DROUGHT FEEDING STUDIES WITH CATTLE

7. THE USE OF SORGHUM GRAIN AS A DROUGHT FODDER FOR CATTLE IN LATE PREGNANCY AND EARLY LACTATION

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SUMMARY

Twenty-eight pregnant Hereford heifers, whose mean stage of gestation was 171 ± 1·2 days, were removed from pasture, allotted to two groups of nine and one group of 10 animals, and confined in bare yards. A group of six non-pregnant heifers was also included in the experiment. The animals were changed to an all-grain ration during a period of two weeks. Thereafter, all groups received crushed sorghum grain, supplemented with 1 per cent. ground limestone. One pregnant group received 6 lb per head per day fed daily (Group I), another was fed twice-weekly at the same rate (Group II) and the other was fed daily at the rate of 10 lb per head per day (Group III). The group of non-pregnant after 24 weeks of grain feeding, when the mean stage of lactation of animals suckling calves was 70 days.

There was little evidence of digestive disturbances due to all-grain feeding. From the commencement of all-grain feeding, the mean weight loss prior to calving was 54 and 70 lb in Groups I and II respectively, compared with a weight gain of 85 lb in Group III heifers during this period. After 24 weeks the average body-weight loss for those animals suckling calves at the conclusion of the experiment was 228, 257 and 87 lb for Groups I, II and III respectively. During the same period the heifers in the non-pregnant Group IV lost an average of 68 lb.

The average birth weight of calves was 57, 55 and 68 lb for Groups I, II and III respectively. There were no deaths in calves after birth. The average weight gain in calves during the first 28 days after birth, when they had access only to their dams' milk, was 17·5, 13·7 and 32·6 lb for Groups I, II and III respectively.

The overall incidence of dystokia, still-births and retained placenta was 15·4, 15·4 and 7·7 per cent. respectively.

Mean 24-hr milk production at the conclusion of the experiment, based on a 4-hr hand-milking interval, was 1500, 1455 and 3502 g for Groups I, II and III respectively.

On the basis of body-weight changes in heifers both prior to calving and throughout the whole experimental period, milk production of heifers, weight of calves at birth and growth of calves to 28 days, the performance of Group III was significantly better than that of Groups I and II. There were no significant differences between Groups I and II.

Blood samples were obtained from all heifers when they were transferred from pasture to the experimental yards, at the beginning of all-grain feeding, and during the twelfth and twenty-fourth weeks of all-grain feeding. Determinations were made for haemoglobin,

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packed cell volume, blood inorganic phosphorus; serum calcium, magnesium, total protein, albumin and globulin; plasma chloride, sodium and potassium. Additional blood samples were obtained from animals in Group IV to determine plasma non-esterified fatty acids at 4-weekly intervals. Some of these determinations were made on blood from the calves when their mean ages were 6 and 10 weeks. There were significant differences within and between groups at different sampling periods in some of the constituents analysed but the levels found did not indicate a pathological condition at any stage.

The initial mean liver vitamin A reserves in all heifers were adequate (298 μg/g). They decreased after 24 weeks on grain containing virtually no carotene, but even in the lactating animals were still considered adequate after this period (mean 150 μg/g). No vitamin A reserves were detectable in the still-born calves.

The heifers gained weight rapidly when returned to pasture at the conclusion of all-grain feeding.

I. INTRODUCTION

The use of restricted rations of sorghum grain as a drought fodder for non-pregnant heifers has been reported in previous papers in this series (Morris 1958; Ryley, Gartner, and Morris 1960). The results showed that this class of animal, with an initial body-weight of approximately 550 lb, could be fed for survival for periods of at least 26 weeks on all-grain rations at the rate of 3 lb per head per day. Although body-weight loss was marked, mortality was low, and gain in weight after the period of feed restriction was rapid. Intermittent feeding of such rations appeared satisfactory.

The aim of the experiment to be reported in this paper was to study the feeding for survival of cattle during late pregnancy and early lactation with restricted rations of crushed sorghum grain. Data were obtained on changes in body-weight, mortality, rate of feed consumption, milk production, incidence of dystokia, retained placenta and oestrus in the heifers, and on birth weight, mortality and growth rate of their calves. Determinations were made on samples from heifers and calves for haemoglobin, packed cell volume, blood inorganic phosphate; serum calcium, magnesium, total protein, albumin and globulin; and plasma chloride, sodium and potassium. Data were obtained on changes in liver vitamin A concentrations in the heifers. A group of non-pregnant heifers, fed restricted amounts of sorghum grain, was also included for comparative purposes. In addition to the abovementioned determinations, plasma non-esterified fatty acid levels were recorded in animals from this group.

II. MATERIALS AND METHODS

(i) *Experimental Yards and Facilities.*—The experiment was conducted in the yards described by Ryley, Gartner, and Morris (1960). Two modifications were made. Separate drinking facilities were provided in each yard from the tenth week of grain feeding to permit the collection of data on water consumption on a group basis. Covered creeps, measuring 8 ft square, were erected in each yard.

(ii) *Experimental Animals.*—Thirty-four dehorned, maiden Hereford heifers, approximately 34 months of age, were selected for mating. These animals had been used previously in studies on feeding of restricted sorghum grain to maiden heifers (Ryley, Gartner, and Morris 1960). Subsequently they had been grazing predominantly *Paspalum dilatatum* pastures at the Animal Husbandry Research Farm, Rocklea, for 10 months. All animals were negative to the single intradermal test for tuberculosis and to the serological tests for brucellosis and *Leptospira pomona*.

The heifers were mated to a Hereford bull during a period of 21 days from November 2 to November 23, 1959. The animals remained on the paspalum pasture until May 3, 1960, when the yard-feeding portion of the experiment commenced. Pregnancy was determined by rectal examination one week before the experimental rations were fed. Twenty-eight animals were found to be pregnant.

The mean stage of gestation at the commencement of yard feeding was 171 $\pm$ 1·2 days (range 162–183 days). The mean body-weight gain of all animals from mating to the commencement of yard feeding was 129 $\pm$ 5 lb (range 70–186 lb). The animals were in fair condition.

To avoid confusion, the term "heifers" will be used throughout this paper for the adult females during pregnancy and post-partum.

(iii) *Sorghum Grain.*—A single consignment of *Sorghum vulgare* L. grain (Alpha variety) was purchased prior to the commencement of the experiment and stored in bags in a closed shed during the experimental period. It was crushed in two portions, each of approximately 10 tons. The first portion was crushed immediately prior to the commencement of the experiment and the second portion when the first portion had been almost consumed.

(iv) *Water.*—The source of water for the cattle was the Brisbane City supply.

(v) *Sampling and Analysis of Grain.*—Samples of grain were collected at the rate of 1 lb per 200 lb fed. These samples were retained in a closed tin and at the conclusion of the experiment were mixed and subsampled for proximate analysis by the methods described by the Association of Official Agricultural Chemists (1955). After each crushing, samples were obtained with a seed trier for determination of grain particle size. Samples from three sites in each bag were taken from a random selection of approximately one-fifth of the bags. A Greeburn laboratory sieve was used to determine grain particle size.

(vi) *Determination of Water Consumption.*—Measurements of group water consumption were made daily with calibrated measuring sticks to an accuracy of $\pm$ 0·5 gal; no allowance was made for evaporation. The water containers were topped daily, which ensured that water was available *ad lib.* at all times. The containers were completely emptied and cleaned at least twice per week to prevent excessive fouling.

(vii) *Body-weight*.—The heifers and calves older than 7 days were individually weighed on a cattle-weighing scale calibrated in 2-lb divisions. The birth weights and 7-day body-weights of the calves were obtained on a scale calibrated in 2-oz divisions.

(viii) *Determination of Milk Production*.—All heifers were segregated from their calves and hand-milked on the last day of all-grain feeding. They were milked again, in the same order, 4 hr later, and again 24 hr after the second milking. An intravenous injection of 10 I.U. of oxytocin in 10 ml of physiological saline was given to each heifer during milking. The time of commencement and completion of each milking was recorded for each animal and the mean used to calculate 24-hr milk yield on the basis of both 4-hr and 24-hr milking interval. The weight of milk was obtained on a physical balance with an accuracy of $\pm$ 1 g.

(ix) *Methods of Chemical Analysis*.—Analytical methods employed were as follows:—haemoglobin, Donaldson *et al.* 1951; packed cell volume (P.C.V.), using heparinized blood and a relative centrifugal force of approximately 2067 *g*, Wintrobe 1947; blood inorganic phosphate, Moir 1954; blood glucose, Mendel, Kemp, and Myers 1954; serum calcium by a modification of the method of Clark and Collip (1925); serum magesnium by a modification of the method of Holzapfel (1934); serum total protein, albumin and globulin, Gornall, Bardawill, and David 1949; plasma chloride, sodium and potassium as described by Morris (1958); plasma non-esterified fatty acids, Annison 1960. In the determination of blood glucose the blood was added to the trichloracetic acid immediately after the sample was drawn. After centrifuging, an aliquot was either analysed within 6 hr or stored in a deep freeze until analysed. Samples of liver were obtained from the heifers by the aspiration biopsy technique of Loosemore and Allcroft (1951), using the instruments described by Dick (1952), and the vitamin A concentration determined as described by Ryley, Gartner, and Morris (1960). Milk fat was determined by the Babcock method (Burgess 1936). Solids-not-fat was obtained using the density bead method of Golding (1959).

(x) *Observations on Oestrus*.—After the lactating heifers were turned out on paspalum pasture at the conclusion of grain feeding, they were yarded at 7 a.m. and 3 p.m. daily in the presence of a vasectomized bull and observed for a $\frac{1}{2}$-hr period on each occasion. Successful service by the vasectomized bull was recorded as oestrus.

III. EXPERIMENTAL

(i) *Design*.—The 28 pregnant heifers were allotted to two groups of 9 and one group of 10 animals on the basis of mating date and body-weight. The groups were then allocated at random to their treatments. The six non-pregnant animals were also included in the experiment as a fourth group.

The animals were removed from pasture, transferred to yards in their respective groups, and changed to an all-grain ration over a period of two weeks according to the following schedule:—

Days	Daily Ration (lb/head/day)	
	Crushed Sorghum Grain	Lucerne Chaff
1– 3	4·0	8·0
4– 6	5·0	6·0
7– 9	5·0	4·0
10–12	5·5	2·5
13–14	6·0	1·0

At the conclusion of this period, the groups were fed their experimental rations. The groups and experimental treatments were as follows:—

Group	Class of Animal	*Crushed Sorghum Grain (lb/head/day)	Frequency of Feeding
I	Pregnant ..	6	Daily
II	Pregnant ..	6	Twice-weekly
III	Pregnant ..	10	Daily
IV	Non-pregnant	6	Daily

* To the sorghum grain was added 1 per cent. ground limestone.

The feed was distributed evenly along the 28 ft of troughing at each feeding. Animals were fed between 9 a.m. and 10 a.m. Group II received 18 lb per head each Tuesday morning and 24 lb per head each Friday morning.

Heifers were removed from the experiment if their calves were born dead or died during the period of yard feeding. This ensured that animals in Groups I, II and III were either pregnant or suckling their calves.

In the statistical treatment of the data, allowance has been made for removal of animals by adjusting the means to include initial blocking on the basis of mating date and body-weight.

All calves were allowed unrestricted access to a creep feed of crushed sorghum grain with 1 per cent. added limestone, after the youngest calf reached 4 weeks of age. This time interval enabled body-weight data to be obtained on unsupplemented suckling calves from birth to 4 weeks of age.

(ii) *Recordings and Observations.*—Individual body-weights of the heifers were obtained weekly by weighing prefeeding at a standard time (8.30 a.m.–9.00 a.m.) on Tuesday mornings. As the calving period approached, all pregnant animals were weighed three times weekly and again on the morning after calving. This allowed the precalving body-weight to be obtained 0–72 hr prior to parturition and the post-calving weight to be taken 0–24 hr after parturition.

Calves born in the morning were weighed in the afternoon and those born during the afternoon were weighed between 7.00 a.m. and 7.30 a.m. on the next day. The birth weight of calves was thus obtained between 6 and 16 hr after birth. All live calves had dry coats at the time of weighing, and excess moisture was removed from the coats of still-born calves. Calves were weighed at the same time 7 days later, but thereafter were weighed on the standard weekly weighing days. Linear interpolation between the weights recorded on the weekly weighing immediately prior to and after 28 days of age was used to calculate weights at 28 days of age.

On the day the animals were transferred from pasture to the experimental yards (from pasture), at the beginning of all-grain feeding (initial grain), at the beginning of the twelfth week of all-grain feeding (after 11 weeks, prior to calving) and at the beginning of the twenty-fourth week of all-grain feeding (final grain) all experimental animals were bled for the determination of haemoglobin, P.C.V., blood inorganic phosphorus; serum calcium, magnesium, total protein, albumin and globulin; plasma chloride, sodium and potassium. Additional blood samples were obtained immediately before feeding from five animals in Group IV to enable the determination of plasma non-esterified fatty acids (NEFA) on the day animals were transferred from pasture, at the beginning of the all-grain feeding and thereafter at 4-week intervals. Liver biopsy samples for vitamin A analyses were obtained on the day that animals were transferred from pasture and at the beginning of the twenty-fourth week of all-grain feeding. Liver samples for vitamin A analyses were also obtained from heifers that either died following parturition or gave birth to still-born calves.

Liver vitamin A reserves were determined in still-born calves. All calves were bled after their dams had been on all-grain feeding for 20 weeks (initial) and 24 weeks (final). Samples were analysed for haemolglobin, P.C.V., blood glucose and inorganic phosphate; serum calcium, magnesium, total protein, albumin and globulin. The mean age of calves was 6 and 10 weeks at these two periods.

Observations were made on the animals during five days each week to obtain data on rate of grain consumption and on animal behaviour. Heifers were observed during calving wherever possible; animals showing manifest difficulty at calving were assisted and have been recorded as dystokias. Those retaining their placenta for longer than 72 hr were recorded and treated.

(iii) *Duration of the Experiment.*—Animals were transferred to yards on May 3, 1960. The change-over from pasture to the all-grain ration occupied two weeks and all-grain feeding continued for a period of 24 weeks. After the determination of milk yield, the heifers were turned out to graze predominantly *Paspalum dilatatum* pastures. At this time the calves were weaned and kept in the yards for studies on early weaning. Body-weights of the heifers were recorded for a further 11 weeks. For the first six weeks of this period, data on oestrus were obtained by test mating.

IV. RESULTS

(a) Analysis of Grain

The proximate analysis of the grain expressed in percentages was as follows:—

Moisture	Crude Protein	Ether Extract	Crude Fibre	N.F.E.	Ash	Ca	P
10·9	9·6	3·0	1·8	73·6	1·1	0·04	0·23

Eighty-nine per cent. of the grain particles were between 0·24 and 0·10 cm in diameter.

(b) Grain and Water Consumption

In Group I, the grain was consumed rapidly at each feeding, the mean time for consumption of the daily ration being 14·1 min. The mean consumption time for Group IV, the non-pregnant group fed on the same regimen as Group I, was 11·4 min.

For the first three weeks of all-grain feeding, the rate of feed consumption by animals in Group III was variable. Times of consumption for the first, second and third days were 25, 32 and 38 min respectively. For the next 15 days there were always some residues. These residues were not removed when the next day's ration was added. On the nineteenth day there was a small residue at 5 p.m.; this was eaten by the following morning. On the twentieth day the feed was eaten in 7–8 hr and on the twenty-first day in 3·7 hr. Thereafter the ration was consumed rapidly, the mean daily consumption time for the next 21 weeks being 23·1 min. The rate of grain consumption for Groups I and IV and for Group III, after the first three weeks, was similar, being approximately 1 lb per 2 min.

The rate of consumption in the twice-weekly fed group (Group II) was variable throughout the experiment. The 18 lb of grain per head was always consumed within 24 hr. The shortest time taken was 1·2 hr and on four occasions more than 8 hr was required. Except on two occasions, the 24 lb of grain per head was eaten within 24 hr. The shortest time taken was 1·7 hr and on 11 occasions the feed was not consumed in 8 hr.

The mean daily water consumption per head in gallons for the last 15 weeks of the experiment was as follows:—Group I, 3·7; Group II, 3·5; Group III, 4·2; and Group IV, 3·8.

(c) Survival of Heifers

One heifer was removed from Group I on the first day of grain feeding, when she aborted after a pregnancy of 183 days. The cause of the abortion could not be determined. Bacteriological examination of the foetus was negative for *Brucella abortus, Leptospira pomona, L. hyos, Vibrio fetus* and *Trichomonas foetus*. Another heifer from Group I died during the thirteenth week of all-grain feeding, five days after calving. During the grain-feeding period, this heifer had lost

100 lb in body-weight prior to calving, compared with the mean body-weight loss of 54 lb for this group. She had been tardy in approaching the trough at feeding and did not always remain at the trough until all feed had been consumed. This heifer retained the placenta, which was manually removed three days after calving. At autopsy the animal was in poor condition and the rumen contents were very fluid, greyish in colour and contained particles of stones and soil. The abomasum contained one hairball measuring 10 cm x 7 cm. There was a purulent metritis.

One heifer was removed from Group II during the tenth week of all-grain feeding after she became prostrate. She gave birth, with assistance, to premature twin bull calves three days subsequent to being withdrawn from the experiment. The gestation period was 253 days. Neither calf was able to stand. The heifer died on the day after calving.

In the post-calving period, one heifer from Group III was accidentally injured and was removed together with her calf. She was in strong condition at the time of the accident. Two heifers were also removed from each of Groups I and III after they had stillborn calves. All other heifers were reasonably strong at the completion of all-grain feeding.

(d) Body-weight of Heifers

The number of heifers calving at term, their mean initial body-weight, their body-weight loss prior to calving, and the mean period of all-grain feeding prior to calving, are shown in Table 1. The body-weight loss during the change from pasture to all-grain feeding was comparable in all groups and can be accounted for largely by loss in gastro-intestinal fill. From the commencement of all-grain feeding Groups I and II lost weight during the precalving period, while Group III gained weight. Much of the weight gain in Group III can be accounted for by the weight increase of the developing fœtus, fœtal fluids and membranes. The weight change prior to calving in Group III was significantly different from that of Groups I and II ($P < 0 \cdot 001$). There was no significant difference in weight change prior to calving between Groups I and II.

TABLE 1

Mean Period of Restricted Grain Feeding of Heifers Calving at Term and Group Mean Body-weight Changes Prior to Calving

Group	No. of Heifers Calving at Term	Mean Period on Grain Feeding Prior to Calving (days)	Mean Body-weight (lb)		
			From Pasture	Initial Grain	Change Initial Grain to Precalving
I	8	100 ± 3	918	814 ± 19	-54 ± 16
II	8	96 ± 3	945	848 ± 20	-70 ± 16
III	10	99 ± 3	942	827 ± 17	$+85 \pm 14$

The mean weight losses in heifers at calving, as determined by weighing within 72 hr of calving and within 24 hr after parturiton, were: Group I, 90 ± 13 lb; Group II, 95 ± 11 lb; and Group III, 131 ± 10 lb. Group III lost significantly more weight at calving than Groups I and II ($P < 0 \cdot 05$). The weight loss at calving expressed as a percentage of weight before calving was 11·7, 12·2, and 14·4 per cent. for Groups I, II and III respectively. The birth weight of the calf accounted for 63·3, 57·9 and 51·9 per cent. of this weight loss in Groups I, II and III respectively. Loss of weight at calving was significantly correlated ($r = + 0 \cdot 75$) with calf weight. The regression coefficient of loss of dam's body-weight on calf weight was $+ 3 \cdot 41 \pm 0 \cdot 90$ lb per lb.

The numbers of heifers lactating at the end of all-grain feeding, their mean body-weight at the commencement of all-grain feeding, within 24 hr after parturition and at the end of all-grain feeding, and their body-weight gain after 11 weeks' recovery on paspalum pasture are shown in Table 2. The reduced numbers of heifers at this period in relation to the number of heifers calving at term is due to animals being removed when they no longer fulfilled the conditions of the experiment.

TABLE 2

Group Mean Body-weight Changes During All-grain Feeding and After 11 Weeks' Recovery on Paspalum Pastures of Heifers Lactating at the End of All-grain Feeding

Group	No. of Lactating Heifers	Group Mean Body-weight (lb)			
		Initial Grain	Post-Calving	Final Grain	Gain During 11 Weeks' Recovery
I	5	808 ± 27	641 ± 40	580 ± 39	266 ± 19
II	8	848 ± 20	684 ± 30	591 ± 30	276 ± 13
III	7	831 ± 23	786 ± 34	744 ± 34	194 ± 18

During lactation there was no significant difference among groups in the body-weight loss recorded. During the whole all-grain feeding period heifers in Group III lost significantly less weight than those in Group I ($P<0 \cdot 05$) and Group II ($P<0 \cdot 01$).

The mean body-weight loss in the non-pregnant heifers (Group IV) for the 24 weeks of all-grain feeding was 68 ± 48 lb. The body-weight of these heifers at the commencement of all-grain feeding was 800 ± 29 lb.

During the 11 weeks' recovery period on pasture, Group III animals gained less weight than those in Group I ($P<0 \cdot 05$) and Group II ($P<0 \cdot 01$). The mean body-weight gain of heifers in Group IV during this period was 228 ± 33 lb.

(e) Calving Data

The mean gestation period, incidence of dystokia, and retained placenta in the heifers calving at term, together with the number of still-born calves, sex ratio and mean birth weight of the calves, are shown in Table 3. There were no significant differences between groups in the gestation period, numbers of dystokia or incidence of retained placenta. The overall incidence of dystokia and retained placenta was 15·4 and 7·7 per cent. respectively. Two of the four still-births were associated with dystokias, and autopsy of the other still-born calves showed subcutaneous oedema of the head and neck region, which was considered to be due to prolonged parturition. One of the still-born calves from Group I weighed 89·3 lb and the two still-born calves from Group III weighed 77·4 and 68·3 lb respectively. Two of the dystokias were due to mal-presentation of the calf.

TABLE 3

GESTATION PERIOD AND INCIDENCE OF DYSTOKIA AND RETAINED PLACENTA IN HEIFERS FED RESTRICTED AMOUNTS OF SORGHUM GRAIN AND NUMBER OF STILL-BIRTHS, MEAN BIRTH WEIGHT AND SEX RATIO OF THEIR CALVES

Group	No. of Heifers Calving at Term	Gestation Period (days)	Dystokia	Retained Placenta	Still-births	Mean Birth Weight of Calves (lb)	Sex Ratio Male : Female
I	8	283 ± 2	1	1	2	57 ± 3	4 : 4
II	8	280 ± 2	1	0	0	55 ± 2	5 : 3
III	10	284 ± 2	2	1	2*	68 ± 2	6 : 4

* One calf classified for the purpose of this table as still-born was associated with a dystokia, did not rise after birth and died within 5 hr.

The calves from Group III had significantly higher birth weights than those from Groups I and II ($P<0 \cdot 01$). Male calves in all groups were on the average $4 \cdot 0 \pm 3 \cdot 2$ lb heavier than females, but this difference was not significant.

(f) Mortality and Growth Rate of Calves

There were no deaths in calves after birth, with the exception of the calf that died within five hours of birth, and which for the purpose of the paper has been classified as still-born. One calf was removed from Group I at five days of age when its dam died. Another calf was removed from Group III at 44 days of age, when its dam was accidentally injured.

The weight gains of calves from birth to 7 days and to 28 days of age are shown in Table 4. All calves had access to their dams' milk, but due to the height of the troughs were unable to obtain any of the grain available to their dams. Calves in Group III gained significantly more weight to 7 days and to 28 days than calves from Group II ($P<0 \cdot 05$). No other differences were significant. Male calves gained more weight than females to 7 days ($1 \cdot 0 \pm 1 \cdot 8$ lb) and to 28 days ($3 \cdot 8 \pm 5 \cdot 5$ lb) but these differences were not significant. There was a significant ($P<0 \cdot 05$) tendency ($r = -0 \cdot 52$, $b = 1 \cdot 02 \pm 0 \cdot 45$) for later born calves to gain less weight to 28 days.

TABLE 4

MEAN BODY-WEIGHT GAIN FROM BIRTH TO 7 DAYS AND TO 28 DAYS OF CALVES SUCKLING HEIFERS FED RESTRICTED GRAIN

Group	No. of Calves	Body-weight Gain (lb)	
		Birth to 7 days	Birth to 28 days
I	5	4·1 ± 1·8	17·5 ± 5·6
II	8	3·1 ± 1·4	13·7 ± 4·3
III	8	9·9 ± 1·4	32·6 ± 4·3

(g) Milk Production

The mean stage of lactation and the mean 24-hr milk production together with fat and solids-not-fat percentage of the milk obtained at the completion of the all-grain feeding period are given in Table 5. The 24-hr milk productions are calculated on the basis of both a 4-hr and a 24-hr milking interval.

TABLE 5

STAGE OF LACTATION, 24-HR MILK PRODUCTION, FAT AND SOLIDS-NOT-FAT PERCENTAGE OF MILK AT THE END OF RESTRICTED ALL-GRAIN FEEDING

Group	No. of Animals	Mean Stage of Lactation (days)	24-hr Milk Production (g)		Fat* (%)	Solids-not-fat* (%)
			Based on 4-hr Milking Interval	Based on 24-hr Milking Interval		
I	5	70 ± 2	1500 ± 458	1074 ± 356	5·22 ± 0·63	8·27 ± 0·15
II	8	72 ± 1	1455 ± 336	949 ± 261	3·37 ± 0·50	8·41 ± 0·12
III	7	68 ± 2	3502 ± 347	2181 ± 269	4·21 ± 0·53	8·30 ± 0·13

* The fat and solids-not-fat percentages were determined on samples obtained at the 24-hr milking interval.

The 24-hr milk production, based on both the 4-hr and 24-hr milking intervals, was significantly higher for heifers in Group III than for heifers in Groups I and II ($P<0\cdot05$).

Although the milk yields based on a 4-hr milking interval were much higher than those obtained from a 24-hr milking interval, the two yields were significantly correlated ($r = +0\cdot86$).

There were no significant differences among groups in either the fat or solids-not-fat percentage of the milk obtained.

(h) Blood, Serum and Liver Vitamin A Analyses of Heifers

Biochemical data for analyses of blood, serum and liver vitamin A from heifers in Groups I, II and III are recorded as group means in Table 6 together with standard errors of means and significant differences within groups. Differences between these groups are shown in Table 7.

There was a tendency in all groups for the mean haemoglobin and P.C.V. levels at the initial grain sampling to be elevated above values at the "from pasture" sampling. The haemoglobin approached the "from pasture" levels again prior to calving, then fell at the final determination. In general, the haemoglobin and P.C.V. values from animals in Group III were less variable and were higher throughout the experiment than the levels found in Groups I and II.

There were significant differences within and between groups at different sampling periods in most of the constituents analysed. However, the levels found did not indicate a pathological change at any stage. Animals in Group III had higher concentrations of some constituents than animals in either Groups I or II.

TABLE 6

GROUP MEANS, STANDARD ERRORS OF MEANS AND SIGNIFICANT DIFFERENCES WITHIN GROUPS IN SOME CONSTITUENTS OF BLOOD AND SERUM AND IN LIVER VITAMIN A OF HEIFERS FED CRUSHED SORGHUM GRAIN IN LATE PREGNANCY AND EARLY LACTATION

Group	I				II				III			
Period	From Pasture	Initial Grain	Prior to Calving	Final Grain [a]	From Pasture	Initial Grain	Prior to Calving	Final Grain	From Pasture	Initial Grain	Prior to Calving	Final Grain
Determination :												
Blood haemoglobin (g/100 ml) ..	13·4	14·3	13·7 ± 0·4	10·3 ± 0·7‡	12·9	14·1*	13·0 ± 0·4†	11·0 ± 0·6‡	14·1	15·0*	14·8 ± 0·4	13·1 ± 0·6†
P.C.V. (%)	40·5	43·7†	35·8 ± 1·0‡	30·2 ± 2·0‡	40.0	41.7	35·0 ± 1·0†	32·4 ± 1·6‡	42·7	45·0†	39·0 ± 0·9‡	37·3 ± 1·7‡
Blood inorganic P (mg/100 ml) ..	3·9	7·3‡	5·2 ± 0·3‡	6·1 ± 0·5	4·3	7·2‡	4·6 ± 0·3‡	5·8 ± 0·4*	4·1	7·4‡	4·7 ± 0·3‡	5·8 ± 0·4*
Serum Ca (mg/100 ml)	10·6	9·7*	9·3 ± 0·2	9·1 ± 0·2*	10·7	9·9*	9·5 ± 0·2	9·7 ± 0·1	10·4	9·6†	9·7 ± 0·2	9·9 ± 0·2
Serum Mg (mg/100 ml)	2·6	3·0‡	2·7 ± 0·1†	2·4 ± 0.1‡	2·7	3·0†	2·6 ± 0·1‡	2·5 ± 0·1‡	2·6	2·9‡	2·7 ± 0·1†	2·9 ± 0·1
Total serum protein (g/100 ml) ..	7·0	7·5†	6·9 ± 0·2†	6·8 ± 0·3*	7·2	7·4	6·6 ± 0·2‡	7·0 ± 0·2	7·0	7·4*	7·1 ± 0·2	7·2 ± 0·2
Serum albumin (g/100 ml) ..	3·2	3·5†	3·4 ± 0·1	3·4 ± 0·1	3·1	3·5‡	3·1 ± 0·1†	3·2 ± 0·1*	3·3	3·6†	3·5 ± 0·1	3·5 ± 0·1
Serum globulin (g/100 ml) ..	3·8	4·0	3·5 ± 0·2†	3·4 ± 0·3*	4·1	3·9	3·4 ± 0·2‡	3·8 ± 0·2	3·7	3·8	3·6 ± 0·2	3·7 ± 0·3
Plasma Cl (m–equiv./l.)	106·5	101·2‡	104·5 ± 1·3*	107·8 ± 2·0*	105·8	102·5†	103·8 ± 1·3	108·8 ± 1·5†	104.2	103·6	107·8 ± 0·5†	108·3 ± 1·7*
Plasma Na (m–equiv./l.) ..	131·6	137·8†	136·8 ± 0·9	139·9 ± 2·0	132·6	137·7†	134·3 ± 0·9*	136·4 ± 1·5	132·3	139·4‡	137·4 ± 0·8	139·4 ± 1·7
Plasma K (m–equiv./l.)	4·8	4·4†	4·5 ± 0·1	4·4 ± 0·1	4·8	4·4†	4·7 ± 0·07†	4·0 ± 0·1†	4·7	4·5*	4·4 ± 0·1	4·7 ± 0·1
Liver vitamin A (μg/g)	307 *b*			145 *c* ± 42‡	260			139 ± 33‡	318			164 *c* ± 35‡
Number of animals	8	8	8	5	8	8	8	8	10	10	10	7

a Final grain means have been adjusted to permit comparison with initial grain means.
b Based on same number of animals as for final grain.
c Tested against values from pasture.
* Significant at 5% probability level.
† Significant at 1% probability level.
‡ Significant at 0·1% probability level.

Changes tested for significance.
From pasture to initial grain noted in latter column.
Initial grain to prior to calving noted in latter column.
Initial grain to final grain noted in latter column.

TABLE 7

Significant Differences Between Groups in Blood, Serum and Liver Vitamin A Analyses of Heifers Fed Crushed Sorghum Grain in Late Pregnancy and Early Lactation

Determination	Significant Differences Between Groups				
	Initial Grain	Prior to Calving	Final Grain	Change Pasture to Initial Grain	Change Initial to Final Grain
Blood haemoglobin ..		III>II†			I>III*
P.C.V.		III>II† III> I*			
Serum Ca					I>III†
Serum Mg			III > II† III > I*		I, II > III†
Serum albumin		III > II*	III > II*		
Plasma Cl	III > I†			I > III†	II > III†
Plasma Na		III > II*			
Plasma K		II > III†	III > II‡ III > I*		

* Significant at 5% probability level.
† Significant at 1% probability level.
‡ Significant at 0·1% probability level.

TABLE 8

Group Means, Standard Errors of Means and Significant Differences in Some Constituents of Blood and Serum and in Liver Vitamin A of Non-pregnant Heifers Fed 6 lb Crushed Sorghum Grain per Head per Day

Period	From Pasture	Initial Grain	After 11 Weeks on Grain	Final Grain
Blood haemoglogbin (g/100 ml) ..	13·8	15·0	15·6 ± 2·1	13·5 ± 2·3
P.C.V. (%)	42·8	46·2	44·7 ± 7·1	38·1 ± 6·0
Blood inorganic P (mg/100 ml) ..	3·8	6·6*	4·7 ± 0·6	5·5 ± 1·3
Serum Ca (mg/100 ml)	10·9	9·1*	9·6 ± 1·1	9·0 ± 0·6
Serum Mg (mg/100 ml)	2·7	2·8	2·6 ± 0·4	2·7 ± 0·3
Total serum protein (g/100 ml) ..	7·3	7·7	6·8 ± 0·5	7·3 ± 0·5
Serum albumin (g/100 ml)	3·4	3·5	3·3 ± 0·3	3·4 ± 0·3
Serum globulin (g/100 ml)	3·9	4·2	3·5 ± 0·3*	3·9 ± 0·3
Plasma Cl (m-equiv./l.)	103·8	101·7	102·8 ± 2·8	107·1 ± 2·3
Plasma Na (m-equiv./l.)	130·1	136·4	133·5 ± 3·9	135·7 ± 3·4
Plasma K (m-equiv./l.)	5·0	4·6	4·1 ± 0·3	4·3 ± 0·4
Liver vitamin A (μg/g)	304			215† ± 115*

* Significant at 5% probability level.
† Tested against values from pasture.

Changes tested for significance
From pasture to initial grain noted in latter column.
Initial grain to after 11 weeks on grain noted in latter column.
Initial grain to final grain noted in latter column.

Data on blood and serum constituents and on liver vitamin A of heifers from Group IV are recorded as group means in Table 8 together with standard errors of means and significant differences. These animals also showed elevated levels for haemoglobin and P.C.V. at the initial grain, and after 11 weeks on grain, sampling periods. The final grain mean haemoglobin level was comparable to the initial pasture mean. This group of non-pregnant heifers showed smaller changes in the constituents analysed at different sampling periods in comparison with those shown by the pregnant and lactating groups. In general, the final grain levels were comparable with levels in animals on a higher plane of nutrition in Group III and were higher than those of animals in Groups I and II on an equivalent plane of nutrition.

The mean liver vitamin A levels decreased in all animals, but after 24 weeks on grain containing virtually no carotene all levels were adequate.

Mean levels for NEFA in plasma determined at monthly intervals in five animals from Group IV were as follows:—

Date	Mean NEFA (m-equiv./l.)
3.v.60 (From Pasture)	·19
16.v.60 (Initial Grain)	·32
15.vi.60	·45
13.vii.60	·50
10.viii.60	·42
7.ix.60	·55
5.x.60	·40
26.x.60 (Final Grain)	·60

The range in individual determinations was 0·13–0·97 m-equiv./1.

(i) Blood, Serum and Liver Vitamin A Analyses of Calves

The liver vitamin A reserves of four still-born calves were < 1 μg/g. The concentration of vitamin A in the livers of their dams at parturition ranged from 103 to 240 μg/g.

Biochemical data on blood and serum constituents and on liver vitamin A of calves from Groups I, II and III are recorded as group means in Table 9 together with standard errors of means and significant differences within groups.

Calves from Group III had significantly higher initial glucose levels than calves from either Groups I or II ($P<0\cdot01$) and the mean final levels in Groups I and III were significantly greater than in Group II ($P<0\cdot05$). The initial magnesium level in calves from Group II was significantly greater ($P<0\cdot05$) than that in either Groups I or III. Compared with the values for their dams, the total serum protein levels were lower in the calves at all periods. This was due to a decreased globulin level.

TABLE 9

GROUP MEANS, STANDARD ERRORS OF MEANS AND SIGNIFICANT DIFFERENCES WITHIN GROUPS FOR CONSTITUENTS IN BLOOD OF CALVES

Group	I		II		III	
Period	Initial	Final	Initial	Final	Initial	Final
Determination :						
Blood haemoglobin (g/100 ml) ..	14·7 ± 0·9	13·5 ± 0·9	15·4 ± 0·7	13·0 ± 0·7‡	16·3 ± 0·8	14·0 ± 0·8†
P.C.V. (%)	45·7 ± 1·9	43·0 ± 2·3	45·0 ± 1·5	40·2 ± 1·8‡	48·5 ± 1·6	46·5 ± 2·0
Blood glucose (mg/100 ml)	52·8 ± 4·4	55·8 ± 2·8	55·3 ± 3·5	45·6 ± 2·2†	71·3 ± 3·7	52·7 ± 2·4‡
Blood inorganic P (mg/100 ml) ..	5·7 ± 0·3	6·7 ± 0·3‡	5·3 ± 0·2	5·6 ± 0·3	6·1 ± 0·2	6·6 ± 0·2 *
Serum Ca (mg/100 ml)	10·7 ± 0·3	10·7 ± 0·3	11·2 ± 0·2	11·0 ± 0·2	11·6 ± 0·2	11·0 ± 0·2†
Serum Mg (mg/100 ml)	2·4 ± 0·07	2·7 ± 0·05‡	2·6 ± 0·06	2·7 ± 0·04	2·4 ± 0·06	2·7 ± 0·04‡
Total serum protein (g/100 ml) ..	6·0 ± 0·2	5·6 ± 0·1†	6·1 ± 0·2	5·5 ± 0·1‡	5·9 ± 0·2	5·7 ± 0·1
Serum albumin (g/100 ml)	3·5 ± 0·12	3·2 ± 0·12*	3·7 ± 0·10	3·1 ± 0·10‡	3·6 ± 0·10	3·4 ± 0·10
Serum globulin (g/100 ml)	2·5 ± 0·2	2·4 ± 0·2	2·4 ± 0·2	2·4 ± 0·1	2·4 ± 0·2	2·2 ± 0·10
Mean age of calves (days)	42	70	44	72	40	68
Number of calves	5		8§		7	

* Significantly lower or higher than inital value at 5% probability level.
† Significantly lower or higher than inital value at 1% probability level.
‡ Significantly lower or higher than inital value 0·1% probability level.
§ Except for final blood inorganic P (6).

(j) Animal Behaviour

One heifer in Group III had a markedly stilted gait in the hind limbs on the fourth day of all-grain feeding, while another in the same group showed similar though milder symptoms on the fifth day of all-grain feeding. The condition was diagnosed as laminitis. Both animals recovered quickly, but the heifer that had been markedly affected became lame in both hind limbs seven weeks later. Examination showed horizontal cracks at the horn skin junction in both hind feet. The lameness disappeared within three days, but the cracks in the hooves were still evident for some weeks.

The heifers were not observed ruminating after the first week of all-grain feeding.

Geophagia was common in all groups. Two animals from Group I and one from Group II showed discrete rounded areas of skin devoid of hair during the eighteenth week of the experiment. This was observed to be due to other animals in the group licking and chewing their coats. Skin scrapings obtained from the denuded areas were negative for fungi and ecto-parasites.

Calves were noted to suckle heifers other than their dams on some occasions during the experimental period. Heifers were frequently observed licking the urine of the calves during urination.

Although it was not possible, under the conditions of yard-feeding, to accurately determine oestrus, two heifers in Group IV were noted to exhibit visible evidence of oestrus regularly throughout grain-feeding.

All animals showed oestrus at least once during the 6 weeks' testing period after animals were returned to grazing on paspalum pasture. The percentages showing oestrus on two or more occasions during the 6 weeks were:—Group I, 40; Group II, 38; Group III, 86; Group IV, 60.

V. DISCUSSION

This experiment has demonstrated that an all-grain ration of crushed sorghum grain can be fed in amounts sufficient to meet the survival requirements of cattle during late pregnancy and early lactation. It was possible to change heifers in the last third of pregnancy from pasture to the all-grain ration of 6 lb per head per day in a period of two weeks without evidence of digestive disturbances. Although there was clinical evidence of a metabolic disturbance in some animals in the group subsequently changed in one day from 6 lb to 10 lb of crushed sorghum grain per head per day, this could probably be avoided in practice by a gradual increase in the daily ration.

Under field conditions the level of all-grain feeding would depend on a number of factors, such as condition of stock at the commencement of feeding, class of animals, economic status of the beef industry in relation to cost of production and price of grain, possible length of feeding based on past weather data and amount of feed either available or stored. In this experiment, it was considered that maximum data would be obtained by selection of constant, but widely different, levels of grain feeding. In practice, the level of feeding could be varied during the course of feeding, depending on the stage of pregnancy or lactation and on the condition of the animals.

As could be expected on nutritional grounds, the performance of the heifers and their calves was much better in the group receiving 10 lb per head per day than that of the groups fed at the rate of 6 lb per head per day. Animals fed at the rate of 10 lb per head per day gained weight in late pregnancy and gave birth to strong calves that grew at the rate of approximately 1·2 lb per day for the first 28 days after birth. During the first 68 days of lactation the heifers lost only 42 lb of body-weight per head and all remained strong throughout the period of all-grain feeding. Thus the performance of both heifers and calves at this rate of feeding is better than that required for survival. It is also apparent from the data obtained in this experiment that a level higher than 6 lb per head per day would be required to minimize losses of heifers and calves and to ensure satisfactory growth of the calves. This would certainly be true under drought conditions in the field, where it must be expected that animals would be in poorer condition than those used in this experiment before feeding is commenced.

The experiment provides further data on the feeding of non-pregnant heifers on all-sorghum grain rations. In an experiment described by Ryley, Gartner, and Morris (1960), maiden heifers with a mean body-weight of 457 lb at the commencement of all-grain feeding lost 23 per cent. of their initial body-weight during a period of 26 weeks' feeding of crushed sorghum grain fed daily at the rate of 3 lb per head per day. In the present experiment, carried out under similar conditions, the group of non-pregnant heifers with a mean initial body-weight of 800 lb lost 8·5 per cent. of the initial body-weight after a period of 24 weeks at the feeding rate of 6 lb per head per day. The latter animals also had higher levels of blood haemoglobin, P.C.V. and serum albumin at the end of the experiment.

Heifers from all groups gained weight rapidly when returned to pasture after the restricted all-grain feeding. Increase in gastro-intestinal fill accounted for some of the initial increase in weight in all groups, and the removal of the stress of lactation from the previously lactating groups no doubt assisted the recovery of these groups. Despite these complicating factors, the results are in agreement with those of Waters (1908), Winchester and Howe (1955), Morris (1958), and Ryley, Gartner, and Morris (1960) for younger cattle after periods of submaintenance feeding.

Ryley, Gartner, and Morris (1960), on the basis of general appearance of animals and on biochemical data, concluded that twice-weekly feeding of maiden heifers appeared better than daily feeding, when animals were fed at the rate of 3 lb of crushed sorghum grain per head per day. In the present experiment, there were no significant differences at the level of feeding used, 6 lb per head per day, between daily and twice-weekly feeding when results are assessed on body-weight changes and milk production of the heifers, and on birth weight and growth rate of calves. There were no marked differences in the general appearance of animals or in the biochemical data. It would appear that intermittent feeding of restricted amounts of an all-grain ration is possible with dry, pregnant, and lactating cattle. However, on the data available from the present experiment and the published findings of Southcott and McClymont (1960) and Ryley, Gartner, and Morris (1960) its value, in relation to animal performance, when compared with daily feeding of survival rations is still not well-defined.

The higher weight loss at calving in heifers receiving the higher level of feeding is in agreement with the finding of Eckles and Swett (1918), Joubert and Bonsma (1957) and Ryley (1961).

The significantly higher birth weights of calves born to the heifers in the group receiving 10 lb of grain per head per day in the last third of pregnancy compared with the birth weights of calves from heifers receiving 6 lb per head per day confirm the conclusion of Blaxter (1957) and the finding of Ryley (1961) that maternal nutrition during this period can influence birth weight. The mean birth weight of calves from the group of heifers receiving 10 lb of grain per head per day is comparable with that recorded by Alexander *et al.* (1960) in grazing Hereford first-calf heifers at "Brian Pastures" Pasture Research Station in the Burnett district of Queensland. This indicates that drought feeding at this level in late pregnancy and under these experimental conditions results in calves comparable at birth with those obtained in at least one of the beef cattle areas in Queensland.

The heifers receiving 10 lb of grain per head per day had a significantly higher milk production than those in the two groups receiving the lower level of grain feeding. The finding is consistent with the better growth rate for the first 28 days in calves suckling heifers from the group receiving the higher level of grain.

The higher 24-hr milk yield based on a 4-hr milking interval than that obtained with a 24-hr interval would indicate that there was a reduction in the rate of secretion during the longer period. This is in agreement with the findings of Schmidt (1960) with dairy cattle, who recorded significant reductions in rates of secretion at 16-hr and 20-hr intervals between milkings as compared to the 4-hr, 8-hr, and 12-hr intervals. Our results with beef cattle could also have been influenced by the necessity to segregate the calves for varying lengths of time during the determinations.

Data on the milk production of Hereford cows have been reported by Gifford (1953) and Arbuckle (1959). The results of Gifford (1953) were obtained for 28 grazing cows in the United States of America by hand-milking. Based on 50 lactations in these cows, he found a mean milk production of 7·67 lb per day in the second month of lactation. The data of Arbuckle (1959) were obtained on grazing cows on a property in the Rockhampton district of

Queensland. The information was obtained by allowing calves to suckle on two occasions during a 24-hr period, and deriving the milk production by pre- and post-suckling weighing of the calves. He recorded a daily yield of 6·8 lb and 7·0 lb at mean lactation periods of 42 days and 85 days respectively in 2-year-old and 3-year-old cows in the 1957-58 season. These results are comparable with the mean 24-hr yield calculated from the 4-hr milking interval in the group receiving 10 lb sorghum grain per head per day. The 24-hr production was 3502 g (7·72 lb) at a mean lactation period of 68 days.

There was no significant difference among groups in either fat or solids-not-fat percentages of the milk. The mean fat content in all groups was higher than that of 2·93 per cent. calculated from the data of Gifford (1953) for grazing Hereford cows in the second month of lactation. Since restriction of hay intake (Powell 1939; Balch *et al.* 1952) and a long milking interval (Johansson and Claesson 1957) depress fat percentage in the milk of dairy cows, it would be expected that the fat percentage in the milk of the experimental heifers on the all-grain rations would have been lower than the values obtained.

The tendency for the haemoglobin and P.C.V. levels of heifers to be elevated above values from pasture in the initial period of a drought feeding experiment of this nature was observed in these same animals, then maiden heifers, by Ryley, Gartner, and Morris (1960). Although the levels found in blood and serum constituents of heifers did not indicate a pathological change at any sampling period, animals in Group III had a higher concentration of some constituents than animals in either Groups I or II. This could be expected on nutritional grounds.

The data on vitamin A (Gartner and Ryley 1962) and on changes in blood constituents at parturition (Payne, Ryley, and Gartner 1962) are presented in detail as separate papers.

The marked effect of time-after-feeding on the concentration of plasma NEFA in ruminants has been recorded by Annison (1960). In our experiment the samples for NEFA were taken from the non-pregnant heifers on each occasion immediately prior to feeding. This ensured a maximum constant interval of approximately 23 hr since the consumption of the previous day's grain. Although there was an increase in mean plasma NEFA after the animals were changed over from pasture to an all-grain ration and again in the subsequent sampling period four weeks later, these increases were not significant.

During the last 12 weeks of gestation the heifers ingested virtually no carotene, and no liver vitamin A reserves were detectable in the newborn calves although the maternal reserves ranged from 103 to 240 μg/g at parturition. That the prepartum diet of the bovine may influence markedly the vitamin A reserves of the newborn calf has been found by Braun and Carle (1943), Spielman *et al.* (1946) and Wise, Caldwell, and Hughes (1946).

Data on blood glucose levels in calves under normal husbandry practices have been reviewed by Ratcliff, Jacobson, and Allen (1958) and Hibbs, Conrad, and Vandersall (1961). A high level is characteristic in young ruminants and this declines with age. Hibbs *et al.* (1956), using Jersey calves fed solely on milk and without bedding, found that a high level of 78–85 mg glucose/100 ml was maintained for 12 weeks. In the present experiment mean blood glucose levels in Hereford calves at six weeks of age were 52·8, 55·3 and 71·3 mg/100 ml in Groups I, II and III respectively. Thus only in Group III was the level comparable with values reported in calves of that age receiving wholemilk only. The lower levels in Groups I and II could be a direct reflection of a lower milk intake by these groups. The mean blood glucose levels found in the calves at 10 weeks of age, namely 45·6–55·8 mg/100 ml, would not be so dependent on milk intake, for at this stage the animals had access to a creep containing sorghum grain. These levels at 10 weeks are comparable with the level of blood glucose found in adult ruminants (Payne, Ryley, and Gartner 1962).

Although there was a significant decline between the initial and final sampling in the haemoglobin, P.C.V., and total serum protein in calves in some groups, the levels obtained at the final sampling were comparable with those obtained in Hereford calves of similar age suckling dams grazing the predominantly *Paspalum dilatatum* pastures at the Animal Husbandry Research Farm, Rocklea (unpublished data). The lower total serum protein found in the calves when compared with their dams is due mainly to decreased serum globulin levels.

In the early stages of grain feeding, the group receiving 10 lb of grain per head per day were unable to consume all their ration, but at the end of three weeks all residual grain had been eaten and animals were eating their daily feed rapidly and at a rate comparable with that of groups receiving 6 lb per head day day. The rate of consumption (1 lb per 2 min) was much faster than that of 1 lb per 5–6 min recorded by Ryley, Gartner, and Morris (1960) for maiden heifers receiving 3 lb of grain per head per day.

The occurrence of oestrus in all animals in the first 6 weeks after cessation of grain-feeding and return to productive rations indicates that animals could be mated within a short time after prolonged submaintenance feeding. The effect on the dams of weaning the calves at the same time as transference to productive rations may have contributed to the satisfactory incidence of oestrus at the time of testing.

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