass crop yielding 62.5 tons/ha, 555 kg of CP were extracted. The CP in the DM of the residual pulp (15.5% CP) was above the recommended protein allowance for beef cattle weighing 300 to 400 kg.

27. THE PRODUCTION OF CARCASS MEAT FROM CATTLE AND PIGS UTILIZING THE PRODUCTS OF GRASS FRACTIONATION

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Grass juice and pulp obtained by passing grass through a screw-press have been evaluated in trials involving 80 pigs from 60 to 105 kg, and 36 Aberdeen Angus × Friesian heifers from 285 to 390 kg. Barley/grass juice mixtures were constituted either as 1 : 2.5 (parts by weight) (BJ₁), 1 : 3.0 (BJ₂), or 1 : 3.5 (BJ₃) and were compared with a barley/fish meal (BF) mixture of 14.8% CP. At the same live weight all pigs received the same amount of barley. The average daily live-weight gains (g) were for BJ₁—1034, BJ₂—1064, BJ₃—1096 and BF—1059. Fresh grass (G) and grass pulp (GP) were offered *ad libitum* to two groups of 12 cattle, and a further 12 cattle were paddock-grazed (P) in 5 paddocks each of 0.32 ha. The average daily live-weight gains (kg) were for G—0.73, GP—0.84 and P—0.72 kg. In terms of land use 20 ha would yield 1250 tons of grass, and 625 tons of juice which could supply the protein needs of 1400 pigs growing from 60 to 105 kg. Two hundred and ten tons of barley would be required to supplement this protein and could be obtained from 49 ha. The 625 tons of residual pulp would be eaten by 180 beef cattle growing from 280 kg to 400 kg. The average carcass gain from the 69 ha would be 925 kg/ha. Utilizing this same acreage for beef animals either zero-grazed on grass or paddock grazed, the carcass gains/ha would be 575 and 435 kg/ha respectively.

28. THE NUTRITIVE VALUE OF MOLASSES AND ITS BY-PRODUCTS

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The nutritive value of cane molasses (M) and Condensed Molasses Solubles (CMS) (a high-protein by-product in the fermentation of beet molasses) for ruminants has been estimated from a series of metabolism and growth experiments using sheep. In the first experiment five wethers were used in a 5 × 5 Latin square metabolism trial to determine the apparently digestible energy and nitrogen balance in a barley-based control diet (C) substituted by molasses and CMS at either 10 or 20% inclusion (10 M, 20 M, 10 CMS and 20 CMS). The apparent digestibility of dry matter (C, 75.5; 10 M, 73.0; 20 M, 73.0; 10 CMS, 73.6; and 20 CMS, 73.0; ± 1.1%) and gross energy (77.3, 75.0, 74.7, 76.1, and 74.0; ± 1.0%) were not significantly influenced by the inclusion of molasses and CMS.

Nitrogen retention was not significantly different between treatments (3.7, 4.0, 5.5, 5.5, and 4.6; ± 1.5 g N/day). The digestibility of crude protein was significantly increased ($P < 0.05$) by the increase of CP content in both rations containing CMS. The apparent digestible energy values of molasses at 10 and 20% and CMS at 10 or 20% inclusion were 13.2, 13.0, 12.6 and 10.9 MJ/kg DM respectively. In the second experiment 72 lambs were used in a feeding trial to investigate the effect of the nitrogen fraction of CMS on growth parameters. The control diet (C) was composed of barley, ground barley straw, minerals and vitamins with 48% of the total nitrogen as urea. CMS was added to a second diet (100 CMS) until CMS nitrogen comprised 48% of the total N. In addition there were four diets in which 25, 50, 75 or 100% of the CMS nitrogen was substituted by soyabean nitrogen (75 CMS, 50 CMS, 25 CMS, 0 CMS respectively). Live-weight gain (C, 203; 100 CMS, 190; 75 CMS, 234; 50 CMS, 272; 25 CMS, 275; 0 CMS, 229; ± 20 g/day) and food conversion efficiency (7.2, 7.9, 7.4, 6.3, 6.1, and 7.6; ± 0.4 kg DM/kg LWG) were significantly increased ($P < 0.05$) by the substitution of up to 50% of CMS nitrogen by soyabean nitrogen, although food intake was not significantly affected.

29. THE EFFECT OF LEVEL OF MILK INTAKE AND LENGTH OF MILK FEEDING PERIOD UPON THE HERBAGE INTAKE AND LIVE-WEIGHT CHANGE OF CALVES

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Forty-eight Hereford \times Friesian castrated male calves were used to investigate the influence of two levels of milk intake (2000 (H) or 1000 kg (L) if fed for 240 days) and the length of the milk feeding period (weaning at 86, 128, 170 and 212 days) upon herbage intake and live-weight change to eight months of age. Milk was fed according to typical lactation curves. Calves were individually housed from purchase, at 7 to 10 days old, in mid-February, for 63 days until turnout to grazing. They were strip-grazed on S24 perennial ryegrass, given a daily allowance equivalent to 6% of total body weight as herbage dry matter (measured from ground level), and were fed their milk allowance twice daily. Herbage intake was measured over eight 5-day periods at 21-day intervals. Prior to weaning herbage organic matter intake per unit live weight (HOMI) by the L groups was consistently greater ($P < 0.001$) than that of the H groups. Within each period HOMI of the unweaned calves was significantly ($P < 0.001$) less than that of their weaned contemporaries, and within these latter groups HOMI was greater for those weaned longer. The magnitude of the post-weaning growth check at all weaning ages was dependent upon weaning age and level of milk consumption prior to weaning. The enhanced performance at grazing from a high level of milk (H v. L) was lost by 8 months of age in the 86- and 128-day groups. These results are discussed in relation to factors controlling the herbage intake of the milk-fed calf.

30. ENERGY RETENTION AND THE COMPOSITION OF BODY GAINS IN GROWING CATTLE

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Eight Hereford \times Friesian castrate male cattle were raised from 100 kg to about 600 kg on one of two diets: 'dried grass' (85% dried grass pellets) or 'barley' (85% barley-based pellets). All animals received the remaining 15% of their food as long dried grass. The metabolizable energy (ME) contents of the dried grass

and barley diets were 10.4 and 11.9 MJ/kg DM respectively. Two rations (High and Low) were given, and within each the cattle received the same ME intake from either diet. The food intake and weight gain of each individual were recorded throughout. At least 10 measurements were made of energy balance for each animal while receiving its usual ration, and a further four were taken when intake was restricted to about maintenance. Body composition was calculated from measurements made of D₂O space at intervals of 100 kg estimated empty body weight. Maintenance energy requirement for all groups was given by 10.1 + 0.086 MJ/kg live weight. The net availability of both diets for growth was about 0.6. Nitrogen retention in the carcass was about 2.30 and 0.90 kg/100 kg empty body weight gain at live weights of 150 kg and 450 kg respectively. Live weight gain, predicted from energy and nitrogen retention for each 100 kg increase in observed live weight gain, was on average 108 kg (SD ± 12) for the dried grass diet and 106 kg (SD ± 11) for the barley diet. The extent to which these observations extend and modify the Agricultural Research Council estimates of the energy requirements for growth in beef cattle is discussed.

31. EFFECT OF EARLY GROWTH RATE UPON BEEF PRODUCTION AND AN EVALUATION OF DRIED GRASS AS A DIETARY COMPONENT

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One hundred and eight Friesian castrates are being used in a factorial experiment to compare the effects of 3 rates of weight gain, 360, 660 or 730 g daily, to 12 weeks of age, and the substitution of barley by dried grass in diets given between 250 kg and slaughter. All treatments are imposed within each of three beef production systems: intensive, all indoor, slaughtered at 400 kg; or finished at 450 kg at 18 months either from yards (using autumn-born calves) or from grass (using winter-born calves). The three production systems have been followed successfully. Early rate of gain has had no marked effect upon subsequent growth rate and feed conversion efficiency, or carcass quality, as indicated by dissection of the wing rib joint. Substitution of barley by dried grass nuts has reduced growth rate and efficiency of feed conversion of cattle given concentrates and straw to appetite in the intensive system, but has had no consistent effect with cattle given fixed allowances of concentrates and grass silage to appetite in the 18-month systems.

32. THE GROWTH OF ENTIRE FRIESIAN BULLS FED ON DRIED WHOLE-CROP MAIZE DIETS

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Twenty-two Friesian bulls were individually fed on two treatments from 140 kg initial live weight. In period 1 (140 to 200 kg) the diet for treatment A contained dried whole-crop maize (64%), molasses (15%), urea (1.8%), soya bean meal (18%), with minerals and vitamins (0.9%). Treatment B diet contained dried whole-crop maize (35%), rolled barley (35%), molasses (15%), urea (1.8%), soya bean meal (13%), with minerals and vitamins (0.9%). The diets were made isonitrogenous by varying the amount of soya bean meal. The crude protein level (16% in period 1) was reduced to 13% in period 2 (200 to 300 kg) and 10% in period 3 (300 to 363 kg)

by reducing the soya bean level and increasing urea. *In vitro* digestibility values were higher for treatment B, significantly so in period 1. As the intake of digestible energy was limiting, the daily live-weight gain was higher on this treatment. In period 2 there were no differences in intake, daily gain or feed conversion efficiency, but again in period 3 the lower energy and nitrogen intake on treatment A led to reduced performance. The experiment suggests that dried whole-crop maize can be used in an intensive diet for bull beef production, but that barley supplementation is essential for high rates of gain before 200 kg and after 300 kg live weight.

33. THE VALUE OF DIFFERENT SUPPLEMENTS TO SILAGE FOR BEEF CATTLE

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Four groups of 8 Friesian steers were grown from 350 to 420 kg on diets with self-feed silage plus 2.8 kg dry matter supplied by rolled barley (B), whole swedes (S), whole fodder beet (F), or to one group whole swedes were offered *ad libitum* (SS). The silage was from a predominantly ryegrass sward and contained 18% dry matter. Swedes and fodder beet contained 9.5 and 17.3% dry matter and 90.0 and 88.0% organic matter respectively. The daily intake of swede dry matter was 4.6 kg for steers self-fed both silage and swedes. Daily dry matter intakes were 7.7, 6.9, 6.7 and 7.6 kg, and daily live-weight gains were 0.57, 0.48, 0.52 and 0.67 kg for steers on treatments B, S, F or SS respectively. Feed intake was measured more accurately in two trials of Latin-square design with the above diets with 3 kg supplements of barley, swedes or fodder beet. Total dry matter intake (kg) was 7.0 (B), 5.9 (S), 6.2 (F). Digestibility of organic matter and acid detergent fibre in the total diet was 73.0 and 73.2 (B), 75.2 and 78.1 (S), 76.7 and 76.5 (F). The intake of digestible organic matter was 17% lower with swedes and 11% lower with fodder beet than with barley. These differences are similar to those found in daily live-weight gain in the growth trial.

34. BEEF PRODUCTION FROM ADDITIVE-TREATED SILAGE

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The results from two experiments are described. Herbage from a perennial ryegrass/white clover sward was ensiled in three silos on 16 to 18 July using either no additive (C), a formalin/sulphuric acid mixture ('Sylade') (S) or formic acid ('Add-F') (F). The additives were applied at the rate of 3.4 litres/tonne fresh herbage. The silages were offered *ad libitum* to 30 British Friesian bull calves (mean initial live weight 117 kg) in the 1st experiment, and 27 castrated males (mean initial live weight 355 kg) of mixed breed in the 2nd experiment. In experiment 1 the animals were offered 1 kg concentrate/day. The animals were blocked according to live weight and allocated to treatments at random within blocks. The treatments were imposed for 77 and 49 days for experiments 1 and 2 respectively, after which three animals per treatment from both experiments were chosen at random for a study of ration digestibility and nitrogen balance. The mean daily DM intakes from silage for experiment 1 were (C) 2.7, (S) 2.9 and (F) 3.1 ± 0.09 kg/day ($C < F$; $P < 0.05$). The corresponding figures for experiment 2 were (C) 5.38, (S) 6.18 and (F) 6.02 ± 0.20 kg/day ($C < F, S$; $P < 0.05$). The mean daily gains for experiment 1 were (C) 0.74, (S) 0.87 and (F) 0.83 ± 0.03 kg/day ($C < S$; $P < 0.05$). The corresponding figures for experiment 2 were (C) 0.38,

(S) 0.70 and (F) 0.78 ± 0.07 kg/day ($C < S, F; P < 0.05$). The mean organic matter digestibilities of the complete diets in experiment 1 were (C) 68.5 , (S) 71.4 and (F) 69.1% , and for the silages in experiment 2, (C) 68.7 , (S) 69.6 and (F) 69.4% . It was concluded that the use of an additive is beneficial in terms of live-weight gain.

35. EFFECT OF CONCENTRATE LEVEL AND STOCKING RATE ON MILK PRODUCTION FROM COWS CALVING DURING JANUARY AND FEBRUARY

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Little is known about the optimum level of feed input during the winter and stocking rate at pasture, and their interaction, for cows calving during January and February. A 2×2 factorial design experiment was carried out over a 2-year period, using a total of 72 British Friesian cows, to assess the effects of two levels of concentrate input (822 (HC) and 610 (LC) ± 13.7 kg/cow), coupled with two stocking rates (6.4 (HS) and 4.9 (LS) cows/ha), on animal performance. All concentrates were given during the post partum indoor feeding period in addition to *ad libitum* grass silage. The animals (mean calving date 22 January) were blocked according to calving date and allocated at random to treatments within each block. All animals received equal concentrate inputs/kg milk produced for the first 4 weeks from calving, after which the input to LC animals was reduced. The animals went to pasture during mid-April and were rotationally grazed for a 24-week period. The pasture received 460 kg N/ha. The mean milk outputs at the 2 concentrate levels were: winter period HC, 2064 ; LC, 1971 ± 23.9 kg; grazing period 2679 , 2739 ± 53.2 kg; and total lactation 4991 , 4984 ± 78.8 kg. The mean cow live weights were: end of winter period HC, 515 , LC, 496 ± 3.1 kg; and end of grazing season 549 , 537 ± 4.1 kg. The effects of stocking rate were: output/cow at pasture: HS, 2571 ; LS 2847 ± 53.2 kg; total lactation yield 4804 , 5170 ± 78.8 kg; and live weight at end of grazing season 529 , 558 ± 4.1 kg. No interaction between concentrate input and stocking rate was found. Milk composition data are also presented. The implications of these results are discussed.

36. FEEDING DAIRY COWS TO APPETITE

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The feasibility of feeding lactating cows to appetite depends on whether they can match food intake to food requirements for maintenance and milk production. Four complete diets were made up from (1) 40 , (2) 50 , (3) 60 and (4) 70% chopped or coarsely milled hay, together with concentrates to 100% . From digestibility trials with sheep, these diets were estimated to supply 2.70 , 2.50 , 2.30 and 2.15 Mcal metabolizable energy (ME)/kg dry matter (DM). Three groups of 12 cows received diet 1 to appetite for lactation weeks 1–6. From week 7 to the end of the winter feeding period (week 25 or later), group A continued on diet 1 to appetite and group B received the same diet in amounts dependent on live weight and milk yield. Group C was fed to appetite on diet 2 for weeks 7–12, diet 3 for weeks 13–18 and diet 4 from week 19 to the end of winter feeding. The results for weeks 7–24, adjusted for corresponding values for weeks 3–6, are given below as mean daily values for treatments A, B and C (\pm SE of difference). Milk yield, 16.2 , 16.1 and 16.5 ± 0.8 kg; DM intake, 14.1 , 11.6 and 12.6 ± 0.5 kg; ME intake, 37.8 , 31.1 and 29.2 Mcal; ME requirement, 30.7 , 30.5 and 32.2 Mcal; live-weight gain, 0.51 ,

0.19 and 0.28 ± 0.10 kg. Group A cows gave no more milk than those in group B despite the extra food they consumed. Group C achieved a reasonable match of intake to requirement. In the two groups fed to appetite there was no indication of low yielding cows overeating to a greater degree than high yielders.

37. NUTRITIONAL FACTORS INFLUENCING MILK YIELD IN THE DAIRY COW

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Twelve, second-calving Friesian dairy cows were randomly allocated to two feeding regimes. One group of six animals was offered a ration consisting of long dried grass (62% digestibility) *ad libitum* plus mineralized supplement (2 kg/head per day) (Treatment A). A further six animals were offered a ration of barley straw, cereal balancer, potatoes and a cereal/protein concentrate (0.4 kg/kg milk) (Ration B). Food intake was individually recorded, and frequent samples of food and milk taken for chemical analysis. Jugular catheters were fitted to each animal and blood samples were taken at 3-hourly intervals over a 48-hour period at 15-day intervals up to day 100 of lactation. Serum from each blood sample was analysed for urea, glucose, ketone bodies, non-esterified fatty acids (NEFA), prolactin and progesterone. There was no significant difference in the intake of dry matter between treatments. Daily milk yield up to 60 days was (A, B) $21.18, 20.53 \pm 1.22$ kg/day; milk fat 0.88, 0.75 ± 0.05 kg/day; milk protein 0.67, 0.69 ± 0.04 kg/day. Maximum body weight loss was 46.5, 51.7 ± 8.4 kg. There was a significant correlation ($P < 0.001$) between NEFA levels and daily milk fat production ($r = 0.7$, A; 0.6, B). In the case of the dried grass diet there was a significant correlation ($P < 0.001$) between blood NEFA levels and daily milk protein production ($r = 0.5$). It would appear that weight loss does not necessarily indicate the true contribution of body tissue to milk production in the dairy cow. The results will be discussed in relation to the practical implications of feeding dairy cows to obtain both high milk yields and a 365-day calving index.

38. THE NUTRITIVE VALUE FOR DAIRY COWS OF ARTIFICIALLY DRIED LUCERNE WAFERS MADE EITHER FROM THE FRESH CROP OR AFTER MECHANICAL DEWATERING

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Artificially dried and wafered lucerne harvested in June and August was compared with the same crops after mechanical dewatering. The dewatering was achieved in a pulper and belt press which removed 35% of the initial crop weight as juice. The dried lucerne wafers from the earlier and later harvests had *in vitro* concentrations of digestible organic matter in the dry matter of 58 and 56 respectively. The corresponding values for the product made from the dewatered lucerne were 55 and 51. Mechanical dewatering reduced the protein content in the dry matter of the lucerne wafers by about 5 percentage units. The feeding trial with 24 mature Friesian cows, in early lactation, was a 2×2 factorial design with a covariance allowance at lactation week 8. The cows were given 20 kg wafers daily as the sole ration, plus a mineral supplement for the first 4 weeks, and thereafter, at monthly intervals until lactation week 24, the allocated feed was reduced by 8% on all treatments. When the trial commenced the mean daily milk production for all cows was 27.5 kg, and this fell to 13.7 kg by the end of the

trial. There were no significant differences between treatments in dry matter intake, milk quality and live-weight change. Only the milk yield from cows fed early lucerne wafers was significantly higher ($P < 0.5$) than from cows fed the late fractionated wafers. In lactation week 24 this difference was 4.7 kg milk per cow per day. Mechanical dewatering did not affect the nutritive value of lucerne dried artificially for dairy cows, but further study is required on the effects of different degrees of dewatering.

39. STUDIES ON FEEDING CHOPPED DRIED GRASS TO DAIRY CATTLE

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In each of the three winters 1971 to 1973, groups of approximately 10 Friesian cows were fed loose-chopped dried grass to appetite to measure the effect on milk production and live weight. One group of cows (A) was fed dried grass and minerals as the sole diet; a second group (B) received the same ration with a daily supplement of rolled barley. In 1972 and 1973 a third group (C) was fed a conventional ration of hay and dairy concentrate according to milk yield. The dried grass was from mixed ryegrass swards in the first two years and from lucerne in the third year. This was fed to Friesian heifers in 1971 and 1973 and to Friesian cows in 1972. The barley supplement was 4.5 kg/day for heifers and 5.4 kg for cows. Average milk yields from calving were (A) 15.0 and (B) 15.7 ± 0.39 kg/day for heifers over a 24-week period in 1971. In 1972 yields over 17 weeks averaged (A) 23.7 kg (B) 25.4 and (C) 24.6 ± 0.83 kg/day. In 1973 corresponding yields up to week 12 were 18.7, 20.0 and 17.5 ± 0.35 kg/day respectively. Milk quality and live-weight gains were generally higher with dried grass feeding than with traditional rationing, due probably to greater feed intakes.

40. THE INFLUENCE OF THE LEVEL OF MILK YIELD ESTABLISHED AT THE START OF THE GRAZING SEASON UPON THE RESPONSE OF SPRING-CALVING DAIRY COWS TO VARIATIONS IN HERBAGE ALLOWANCE

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Two groups of 18 Friesian cows were balanced for age, previous lactation and expected date of calving. Mean milk yields of 19.7 and 23.7 kg per day were established at the start of grazing on 22 April by controlling the plane of nutrition in the last three months of pregnancy and after calving (mean date 24 March). Three levels of herbage allowance (25 g (L), 50 g (M) and 75 g (H) herbage DM measured to ground level/kg LW per day) were then imposed in a 28-day paddock-grazing system. Animals were re-distributed between allowances, within levels of winter nutrition, in successive 8-week periods. No concentrates were fed during the grazing season. The effects of winter nutrition on mean live weight, milk yield and composition during grazing were all non-significant. Restricting the level of herbage allowance significantly depressed mean live weight (506 kg (H), 498 kg (M) and 484 kg (L)), milk yield (17.7, 17.1 and 14.0 kg/day), protein (3.34, 3.31 and 3.22%) and lactose content (4.55, 4.53 and 4.43%), and increased fat content (3.48, 3.56 and 3.74%). There were no significant interactions between the effects of level of winter nutrition and herbage allowance. The results demonstrate the

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potential for maintaining high milk yields in spring-calving cows from grazed herbage alone. The production responses are discussed in relation to measurements of herbage intake made throughout the experiment.

41. EXTENSIVE OR PADDOCK TYPE GRAZING FOR LACTATING DAIRY COWS

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Two hundred and seventy-eight milking Friesian dairy cows were divided into two groups, matched for calving date, past and current milk yield. One group was extensively grazed on an area of 34 ha divided into three fields, two of 9.7 ha and one of 14.6 ha. The other group was grazed on an equal area, divided into fourteen paddocks each of 2.4 ha. Grazing lasted from mid April 1974 until the beginning of September 1974. There was no difference in live-weight gain between the two groups, which averaged 0.8 kg per head per day. Total milk yield was 7.7% lower from the extensively grazed group. Any stress of weather appeared to have more influence on the performance of this group. A small number of animals in the extensively grazed group aborted in mid-season, possibly due to oestrogenic activity of clover encouraged in the closer sward type produced by the different grazing system. No other health differences were observed. The behaviour of the groups was different: the extensively grazed group grazed as a free range herd, roaming the allotted area, and appeared more content and settled. The paddock grazed group, because of greater daily stocking intensity, did not have sufficient free space per cow to operate as a free range herd, and appeared to be under competition for feed, with less resting time, and a less distinct grazing pattern. The time taken to collect cows from the extensively grazed areas was three times that taken with the paddock grazed group.

42. THE EFFECTS OF VARIED ENVIRONMENTS AND LEVELS OF NUTRITION ON LAMB OUTPUT FROM WELSH MOUNTAIN EWES

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Experiments during 1971/2 and 1972/3 with Welsh Mountain ewes studied the effect of flushing and housing during mating, during late pregnancy, at lambing, and in early lactation, on ewe and lamb performance. Variation in the degree of flushing imposed only slightly increased the proportion of ewes bearing twins, but the proportion of barren ewes was reduced in year 1. The shelter provided by housing during tupping appeared to be a less important factor in increasing the number of lambs born than was confinement of the ewes with the rams. The unhoused ewes had to roam over a large area (80 ha) seeking a mate. Extra food given to housed ewes in late pregnancy resulted in an increase of 3.1 kg live weight in year 1 and 7.6 kg in year 2 over the corresponding ewes on the hill, but did not reduce the number of barren ewes (year 1: 11.0 v. 10.8%; year 2: 7.0 v. 4.4%), or increase the number of twins (4.0 v. 3.7%; 4.7 v. 4.8%). It also failed to increase lamb birth weight significantly (3.24 v. 3.38 kg; 3.26 v. 3.30 kg). Housing at lambing, compared with outdoor lambing, reduced lamb mortality for the first 24 hours from birth (3.1 v. 5.1%; 5.9 v. 7.2%). When a suitable post lambing management system was used subsequent mortality was nil. Both ewes and lambs performed poorly if housed in early lactation.

43. THE LONG-TERM REPRODUCTIVE PERFORMANCE OF FINNISH LANDRACE × DORSET HORN EWES SUBJECTED TO PHOTOSTIMULATION AND HORMONE THERAPY

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Ninety-six Finnish Landrace (♂) × Polled Dorset Horn (♀) F₁ generation ewes were repeatedly subjected to an artificial daylength regime, comprising an abrupt increase in daylength to 18 hr at 60 days of gestation followed by a gradual reduction of 3.5 min per day from 90 days of gestation. The ewes were synchronized in oestrus using polyurethane intravaginal pessaries impregnated with 30 mg 9 α -fluoro-11-hydroxy-17 α -acetoxy progesterone (SC 9880, G. D. Searle) plus 400 mg progesterone, inserted for 12 days. All the ewes were mated to Suffolk rams at the induced and first repeat oestrous cycles, and all the lambs were abruptly weaned on to concentrate diets at 28 days of age. The reproductive cycle length was 205 days. The overall mean percentage conception for five consecutive reproductive cycles at the reduced lambing interval of 205 days was 87.8 and the mean litter size 2.1. Of the original 96 ewes, 47, 30, 12, 5 and 2 conceived in a total of 5, 4, 3, 2 or 1 reproductive cycles respectively. Annual lamb production per ewe, calculated on the basis that the original 96 ewes were all available for breeding in all five reproductive cycles, was 3.3. On the basis of actual ewes exposed to the ram the value was 3.5. The reproductive performance of the ewes was affected by their level of energy intake.

44. PROGESTERONE LEVELS IN THE LACTATING COW

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The aim of the experiment was to gain information on the effect of lactation on progesterone output, as a guide to the resumption of cyclical reproductive activity in the lactating dairy cow. Twelve second calving Friesian cows were divided into two groups: group A fed *ad libitum* on a diet of long dried grass; and group B fed on a concentrate-based diet (long barley straw plus 0.4 kg concentrate/kg milk). The cows were weighed once a week and milk output and composition measured twice daily. Blood samples were taken every 2 days for 90 days by venipuncture or from indwelling jugular catheters. The cows were rectally palpated once a week, from the second week after calving to the end of the experiment. They were studied for signs of 'standing heat' during the daily exercise period. Progesterone plasma levels were measured by radioimmunoassay. Progesterone measurements indicated that all except one of the cows showed cyclical progesterone output: 16.8 ± 2.3 days after calving for cows fed on the concentrate diet (group B), and 17.2 ± 2.0 days after calving for cows fed on the long grass diet (group A). There was a wide variation about the mean peak levels of 5.5 ng/ml (1.1–10.8 ng/ml) between animals. The relationship between plasma progesterone levels and milk yield, body weight change and plasma free fatty acid levels is discussed.

45. CONTROL OF THE BOVINE OESTROUS CYCLE WITH A SYNTHETIC PROSTAGLANDIN ANALOGUE, ICI 80 996—PRELIMINARY FIELD EXPERIENCES IN LACTATING BEEF CATTLE

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It is now well established that prostaglandins are luteolytic in cattle at various doses and by various routes of administration. Compound ICI 80 996 is a synthetic

prostaglandin analogue, closely related chemically to natural prostaglandin $F_{2\alpha}$. This compound will induce luteolysis in cattle at a single intramuscular dose of 500 μg , but in common with all other prostaglandins it is ineffective if given before the 5th day of the oestrous cycle, or after the occurrence of natural luteal regression. However, two single injections administered 11 days apart have been shown to be an effective method of controlling the oestrous cycle, not only in cycling Friesian heifers but also in lactating beef cattle. Using compound ICI 80 996, changes in the plasma concentrations of LH, oestradiol- 17β and progesterone have been measured during this regime and found to be similar, both in magnitude and time course, to those reported to occur at a spontaneous oestrus. They are also similar to those induced by administration of natural $\text{PGF}_{2\alpha}$. Insemination of animals at the synchronized heat following such treatment shows fertility to be the same as in control animals. Field experiences with ICI 80 996 in over 1600 lactating beef cattle shows that fixed-time inseminations at 72 and 96 hours after the 2nd injection also produce normal fertility, but that a single insemination at 78 hours yields a significantly lower conception rate.

46. CALCIUM AND PHOSPHORUS AVAILABILITY AND UTILIZATION IN THE GROWING PIG

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The availability and utilization of dietary calcium (Ca) and phosphorus (P) in the growing pig were investigated in a 70-day metabolism study involving eight littermate pairs of Large White castrated male pigs. The animals were individually and scale fed the Meat and Livestock Commission sib-testing diet, which contained 0.76% Ca and 0.76% P on a dry matter basis. Mineral retention and excretion were individually recorded throughout the experimental period. Dietary Ca and P availabilities were determined at live weights of 25, 48 and 70 kg using a comparative balance radioisotopic procedure. Over the live-weight range 25 to 70 kg a significant decline in availability was observed for Ca (59.2% to 49.5%) and P (83.0% to 73.8%). Dietary Ca retention over the same period increased from 7.2 to 15.3 g per kg live-weight gain, the corresponding values for P being 5.2 and 9.5 g respectively. The decline in Ca and P availabilities with increasing live weight was accompanied by changes in efficiency of retention of the absorbed minerals. Thus, the percentage of absorbed Ca retained decreased from 98% at 25 kg live weight to 92% at 70 kg; the corresponding change for absorbed P was from 48% to 38%. The results are discussed with reference to the Agricultural Research Council recommendations for Ca and P dietary and net requirements and the availability of these elements for the growing pig.

47. USE OF A MODEL TO ESTIMATE NUTRIENT ALLOWANCE FOR GROWING PIGS

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A model which predicts growth responses to protein and energy intake is proposed as an approach to the factorial formulation of energy and protein allowances for growing pigs. A general procedure is described which estimates, within specified limits, the growth rate, food conversion efficiency and carcass quality of pigs fed different nutritional regimes. This model is shown to be of enhanced value when it is sufficiently flexible to be adapted to the specific circumstances of

an individual pig production unit. Examples are considered of the way in which individual producers might be assisted to choose the nutritive regime appropriate to prevailing production objectives and market conditions.

48. DOSE/RESPONSE TO NUTRIENT INTAKE IN GROWING PIGS

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Information concerning optimal feeding levels of high density and conventional diets for growing pigs is conflicting. Before financial comparisons can be made at any given set of economic conditions, basic performance data are essential. This experiment involved two diets, and six feeding scales, fed to growing pigs from 18 kg live weight. A total of 192 pigs was used in a 2×6 factorial design, arranged in 4 randomized blocks, with 4 pigs per pen. All pigs were fed on a time scale until they reached the six levels of maximum feeding: 1.625, 1.800, 1.975, 2.150, 2.325 and 2.500 kg/pig per day. The high density diet was based on mixed cereals and added fat; it contained 18.6% CP and 13.1 MJ ME/kg. The control diet, which conformed to ARC recommendations, comprised two stages, containing 17.7% and 15.8% CP, and 11.2 MJ ME/kg. Both diets were fed as 0.8 cm pellets, the pigs being fed twice daily up to 45 kg live weight, and once per day thereafter. The high density diet improved growth rate and food conversion by 20% from 18 to 60 kg, and by 17% from 60 to 90 kg liveweight; killing-out percentage was increased by 2.1%. Growth rate and food conversion improved with daily food intake with both diets. Results are discussed in relation to carcass composition as measured by ultrasonic backfat and carcass measurements. Regression analyses of performance as a function of food intake are presented for each diet.

49. THE RESPONSES IN THE GROWTH AND CARCASS QUALITY OF GILTS AND CASTRATES TO PROGRESSIVE REDUCTIONS IN FOOD INTAKE

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Growth rate, food conversion and carcass quality are the major determinants of the profitability of bacon pig production. They are interrelated and each is dependent on daily food intake. The experiment compared these relationships in gilts and castrates over a wide range of food intake. Thirty-two female and 32 castrated male pigs were individually given a barley-based diet, containing 16% protein, at average daily rates from 1.2 to 2.5 kg (16 to 32 MJ ME) during their growth from 25 to 90 kg. A reduction of 1 MJ in average daily ME intake reduced the average daily gain of castrates by 29.0 g and of gilts by 24.2 g ($P < 0.05$). Castrates and gilts achieved minimum food conversion ratios of 2.93 and 2.79 at similar ME intakes, approximately 25 MJ. The reductions in fat thickness with progressive restriction of ME intake were greater by approximately 20% in the gilts than in the castrates; mean reductions (mm/MJ) for the two sexes were 0.52 ± 0.10 , 0.48 ± 0.08 , 0.75 ± 0.08 , and 0.42 ± 0.07 for the shoulder, midback, minimum loin and P_2 measurements respectively. To achieve the same mean carcass fatness the daily ME of the gilts was 25.7 MJ and of the castrates 21.0 MJ ($P < 0.05$). Daily lean tissue deposition, estimated from specific gravity, was not reduced perceptibly by reductions in daily ME intake down to 24 MJ; with further reductions daily lean tissue deposition decreased by approximately 25 g/MJ.

50. SOME EFFECTS OF PHYSICAL FORM AND TOCOPHEROL SUPPLEMENTATION ON THE ACCEPTABILITY AND UTILIZATION OF HIGH MOISTURE MAIZE GRAIN BY THE GROWING PIG

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Propionic acid-preserved moist maize was compared, at dietary inclusion levels of $\approx 85\%$, in whole (W) or rolled (R) forms, with dried ground (DrG) maize. In the first series of experiments the moist maize contained 37.4% moisture, was included in diets to which no synthetic tocopherol was added, and was approximately one year old when experiments on acceptability (using 54 pigs) and digestibility (using 12 pigs) were started. In the second series, conducted between 2 and 12 months post harvesting, the moist maize contained 45.8% moisture and, 4 months post harvesting, 0.5 mg/kg α tocopherol (cf. 7.2 mg/kg in the DrG form). Digestibility (using 18 pigs) and performance studies (using 3 sets of 48 *ad libitum* group-fed pigs per set) were conducted with all diets supplemented with 10 mg/kg α tocopherol. A further performance study used 72 pigs, individually fed on a restricted regime, to investigate responses from R, W and DrG diets, with or without the addition of 10 mg/kg α tocopherol. Overall, and up to 8 months after harvesting, the efficiency of utilization of dietary DM was poorer for the W based diets than for those based on the R and DrG forms of maize. When the moist cereal was over 8 months of age, daily intakes of DM were depressed and growth rates retarded when diets containing the R and W forms were fed. Moist one-year-old maize induced tocopherol deficiency symptoms, but the addition of 10 mg/kg α -tocopherol to diets based on moist (and dried) cereal between 2 and 5 months post harvesting did not affect performance.

51. DEVELOPMENT OF IMPROVED SOW NUTRITION AND REPRODUCTIVE PERFORMANCE IN COMMERCIAL UNITS

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A long-term development project involving approximately 2500 sows and progeny on 12 commercial pig units was started in 1972. Biological and economic performance is monitored and the application of improved management practices is being evaluated. Experimental evidence indicates that for satisfactory reproductive performance sows should gain 12 to 15 kg live weight between each of the first three or four parities. The adjustment of feeding to obtain such a pattern of gain is a major problem on farms. The first stage of this project has therefore been particularly concerned with body-weight changes of sows and their reproductive performance, and also the effect of management practices on efficiency of breeding units. Gilts are weighed at first service and sows at each weaning. Feed allowances during gestation and lactation are check-weighed every three weeks, and diets are analysed quarterly or whenever the formulation is changed. Producers receive regular information on live weight changes of individual sows, together with recommended changes in feeding levels and composition. The majority of sows are now in the second recorded reproductive cycle. Adoption of recommended feeding levels appears to be associated with reduced variation in sow-weight changes, and potential saving in feed costs.