THE QUEENSLAND JOURNAL OF AGRICULTURAL SCIENCE

DECEMBER, 1958.

Vol. 15. - - No. 4.

DROUGHT FEEDING STUDIES WITH CATTLE AND SHEEP

1. The Use of Native Grass Hay (Bush Hay) as the Basal Component of a Drought Fodder for Cattle.

By J. G. MORRIS, M.Agr.Sc., B.Sc., Husbandry Officer, Animal Research Institute, Yeerongpilly.

SUMMARY.

In two experiments, four groups of six beef-type maiden heifers 15-24 months old were group-fed in bare yards a basal diet of long-chaffed bush hay *ad lib.* with and without supplements.

In one experiment, heifers fed bush hay and a mineral lick *ad lib.* lost an average of 20 lb. body weight over 26 weeks. Over the same period heifers fed bush hay and a mineral lick with 1.3 lb. or 3.0 lb. lucerne chaff per head per day gained an average of 21 lb. and 83 lb. respectively. Heifers receiving a supplement of 0.41 lb. meatmeal instead of lucerne chaff showed an average weight increase of 39 lb.

In a second experiment, heifers fed the same bush hay without and with a lick *ad lib.* lost an average of 40 lb. and 48 lb. body weight respectively over a period of 21 weeks. The addition of 1 lb. crushed grain sorghum per head per day to the basal diet with lick *ad lib.* decreased the weight loss to an average of 14 lb. per head, while the further addition of 2 oz. urea and 0.14 oz. sodium sulphate per head per day permitted a body weight increase of 60 lb. per head.

Nitrogenous supplements (lucerne chaff, meatmeal and urea) increased total dry matter consumption.

In both experiments plasma vitamin A concentration steadily declined while bush hay was fed; the minimum recorded concentration was 16 ug./100 ml. plasma.

The minimum blood inorganic phosphate concentration recorded was 4.2 mg.P/100 ml.

In the second experiment, the ovarian activity of the heifers at the conclusion of bush hay feeding was significantly increased by a supplement of 1 lb. crushed sorghum grain, 2 oz. urea and 0.14 oz. sodium sulphate per head per day.

Heifers which were fed bush hay alone or bush hay and the lick became lethargic and apathetic. Those fed bush hay and nitrogenous supplements remained active.

I. INTRODUCTION.

Beef cattle in Australia are grazed almost universally on native and sown pastures, the growth of which fluctuates markedly with temperature and rainfall. As a result of dependence on pasture growth, periods of nutritional stress occur annually. Throughout much of Australia (Alexander and Chester 1956, Franklin 1956), grazing cattle exhibit a biphasic type of growth curve which is a reflection of this variation in the nutritional plane. In the major beef producing areas of Queensland the net growing season is approximately four months. Chester (1952) stated that cattle usually gain in weight from November to June and lose weight from July to October. A pronounced seasonal pattern in the production of beef results, approximately half the annual beef production being from cattle slaughtered in the three winter months, May to July.

Beef producers in Queensland are faced with even more difficult nutritional problems during recurrent periods of drought. Failure to meet these problems adequately has resulted in heavy loss of production. Recorded losses of cattle (mainly beef cattle) attributed chiefly to drought during 1951 and again during 1956-57 were of the order of 500,000 head (Queensland Government Statistician 1958), and Patterson (1957) showed that during the period 1894-1955 beef cattle numbers in Queensland were closely related to a weighted rainfall index. Kinsman (1953) estimated that the six major droughts in Queensland between 1920 and 1950 reduced the potential production of beef by $8\frac{1}{2}$ per cent.

Supplementary feeding to reduce production losses due to drought has not been widely practised in Queensland. The inadequacy of the fodder reserves held on rural holdings in Queensland is evident from statistics compiled by the Queensland and Commonwealth Government Statisticians. For instance, at the end of March 1957, after a series of seasons generally favourable for fodder conservation, the total recorded fodder stocks on rural holdings were 157,000 tons of hay and chaff, 75,000 tons of silage, and 1,410,000 bus. of grain. The recorded livestock population at that time included 23 million sheep and $7\frac{1}{2}$ million cattle.

As a result of the work of Franklin (1946a, 1946b, 1951, 1952), Franklin *et al.* (1955) and Briggs, Franklin and McClymont (1956, 1957), a considerable amount of information regarding the suitability of rations for the maintenance of sheep during periods of drought is now available. Similar information pertaining to cattle is scanty. This may be one of the reasons for the reluctance to conserve fodder shown by many owners of beef cattle.

The feedstuffs available for the drought feeding of cattle in Queensland may be divided into three groups:

(*a*) Conserved roughages, including conserved native grass pasture (bush hay) and silage and hay made from crops such as sorghum (*Sorghum vulgare*) and Sudan grass (*Sorghum sudanense*).

(*b*) Grains, of which grain sorghum probably has the greatest potential for production and storage on beef cattle properties.

(*c*) Nitrogenous supplements for low quality roughage, including meatmeal, lucerne chaff and urea.

A series of experiments was undertaken to provide information concerning the suitability of a number of these feedstuffs for the drought feeding of cattle under Queensland conditions. This paper is concerned with the use of bush hay fed alone and with various supplements. Two experiments are described. The first was designed to evaluate bush hay as a drought fodder and to examine the effect of the addition of two levels of lucerne chaff and one level of meatmeal to a basal ration of bush hay. At the rate of supplementation employed, the lucerne chaff and the meatmeal supplied approximately equal quantities of crude protein. The second experiment was of a confirmatory nature, but was designed also to evaluate the addition of a salt-boneflour mineralised lick and two iso-caloric supplements of different nitrogen content.

In both experiments, the effects of the rations upon the body weight, feed consumption, coat changes, behaviour and ovarian activity were studied. Blood samples were taken from animals in each group, and blood inorganic phosphate, packed cell volume, haemoglobin, plasma protein, vitamin A, and carotenoid concentrations determined.

II. METHODS AND MATERIALS.

(1) Bush Hay.

The bush hay fed in both experiments comprised part of a cut of 85 tons from 92 acres of pasture on a property in the Central Highlands of Queensland in the autumn of 1954. The pasture, growing on a black earth, was mechanically harvested by a small tractor having an attached power-take-off mower and pulling a ground-driven mower and a side-delivery rake in tandem. This combination of implements delivered the cut pasture into windrows, in which it cured. It was later baled by a mechanical pick-up baler. The hay was stored under cover on the property for approximately 18 months before being despatched for feeding in the first experiment. Hay used in the second experiment had been stored for approximately two years. All hay was chaffed before feeding, the chaffcutter being set to give a cut of half an inch. Chaff was used to reduce wastage in feeding from troughs and to allow accurate measurement of feed intakes.

During the feeding experiments a grab sample was taken from each bag of chaffed hay immediately before feeding. These daily samples were bulked to give a composite sample for chemical analysis.

(2) Lick.

The lick was prepared by intimately mixing 50 lb. of degelatinised bone flour with 50 lb. of coarse salt (sun-dried sodium chloride) over which had been sprayed a solution of 8 oz. of copper sulphate and 2 oz. of cobalt chloride in water.

(3) Experimental Animals.

Beef-type maiden heifers in store condition were used in both experiments. They were inoculated with tenanus toxoid, blackleg vaccine and blood containing the protozoans *Babesia bigemina and B. argentina.* They gave negative reactions to the intradermal caudal fold test for tuberculosis and to serological tests for brucellosis and contagious pleuropneumonia. All animals not polled were dehorned. Sufficient time was allowed for dehorning lesions to heal completely before experimental treatment was commenced. All cattle were free from ticks throughout the experiment.

In the first experiment a line of 30 Hereford heifers, 18–24 months of age, was selected for uniformity of weight on a beef property in Central Queensland. The animals were transported to the Animal Husbandry Research Farm at Rocklea, near Brisbane, and during the next 17 weeks subjected to the necessary inoculations and tests. At the conclusion of this period intractable heifers were eliminated, and from those remaining, four groups each of six animals were selected by stratified random allocation on a body weight and conformation basis. This allowed every animal to be compared with three similar animals in the same weight stratum, thus constituting a quartet.

In the second experiment a line of 30 heifers, predominantly Hereford-Shorthorn cross, was selected for uniformity of body weight on a beef property in Central Queensland. The heifers were transported to Rocklea and over the following nine weeks were subjected to the series of tests and inoculations used in Experiment I.

(4) Body Weight.

At weekly intervals on the same morning as feed residues were removed the body weights were obtained by weighing the individual animals at a standard time (7 a.m. to 8 a.m.) on a cattle weighing scale with an accuracy of $\pm$ 2 lb. Water and bush hay were available *ad lib.* before weighing.

(5) Experimental Yards.

Both experiments were conducted in a unit which comprised a set of four open yards (40 ft. x 48 ft.) of identical design. The yards and an area of 2 ft. around the perimeter of the unit were maintained bare of vegetation by spraying with fuel oil.

Each yard had 28 running feet of troughing, arranged to allow addition of feed without entering the yards. In Experiment I, these troughs were uncovered, but in Experiment II a 12 ft. wide hip roof was provided to protect the feed troughs from the weather. When a lick was fed it was supplied in separate boxes, protected from the weather. Water was available *ad lib.*, one trough in the dividing fence serving two yards. In each yard shade was provided by a structure 10 ft. x 8 ft. with a thatched roof.

(6) Method of Feeding.

For each group in Experiment I two feed troughs, each 7 ft. long, were kept approximately half full by adding the chaffed bush hay thrice daily. Supplements were fed once daily. For Groups II and III the lucerne chaff was fed separately in two troughs each 7 ft. long. For Group IV, the meatmeal was sprinkled over the bush hay.

For each group in Experiment II four feed troughs each 7 ft. long were kept approximately half full by adding chaffed bush hay twice daily. For Groups III and IV the respective supplements were fed once daily by sprinkling on top of the bush hay in the troughs and mixing into the upper layers. The urea and sodium sulphate for Group IV were mixed with the crushed sorghum grain immediately before feeding.

In both experiments uneaten residues of bush hay were removed at weekly intervals and discarded after weighing and sampling for chemical analysis. Lick was added to the boxes at weekly intervals to ensure *ad lib.* consumption.

(7) Methods of Chemical Analysis.

Analytical methods employed were as follows: proximate analysis of feed and faeces, Association of Official Agricultural Chemists (1955); blood inorganic phosphate, Moir (1954); plasma vitamin A and carotenoids, Peirce (1945); carotene in plant material, McGillivray (1952); chromium sesquioxide in faeces, Schurch, Lloyd and Crampton (1950); copper in plant material, Clare, Cunningham and Perrin (1945); blood haemoglobin, Donaldson *et al.* (1951); packed cell volume, Wintrobe (1947); and serum protein, Phillips *et al.* (1950) and Van Slyke *et al.* (1950).

(8) Digestibility of Bush Hay.

Digestibility coefficients of bush hay for sheep were determined by the procedure of Harvey (1952) at the commencement of the cattle pen feeding trial, using the chaffed material from 40 randomly selected bales. Digestibility coefficients for cattle were determined at the conclusion of the feeding phase of Experiment I, using two of the experimental animals from each of Groups I and IV. During the digestibility determinations, cattle were transferred to individual feeding stalls and faeces were collected manually as voided.

For the calculation of apparent digestibility coefficients by difference, the coefficients used for meatmeal were organic matter 92·7 per cent., crude protein 87 per cent. and N.F.E. 100 per cent., and that for the protein in boneflour 50 per cent.

(9) Ovarian Activity Studies.

In Experiment I the ovaries recovered on slaughter were examined for the number of follicles and presence of a corpus luteum, albicans or haemorrhagicum.

In Experiment II the ovaries were scored on the following scale:

0 No activity.

1 Corpus albicans.

2 Small follicles.

3 Developing follicle more than 0·75 cm.

4 Corpus luteum or corpus haemorrhagicum.

The scores of both left and right ovaries were added to give an "ovarian activity score" for each animal.

(10) Coat Studies.

For the assessment of coat texture (pliability of the skin) and woolliness (presence of long curly hair), arbitrary scales scoring from 1 to 5 were employed. The highest figure was for the most pliant skin and the smoothest coat, respectively.

(11) Observations and Recordings.

In both experiments the mean group average body weight and consumption of bush hay and lick were determined at weekly intervals.

Plasma vitamin A and carotenoid concentration changes were determined on the plasma from the heaviest and lightest quartets entering both experiments.

In Experiment I plasma levels were determined at the end of the 2nd, 18th and 21st weeks; in Experiment II at the commencement and termination of the experiment.

Blood inorganic phosphate concentration was determined on all animals in both experiments. In Experiment I the level was determined at the end of the 2nd, 8th, 14th and 21st weeks; in Experiment II at the end of the 17th week.

Serum protein concentration was determined on all animals at the conclusion of both feeding experiments.

Haemoglobin concentration, packed cell volume, coat texture and woolliness were estimated on all animals at the conclusion of the feeding phase of Experiment I.

For three weeks before the conclusion of Experiment I, 120 g. of chromium sesquioxide was intimately mixed with the meatmeal supplement fed daily to Group IV. During the last seven days of this 3-weeks period, samples were collected manually at 7 a.m. and 4 p.m. from the rectum of each animal in this group. The level of chromium sesquioxide in the faeces was used as an index of meatmeal consumption.

Ovaries were recovered from all animals on slaughter: in Experiment I this was 19 weeks after termination of bush hay feeding; in Experiment II at the conclusion of bush hay feeding.

III. EXPERIMENT I.

(1) Design.

The four groups of heifers were confined to bare yards and fed the following rations:

Group I: Bush hay *ad lib.* + lick *ad lib.*

Group II: Bush hay *ad lib.* + lick *ad lib.* + 1·3 lb. lucerne chaff per head per day.

Group III: Bush hay *ad lib.* + lick *ad lib.* + 3·0 lb. lucerne chaff per head per day.

Group IV: Bush hay *ad lib.* + lick *ad lib.* + 0·41 lb. meatmeal per head per day.

Bush hay feeding continued for a period of 26 weeks, after which all but four of the heifers were turned out on pasture for 19 weeks and then slaughtered. These four heifers were from Groups I and IV, and represented members of the heaviest and lightest quartets entering the experiment. They were fed daily 8 oz. less than the group average intake of bush hay, together with the group average intake of supplements.

(2) Results.

The botanical analysis of the bush hay, presented in Table 1, shows that it is predominantly composed of *Paspalidium globoideum* and *Eriochloa* species.

The chemical composition of composite samples of the bush hay and other feedstuffs as presented to the animals is given in Table 2. The bush hay is high in crude fibre (36 per cent.), low in crude protein (5 per cent.) and devoid of carotene.

Table 1.

BOTANICAL ANALYSIS OF HAY FROM THE CENTRAL QUEENSLAND HIGHLANDS (EXPERIMENTS I AND II).

Grass.		Approximate Percentage by Weight.
Paspalidium globoideum	(shot grass)	20
Erichloa sp.	(spring grass)	20
Dichanthium sericeum	(Queensland blue grass)	15
Aristida leptopoda	(white spear grass)	10
Panicum decompositum	(native millet)	5
Panicum queenslandicum	(yabila grass)	
Iseilema membranaceum	(small Flinders grass)	5
Small quantities of *Digitaria brownei*, *Chloris* spp., *Phyllanthus simplex* and unidentified material		25

Table 2.

PROXIMATE ANALYSIS OF THE FEEDSTUFFS (EXPERIMENT 1).

Feedstuff.	Moisture.	Crude Protein.	Ether Extract.	Crude Fibre.	Nitrogen-free Extract.	Ash.	Ca.	P.	SO_4	Cu.	Mo.
	%	%	%	%	%	%	%	%	%	ppm.	ppm.
Bush hay ..	6·6	4·6	1·3	33·4	43·4	10·7	0·29	0·24	0·05	2·9	0·5
	..	*5·0*	*1·4*	*35·7*	*46·5*	*11·4*	*0·31*	*0·26*	..	..	..
Lucerne chaff	10·0	19·7	1·5	23·9	38·0	6·9	1·03	0·33	0·19	4·5	0·6
	..	*21·9*	*1·7*	*26·6*	*42·2*	*7·6*	*1·14*	*0·37*	..	..	..
Meatmeal ..	7·8	62·1	8·9	..	1·5	19·7	5·80	3·12	..	..	..
	..	*67·4*	*9·6*	..	*1·6*	*21·3*	*6·29*	*3·38*	..	..	..

Italics indicate composition on a dry matter basis.

Table 3.

APPARENT DIGESTIBILITY COEFFICIENTS OF THE NUTRIENTS OF BUSH HAY BY SHEEP AND CATTLE (EXPERIMENT I).

Species.	Number of Animals.	Organic Matter.	Crude Protein.	Ether Extract.	Crude Fibre.	Nitrogen-free Extract.
		%	%	%	%	%
Sheep ..	Mean of six animals	42·6	24·1	26·0	54·6	44·7
Cattle ..	Group I—					
	No. A* ..	53·8	36·2	55·0	61·0	50·5
	No. B	48·7	32·1	50·0	54·9	46·0
	Group IV†—					
	No. C	51·5	29·8	48·0	59·2	48·3
	No. D	52·2	29·4	50·0	59·4	50·1

* This animal did not maintain group average intake of bush hay.

† Apparent digestibility coefficients calculated by difference.

Apparent digestibility coefficients of the bush hay by both sheep and cattle are given in Table 3. The sheep digestibility coefficients represent mean figures from six animals fed a diet consisting solely of bush hay. The cattle digestibility coefficients are given for individual animals. The digestibility coefficients for all nutrients determined were greater for cattle than for sheep.

All animals survived the bush hay feeding experiment. The group average changes in body weight, and mean daily bush hay and lick consumption over the 26 weeks of bush hay feeding, are given in Table 4. The weekly group average body weight and bush hay and lick consumption are shown in Fig. 1.

Statistical analyses of body weight at the end of the 8th, 17th and 26th weeks of the experiment, and of overall growth rate, are given in Table 5. There was a significant difference in body weight and growth rate between all groups with the exception of Groups II and IV. These two groups were fed approximately the same amount of crude protein in the supplement.

Feed consumption of all groups exhibited an upward trend during the course of the experiment. The greatest dry matter consumption was recorded by Group III, which received the highest level of protein supplementation.

The wastage of bush hay as uneaten residue accounted for only a small proportion of the bush hay fed. The 26 weeks' average wastage was as follows: Group I, 6·0 per cent.; Group II, 4·0 per cent.; Group III, 3·4 per cent.; Group IV, 1·9 per cent. This indicates that the greater intake of bush hay by Groups II, III and IV was not due to greater selectivity.

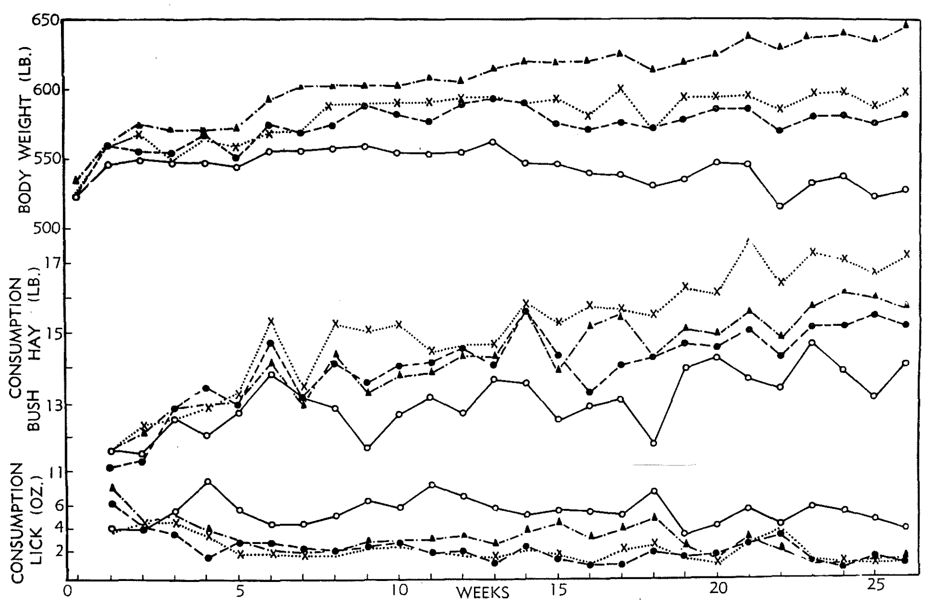

Fig. 1.

Weekly Body Weights and Bush Hay and Lick Consumption of Maiden Heifers Fed Various Supplements (Experiment I).

O————O Group I: Bush hay *ad lib.* + lick *ad lib.*

●— — —● Group II: Bush hay *ad lib.* + lick *ad lib.* + 1.3 lb. lucerne chaff per head per day.

△ — · — △ Group III: Bush hay *ad lib.* + lick *ad lib.* + 3.0 lb. lucerne chaff per head per day.

× .... × Group IV: Bush hay *ad lib.* + lick *ad lib.* + 0.41 lb. meatmeal per head per day.

The analyses of the residues of bush hay removed from each group at weekly intervals also indicate that there was no selection of portions of the hay. Because of residual meatmeal, the crude protein, calcium and phosphorus contents of the residue from Group IV were higher than in the bush hay as fed.

The ovarian activity 19 weeks after the conclusion of the experiment indicated that the experimental treatment may have influenced the oestral cycle.

The assessment of coat texture and woolliness on the arbitrary scales referred to on page 166 gave the following group mean scoring:

Group.	Mean Score.	
	Coat Texture.	Woolliness.
I	2·2	1·7
II	3·2	2·3
III	3·0	3·5
IV	2·8	2·8

Table 4.

CHANGES IN BODY WEIGHT AND AVERAGE BUSH HAY AND LICK CONSUMPTION OF HEIFERS (EXPERIMENT I).

Group.	Supplements Per Head Per Day.	Body Weight.			Average Daily Intake Per Head over 26 weeks.		
		Initial.	After Feeding Bush Hay. 1 Week.	After Feeding Bush Hay. 26 Weeks.	Bush Hay.	Lick.	Total Dry Matter.
		lb.	lb.	lb.	lb.	oz.	lb.
I ..	Nil	523	547	527	13·1	5·3	12·5
II ..	1·3 lb. lucerne chaff ..	524	559	580	14·1	2·2	14·5
III ..	3·0 lb. lucerne chaff ..	532	561	644	14·4	2·8	16·3
IV ..	0·41 lb. meatmeal ..	526	558	597	15·2	1·9	14·7

Table 5.

STATISTICAL ANALYSIS OF THE BODY WEIGHTS AND GROWTH RATES OF HEIFERS FED BUSH HAY AND VARIOUS SUPPLEMENTS (EXPERIMENT I).

Groups.	Body Weight at—			Growth Rate over 26 Weeks.
	8 weeks.	17 weeks.	26 weeks.	
III greater than I ..	†	†	†	†
III greater than II ..	NS	*	†	†
III greater than IV ..	NS	NS	*	*
IV greater than II ..	NS	NS	NS	NS
II greater than I ..	NS	*	*	†
IV greater than I ..	*	†	†	†

NS = not significant.
* = $P < 0·05$.
† = $P < 0·01$.

Table 6.

Blood Inorganic Phosphate, Body Weight Changes, and Chromium Sesquioxide Content of the Faeces of the Six Heifers in Group IV (Experiment I).

Animal No.	Blood Inorganic P (mg./100 ml.).	Body Weight Change.	Cr_2O_3/g. Dry Faeces.
		lb.	
CH2867 ..	8·8	+99	5·4
CH2849 ..	8·3	+57	4·7
CH2845 ..	8·3	+44	4·4
CH2842 ..	6·2	+17	4·3
CH2856 ..	6·2	+38	3·7
CH2862 ..	5·5	−22	2·9

Correlation between :—

Chromium sesquioxide level of faeces and body weight change : $r = 0{\cdot}93$ $(P<0{\cdot}01)$.

Chromium sesquioxide level of faeces and blood phosphate : $r = 0{\cdot}88$ $(P<0{\cdot}02)$.

Blood inorganic phosphate levels were at all times within the normal range. The minimum recorded value was 4·2 mg.P/100 ml.

When all animals were bled at the end of the 8th, 14th and 21st weeks of the experiment, Group I, which had the highest intake of salt-boneflour lick, on each occasion recorded the highest group mean blood inorganic phosphate level.

Table 6 shows that the level of chromium sesquioxide in the faeces, an index of the intake of meatmeal, for individual animals in Group IV was positively correlated with the blood inorganic phosphate level at the 21st week of the experiment and with the body weight change of the experimental animals.

Repetitive analyses during the course of the bush hay feeding showed a steady fall in plasma carotenoids; plasma vitamin A concentration declined more slowly.

At the conclusion of the bush hay feeding, the lowest individual level recorded was 16·8 μg. vitamin A/100 ml. plasma in an animal from Group I. Packed cell volume, haemoglobin and serum protein determinations did not indicate gross abnormality. Groups III and IV, however, had a greater mean packed cell volume, haemoglobin and serum protein level than Groups I and II.

The behaviour of the animals was affected by the experimental rations. The heifers in Group I, which received only the lick in addition to bush hay, became apathetic and dejected. Those receiving the low level of lucerne chaff (Group II) and meatmeal (Group IV) were much brighter, and those in Group III, on the high level of lucerne chaff, were alert.

IV. EXPERIMENT II.

The objects of Experiment II were to assess the value of the salt-boneflour lick as a supplement to bush hay, and to determine whether the main response to the supplements of meatmeal and lucerne chaff was due to the addition of energy or of protein to the diet.

(1) Design.

The four groups of heifers confined to bare yards were fed the following rations:

Group I : Bush hay *ad lib.*

Group II : Bush hay *ad lib.* + lick *ad lib.*

Group III: Bush hay *ad lib.* + lick *ad lib.* + 1 lb. crushed grain sorghum per head per day.

Group IV: Bush hay *ad lib.* + lick *ad lib.* + 1 lb. crushed grain sorghum, 2 oz. urea and 0·17 oz. sodium sulphate per head per day.

The experiment was terminated after 21 weeks when the supply of bush hay was exhausted. All animals were then slaughtered and their ovaries recovered.

(2) Results.

The chemical analyses of composite samples of the feedstuffs are given in Table 7. The bush hay fed in this experiment had essentially the same chemical composition as that used in Experiment I. The analysis of the crushed grain sorghum showed that it was a typical commercial sample.

All animals survived the experiment. The group average changes in body weight, and mean daily bush hay and lick consumption over the 21-weeks period, are given in Table 8. The weekly group average body weight and bush hay and lick consumption are shown in Fig. 2.

Statistical analyses of the body weights at the 7th, 14th and 21st weeks and the growth rate (Table 9) did not indicate that the lick was beneficial. The supplement of 1 lb. crushed grain sorghum caused a significant retardation ($P<0{\cdot}05$) of the rate of decline of body weight in Group III. However, a supplement of 2 oz. urea with 0·17 oz. of sodium sulphate in addition to the grain sorghum resulted in an increase in body weight. These animals were significantly heavier at 14 weeks ($P<0{\cdot}05$) and had a significantly better overall growth rate ($P<0{\cdot}01$).

The urea and sorghum supplement had the greatest effect upon increasing consumption of bush hay; the group average increase was 3·1 lb. per head per day over that of Group I. The sorghum supplement alone increased consumption by 1·2 lb. per head per day, whereas the effect of the salt-bonefiour lick was negligible, an increase in consumption of 0·3 lb. per head per day over that of Group I.

Table 7.

PROXIMATE ANALYSIS OF THE FEEDSTUFFS (EXPERIMENT II).

Feedstuff.	Moisture.	Crude Protein.	Ether Extract.	Crude Fibre.	Nitrogen-free Extract.	Ash.	Ca.	P.
	%	%	%	%	%	%	%	%
Bush hay	6·4	4·2	0·3	34·4	42·7	12·0	0·26	0·21
	..	*4·5*	*0·3*	*36·6*	*45·9*	*12·7*	*0·27*	*0·22*
Crushed grain sorghum	4·7	10·7	2·8	1·5	78·8	1·5	0·06	0·28
	..	*11·2*	*2·9*	*1·6*	*82·7*	*1·6*	*0·06*	*0·29*

Italics indicate composition on a dry matter basis.

Table 8.

CHANGES IN BODY WEIGHT AND GROUP AVERAGE INTAKE OF BUSH HAY AND LICK BY HEIFERS (EXPERIMENT II).

Group.	Supplements Per Head Per Day.			Group Average Body Weight.			Group Average Daily Intake Over 21 Weeks.		
	Lick.	Crushed Sorghum. (1 lb.)	2 oz. Urea + 0·17 oz. Sodium Sulphate.	Initial.	*After 1 week.	After 21 weeks.	Bush Hay.	Lick.	Total Dry Matter.
				lb.	lb.	lb.	lb.	oz.	lb.
I ..	nil	nil	nil	461	482	442	11·4	—	10·7
II ..	+	nil	nil	462	486	438	11·7	6·9	11·3
III ..	+	+	nil	476	490	476	12·6	3·2	13·0
IV ..	+	+	+	466	485	545	14·5	3·0	14·8

* This increase in body weight over the first week is probably due to rumen " fill."

Table 9.

STATISTICAL ANALYSIS OF THE BODY WEIGHTS AND GROWTH RATE OF HEIFERS FED BUSH HAY ALONE AND BUSH HAY WITH VARIOUS SUPPLEMENTS (EXPERIMENT II).

Groups.	Body Weight at— 7 weeks.	14 weeks.	21 weeks.	Growth Rate over 21 Weeks.
IV greater than I ..	†	†	†	†
IV greater than II ..	*	†	†	†
IV greater than III ..	NS	*	†	†
III greater than I ..	NS	NS	NS	*
III greater than II ..	NS	NS	NS	*
II greater than I ..	NS	NS	NS	NS

NS = not significant.
* = P<0·05.
† = P<0·01.

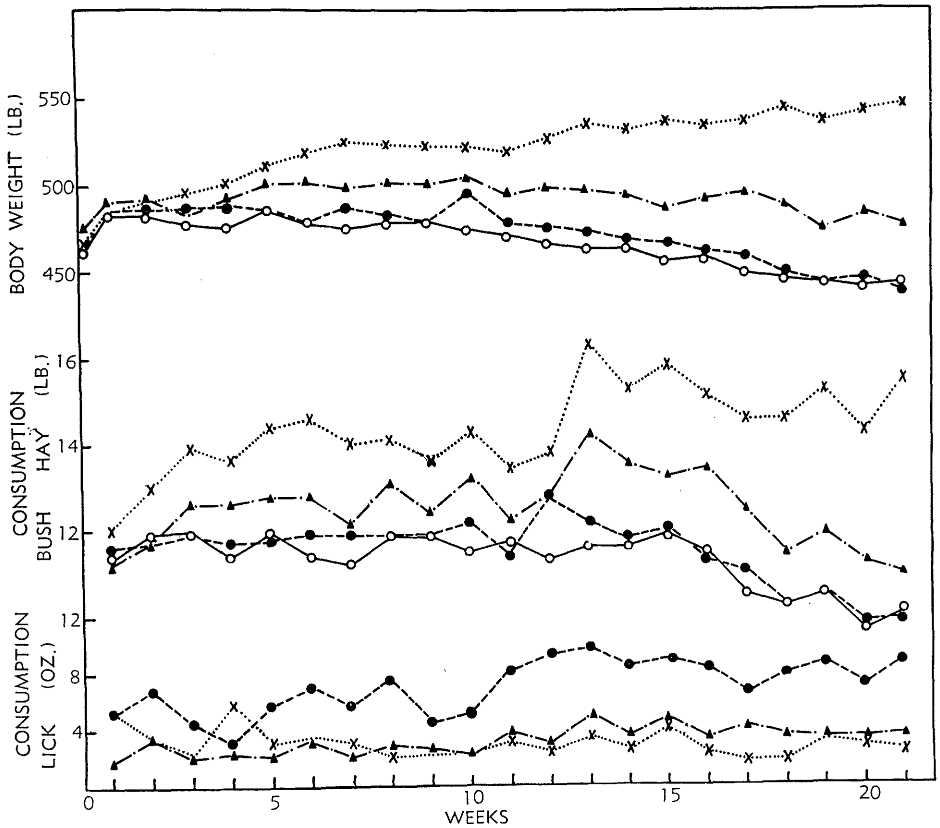

Fig. 2.

Weekly Body Weights and Bush Hay and Lick Consumption of Maiden Heifers Fed Various Supplements (Experiment II).

O————O	Group I:	Bush hay *ad lib.*
●— — —●	Group II:	Bush hay *ad lib.* + lick *ad lib.*
△ — . — △	Group III:	Bush hay *ad lib.* + lick *ad lib.* + 1 lb. crushed grain sorghum per head per day.
× .... ×	Group IV:	Bush hay *ad lib.* + lick *ad lib.* + 1 lb. crushed grain sorghum + 2 oz. urea and 0.17 oz. sodium sulphate per head per day.

The wastage of bush hay as uneaten residues accounted for only a small proportion of the bush hay fed. The 21-weeks average wastages were as follows: Group I, 10·8 per cent.; Group II, 10·7 per cent.; Group III, 9·4 per cent.; and Group IV, 6·0 per cent. Chemical analyses of the residues indicated that selection of portion of the hay had not been practised by any of the groups. Thus, increased selection does not account for the greater intake of bush hay by Group IV.

The carotenoid concentration of the plasma declined from an initial mean value of 81 μg./100 ml. to a mean value of 28 μg./100 ml. after 21 weeks. The plasma vitamin A concentration, however, declined at a slower rate: the initial mean value of 37 μg./100 ml. fell to 26 μg./100 ml. after 21 weeks; the lowest recorded value was 16 μg./100 ml.

Blood inorganic phosphate levels recorded at the end of the 17th week were all within the normal range, the minimum value being 6 mg.P/100 ml. The group mean blood inorganic phosphate levels in descending order were Group II, 7·5 mg.P/100 ml.; Group I, 7·2 mg.P/100 ml.; Group III, 7·1 mg.P/100 ml.; and Group IV, 6·1 mg.P/100 ml.

Table 10.

GROUP MEAN "OVARIAN ACTIVITY" SCORE OF FOUR GROUPS OF HEIFERS FED A BASAL DIET OF BUSH HAY WITH VARIOUS SUPPLEMENTS (EXPERIMENT II).

Group.	Mean "Ovarian Activity" Score.	Significant Differences.
I ..	1·8	Group IV $>$ II ($P < 0{\cdot}01$)
II ..	1·3	Group IV $>$ I ($P < 0{\cdot}05$)
III ..	3·6	Group III $>$ II ($P < 0{\cdot}05$)
IV ..	4·5	..

The group average score shown in Table 10 indicates that ovarian activity was significantly affected by plane of nutrition.

The behaviour of the animals was influenced markedly by the experimental rations. The heifers fed bush hay alone or with a salt lick initially became very tractable, then assumed a dejected and apathetic appearance. Their whole concern appeared to be eating, drinking, loafing and lying around. These animals rarely licked their coats. The heifers receiving the supplement of 1 lb. crushed grain sorghum were brighter but not as alert as those which received the additional supplement of urea.

V. DISCUSSION.

These two experiments demonstrate that hay conserved from the native grass pasture of the open black soil downs of the Central Queensland highlands has a potential as a drought fodder. When maiden heifers were confined to bare yards with an ample supply of water, the hay used in these experiments was capable of keeping them alive with only a slight loss in body weight for periods up to six months. Small quantities of high quality supplements fed in addition to bush hay were capable of elevating the combined ration to a maintenance or even to a production level.

In common with all bush hays, the hay used contained a high percentage of crude fibre and a low percentage of crude protein. Hallsworth (1949) showed that there is a negative correlation between the organic matter digestibility and the crude fibre content of feedstuffs. However, the digestibility of the crude fibre component of most subtropical grasses is reasonably high. From the limited number of bush hays examined in Queensland (Marriott and Harvey 1951, Harvey 1952), the apparent digestibility coefficient of the crude fibre is of the order of 50 per cent. This fibre must therefore make a significant contribution to the energy available to ruminants from such feedstuffs.

Although the digestibility data for cattle are limited, the digestibility coefficients of the nutrients in bush hay fed to cattle were, in all cases, higher than those obtained with sheep, a finding which may account for the better performance of cattle compared with sheep when fed the same bush hay (Morris 1958b). The digestibility coefficients of organic matter for the two groups of heifers fed bush hay with and without a meatmeal supplement were similar. This evidence, although derived from only three animals, suggests that meatmeal does not markedly increase the digestibility coefficient of any of the nutrients in bush hay.

It is apparent from Tables 4, 6 and 8 that nitrogenous supplements, meatmeal, lucerne chaff and crushed grain sorghum with urea increased the voluntary intake of bush hay and permitted body weight increase. Within Group IV (Experiment I) the performance of heifers fed bush hay was related to the intake of meatmeal. The content of chromium sesquioxide in the faeces, however, is only an index, being a compounded variable of meatmeal intake, digestibility of the ration and bush hay consumption. The increase in bush hay intake resulting from feeding a predominantly carbohydrate supplement (crushed grain sorghum) was not as great as when the urea was fed simultaneously—1·2 lb. per day against 3·1 lb. per day. It appears that with native subtropical grasses which have relatively high crude fibre digestibility coefficients, nitrogen limits bacterial growth in the rumen and the rate of degradation of the cellulose to volatile fatty acids. If this is valid, nitrogenous supplements increase rate of digestion and thereby increase voluntary consumption of bush hay. Additional evidence to support this will be presented in the results of a later experiment (Morris 1958a), in which a supplement of 2·5 oz. of urea with sodium sulphate resulted in an 82 per cent. increase in the voluntary consumption of sorghum silage by cattle.

Neither the body weight of heifers nor their intake of bush hay was increased by providing a lick containing sterilized degelatinised boneflour sodium chloride and salts of copper and cobalt. The voluntary consumption of lick was reduced to approximately 50 per cent. by feeding a small supplement of meatmeal, lucerne chaff, sorghum grain, or sorghum grain and urea in addition to the bush hay. The high consumption of lick by animals not receiving any other supplement (Group I in Experiment I and Group II in Experiment II) is probably a reflection of a depraved appetite. Geophagia was observed frequently in these animals. Keys *et al.* (1950) similarly reported a greatly increased hunger for salt in severely under-nourished human subjects. The mean blood inorganic phosphate level of the animals not receiving lick (Group I, Experiment II) was within the normal range. Aphosphorosis cannot account therefore for the luxury consumption of lick. Analysis of the bush hay shows that it contains sufficient calcium and phosphorus to satisfy the allowance of the National Research Council Recommendations (1950) for wintering heifers.

Using the depletion value for calves of 4 μg. of vitamin A/100 ml. plasma given by Eaton *et al.* (1951), plasma vitamin A levels in both experiments indicate that avitaminosis A was not a complicating factor. As the hay was devoid of beta-carotene, the experimental animals not receiving a lucerne chaff supplement were drawing entirely on body reserves. The extent of these reserves will determine the duration for which plasma vitamin A can be maintained above a deficient level. These experiments indicate that, provided maiden heifers have been grazing green pasture prior to the feeding of bush hay, avitaminosis A is not of importance for periods of at least six months. These results are in agreement with those reported by Briggs *et al.* (1956), who showed that 2½-years-old Merino wethers taken from good pasture and fed all-grain rations for seven months did not exhibit avitaminosis A as judged by plasma vitamin A levels.

In Experiment I, there was an indication that heifers fed bush hay and a lick had a lower level of activity in the ovary than heifers fed supplements of lucerne chaff and meatmeal. In Experiment II, significant differences in the ovarian activity score were found when crushed grain sorghum and crushed grain sorghum and urea were added to a basal diet of bush hay. These findings have a practical implication: stronger and heavier animals with greater ovarian activity could be mated at an earlier date after cessation of drought feeding than weaker animals with inactive ovaries.

Studies indicated that coat texture and woolliness were influenced by the experimental treatments. The coats of the heifers in Experiment I were assessed at the termination of the feeding experiment in late summer. Normal cattle grazing good pastures have sleek coats at this time of the year. Yeates (1955) showed by reversible light experiments that a major environmental stimulus to coat shedding of well-nourished cattle is the seasonal variation in the length of daylight. The results of this experiment indicate that the plane of nutrition influences the ability of heifers to react to this stimulus. These findings are in agreement with those reported by Yeates (1958). In Experiment II, which concluded in midwinter when the coat is normally woolly, there appeared to be no group differences in hair cover of the animals.

The dejected and apathetic behaviour of the heifers which received bush hay or bush hay and a lick was common to both experiments. The supplements of lucerne chaff, meatmeal and crushed grain sorghum, especially in conjunction with urea, markedly affected behaviour, resulting in the animals being much more alert and increasing energy expenditure. There was a close similarity in the behaviour pattern of these animals and that reported by Keys *et al.* (1950) for human subjects during semi-starvation.

VI. ACKNOWLEDGEMENTS.

The author wishes to acknowledge indebtedness to the following officers of the Department of Agriculture and Stock:—officers of the Biochemical Branch for chemical assistance, officers of the Cattle Husbandry Branch for selecting the experimental animals, Mr. J. W. Ryley for veterinary assistance, Miss G. P. Davey for statistical analyses, Mr. M. J. Radel for care and feeding of the experimental animals, and Miss Janice Smiles for technical assistance.

REFERENCES.

ALEXANDER, G. I., and CHESTER, R. D. 1956. Growth studies of beef cattle in Queensland. Qd J. Agric. Sci. 13: 69-95.

ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS. 1955. Methods of Analysis of the Association of Official Agricultural Chemists. 8th Ed.

BRIGGS, P. K., FRANKLIN, M. C., and MCCLYMONT, G. L. 1956. Maintenance rations for Merino sheep. III. The performance of adult Merino wethers fed weekly on all-grain rations of wheat, maize, oats, barley or grain sorghum. Aust. Vet. J. 32: 299-304.

BRIGGS, P. K., FRANKLIN, M. C., and MCCLYMONT, G. L. 1957. Maintenance rations for Merino sheep. IV. The performance of adult Merino ewes fed daily and weekly at three levels of energy intake. Aust. J. Agric. Res. 8: 75-82.

CHESTER, R. D. 1952. Some problems of beef cattle production. Aust. Vet. J. 28: 273-287.

CLARE, N. T., CUNNINGHAM, I. J., and PERRIN, D. D. 1945. The determination of copper in pastures and livers. N.Z. J. Sci. Tech. A. 26: 340-350.

DONALDSON, R., SISSON, R. B., KING, E. J., WOOTTON, I. D. P., and MACFARLANE, R. G. 1951. Determination of haemoglobin. VII. Standardised optical data for absolute estimations. Lancet 260: 874-881.

EATON, H. D., HELMBOLDT, C. F., JUNGHERR, E. L., CARPENTER, C. A., and MOORE, L. A. 1951. Effect of vitamin A depletion on liveweight, plasma and liver levels of vitamin A and microanatomy in young dairy calves. J. Dairy Sci. 34: 386-395.

FRANKLIN, M. C. 1946a. Experimental observations on the efficiency and economics of rations for drought feeding of sheep. Aust. Vet. J. 22: 78-84.

FRANKLIN, M. C. 1946b. Some nutritional observations on the drought feeding of sheep. Aust. Vet. J. 22: 104-112.

FRANKLIN, M. C. 1951. The drought feeding of sheep. Aust. Vet. J. 27: 326-333.

FRANKLIN, M. C. 1952. Maintenance rations for Merino sheep. 1. Comparative study of daily and weekly feeding on rations containing high proportions of wheat and several proportions of roughage to concentrate. Aust. J. Agric. Res. 3: 168-186.

FRANKLIN, M. C. 1956. Report of beef cattle investigations in the southern States of Australia. C.S.I.R.O. Aust. Anim. Prod. Committee Rep. 1956.

FRANKLIN, M. C., MCCLYMONT, G. L., BRIGGS, P. K., and CAMPBELL, B. L. 1955. Maintenance rations for Merino sheep. II. The performance of weaners fed daily and weekly on rations of wheat and wheaten chaff at maintenance levels and the effect thereon of vitamin A supplements. Aust. J. Agric. Res. 6: 324-342.

HALLSWORTH, E. G. 1949. The relationship between the crude-fibre content of pasture and other feeding-stuffs and their digestibility and starch equivalent. J. Agric. Sci. 39: 254-258.

HARVEY, J. M. 1952. The nutritive value of some Queensland fodders. Qd J. Agric. Sci. 9: 169-184.

KEYS, A., BROZEK, J., HENSCHEL, A., MICKELSEN, O., and TAYLOR, H. L. 1950. The Biology of Human Starvation. University of Minnesota Press, Minneapolis.

KINSMAN, K. L. 1953. Incidence of drought loss. Effects on the Queensland cattle industry. Quart. Rev. Agric. Econ. 6: 19-23.

MCGILLIVRAY, W. A. 1952. The estimation of carotene in plant material and faeces. N.Z. J. Sci. Tech. A. 33: 31-39.

MARRIOTT, S., and HARVEY, J. M. 1951. Bush hay conservation in north-western Queensland. Qd Agric. J. 73: 249-255.

MOIR, K. W. 1954. The preservation of bovine blood for the determination of inorganic phosphate in the diagnosis of aphosphorosis. Qd J. Agric. Sci. 11: 143-147.

MORRIS, J. G. 1958a. Drought feeding studies with cattle and sheep. 2. The use of sorghum silage with and without urea as a drought fodder for cattle. Qd J. Agric. Sci. 15: 181-194.

MORRIS, J. G. 1958b. Drought feeding studies with cattle and sheep. 4. The use of native grass hay (bush hay) and sorghum silage as basal components of drought fodders for sheep. Qd J. Agric. Sci. 15: 203-213.

NATIONAL RESEARCH COUNCIL. 1950. Recommended nutrient allowances for domestic animals. IV. Recommended nutrient allowances for beef cattle.

PATTERSON, R. 1957. The influence of rainfall on beef cattle numbers. Quart. Rev. Agric. Econ. 10: 16-21.

PEIRCE, A. W., 1945. The effect of intake of carotene on the general health and on the concentration of carotene and of vitamin A in the blood and liver of sheep. Aust. J. Exp. Biol. Med. Sci. 23: 295-303.

PHILLIPS, R. A., VAN SLYKE, D. D., HAMILTON, P. B., DOLE, V. P., EMERSON, K., and ARCHIBALD, R. M. 1950. Measurement of specific gravities of whole blood and plasma by standard copper sulphate solutions. J. Biol. Chem. 183: 305-330.

SCHURCH, A. F., LLOYD, L. E., and CRAMPTON, E. W. 1950. The use of chromic oxide as an index for determining the digestibility of a diet. J. Nutr. 41: 629-636.

VAN SLYKE, D. D., HILLER, ALMA, PHILLIPS, R. A., HAMILTON, P. B., DOLE, V. P., ARCHIBALD, R. M., and EDER, H. A. 1950. The estimation of plasma protein concentration from plasma specific gravity. J. Biol. Chem. 183: 331-347.

WINTROBE, M. M. 1947. Clinical Haematology. 2nd. ed. Lea and Febiger, Philadelphia.

YEATES, N. T. M. 1955. Photoperiodicity in cattle. I. Seasonal changes in coat character and their importance in heat regulation. Aust. J. Agric. Res. 6: 891-902.

YEATES, N. T. M. 1958. Observations on the role of nutrition in coat shedding in cattle. J. Agric. Sci. 50: 110-112.