M. C. FRANKLIN MEMORIAL SYMPOSIUM

THE SURVIVAL FEEDING OF BEEF CATTLE DURING DROUGHT

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Summary

Extended periods of drought occur periodically in the pastoral regions of Australia. The survival of beef cattle grazing under these conditions is dependent on the class and age of the animal, the body condition, the level of feed intake, the duration of the drought period and environment factors.

The feeding of cattle for survival under simulated drought conditions, has been investigated in a number of experiments. The results show that significant linear relationships exist between the intake of digestible energy (kcal D.E./W^{0.75}/day) and daily change in body weight. Energy equilibria, as indicated by zero change in body weight of non-pregnant cattle, were predicted to occur at intakes of 115 kcal D.E./W^{0.75}/day for all-grain and Rhodes grass-lucerne hay rations.

Survival feeding is essentially a problem of adjusting energy intake to a level which allows the deficit of energy expenditure over intake to be met from declining body reserves. Under simulated drought conditions, cattle are capable of metabolizing body reserves until the fat content of the total body is less than 0.5% before death occurs.

The loss of cattle during drought can be reduced by a number of managerial practices which are important components of any drought mitigation programme.

I. INTRODUCTION

Russell (1896), a pioneer meteorologist in New South Wales, described the term “drought” as used in Australia as “a period of months or years during which little rain falls and the country gets burnt up, grass and water disappear, crops become worthless and sheep and cattle die.”

The history of agriculture in Australia has been marred by a succession of these droughts of varying intensity, duration, and distribution, which have been important factors in determining the course of development of the Australian livestock industries.

At the first Biennial Conference of the Australian Society of Animal Production held at Armidale in 1956, the late Dr. M. C. Franklin in his Presidential Address emphasised the serious limitation imposed by recurrent droughts on the productivity of our livestock industries. The intervening 12 years have vividly demonstrated that drought is still a major limitation to the production of beef,

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and that extensive stock losses can occur in a major drought of the type experienced in Queensland and New South Wales in 1965. However, considerable experience has accumulated in this period of the application of drought mitigation techniques. It is my privilege in this paper to review current concepts regarding the nutrition of beef cattle in drought and to recall the important contribution made to them by the late Dr. M. C. Franklin.

As nutritional concepts are dynamic and change with the advancement of knowledge, and as economic pressures vary, it is apparent that no single drought mitigation plan can be applied to all situations. The individual cattle owner has to evaluate a number of possible courses of action in relation to his particular situation. Therefore, the nutrition of beef cattle in drought has ultimately to be related to managerial practices and current economic consideration. Notwithstanding this fact, it is intended in this paper to consider nutritional aspects in detail, and to make only brief reference to the two latter considerations.

II. POSSIBLE COURSES OF ACTION DURING A DROUGHT SITUATION

The courses of action available to the owner of cattle once a drought occurs are essentially those enumerated by Franklin for the management of sheep, namely:-

(i) The reduction of stock numbers by removal of cattle from the drought environment by agistment, or sale of part or all of the herd.
(ii) The feeding of stock in the drought area on edible trees and shrubs, and by hand feeding.
(iii) No action.

These three courses of action may be employed singly, or in combination, to portions of the herd. The decision should be based on an analysis of the situation in relation to:-

(i) Estimated length of the drought or prospect of effective rainfall.
(ii) The current value of stock and likely cost of replacing the cattle after the drought.
(iii) The condition of the stock.
(iv) The relative susceptibility of different classes of livestock to death.
(v) The quantity and value of the feed on hand and the cost of providing edible trees and shrubs and purchased feed.

The prediction of the duration of an existing drought is extremely difficult, although some estimate of the probability of effective rainfall occurring in any “normal” month can be computed from existing rainfall information (Everist and Moule 1952).

111. FACTORS AFFECTING SURVIVAL OF CATTLE IN DROUGHT

When cattle are to be fed during a drought, the factors governing survival assume major importance. Survival appears to be determined by the variables class and age of the animal, body condition, level of feed intake, length of time on the “drought” ration, and environmental factors.

(a) Class and Age of the Animal

Observations in the field indicate that the classes of cattle most likely to die in drought are pregnant and lactating cows, and calves. Aged cows and young
pregnant heifers in poor condition also appear to be more susceptible than mature cows. Essentially, the most susceptible pregnant females are those which either have not had the opportunity to build up an energy reserve, or those which have depleted their reserves by a previous pregnancy and lactation. Mature steers appear to be the least susceptible class of cattle.

(b) Body Condition, Level and Length of the Period of Feeding

Cattle which are being fed for survival in drought are almost always in negative energy balance. The magnitude of this energy deficit, which has to be met from body reserves, is the difference between energy expenditure and intake. Those animals with the greatest reserves of energy, therefore, are able to meet this energy deficit and survive for the longest period, while those with the least reserves, i.e. the animals in poor condition and calves, are the first to succumb.

However, metabolic disturbances precipitated by sudden stress may interfere with the utilization of energy from the fat reserves, as in pregnancy toxaemia in ewes. There do not appear to be any reports of a condition comparable to pregnancy toxaemia occurring in pregnant cows fed drought rations, but all pregnant cattle presumed to have died from starvation do not show complete exhaustion of the body fat reserves. However, when non-pregnant cattle are subjected to sub-maintenance intakes of energy for long periods, their total body reserves of fat (ether extract) can be depleted to 0.2 to 0.3% of the whole body on a wet weight basis (Morris and Moir, unpublished data). Thus, for the survival of cattle in a drought, body fat reserves constitute an important form of “fodder conservation”. The variables body condition, level of feeding and time constitute a large number of possible combinations which may occur in a drought.

(c) Environment Factors.

Blaxter (1962), and Blaxter and Wainman (1964) have shown that the critical temperature at which cattle increase heat production under cold conditions depends on the level of energy intake and factors governing heat loss such as coat characteristics and wind movement. From the calculations of Blaxter (1962), it could be expected that the critical temperature for cattle with “normal” coats given drought rations would be in the range of 7°C (maintenance) to 18°C (fasting) depending upon the level of feeding. As night temperatures in the beef cattle areas of Australia frequently fall below 7°C, cold stress may increase the rate of depletion of energy reserves and decrease survival time.

IV. SURVIVAL FEEDING OF CATTLE

(a) General Considerations

Survival feeding may involve either supplementary feeding or complete hand feeding. The object of supplementary feeding is to supply nutrients in addition to those already available. Unfortunately, even for survival feeding, this ideal is not always realised as the supplement may depress the intake of the forage grazed and act as a partial replacement for it.
Although a variety of supplements have been fed to cattle in drought, they are basically either:-(i) those aimed primarily at supplementing the nitrogen intake of grazing cattle, or (ii) supplements to supply additional energy.

The first category includes natural protein-rich feeds and licks in solid and liquid form based on urea. Both forms of urea supplementation are fairly extensively used in Queensland. Field observations indicate that where adequate low-nitrogen roughage is available, licks based on urea reduce the rate of body weight decline, and in consequence can be expected to improve the chance of survival (Morris 1966a). Information on the value of energy supplements for the survival feeding of grazing cattle is not available, and there is a need for field trials with adequate controls to measure their effects.

Compensatory body weight gains of unsupplemented animals in the post-drought period may greatly reduce or even nullify the differences in body weights which existed between supplemented and unsupplemented animals at the end of a drought. Therefore, unless supplementation increases survival or reproductive performance, it is unlikely to be of economic value. Observations from simulated drought feeding experiments have frequently indicated that the strength of cattle is not always reflected in significant differences in body weight (Southcott and McClymont 1960b; Ryley, Gartner and Morris 1960). It appears that small differences in body weight which per se may be of little economic value, are important in affecting survival.

For the complete hand feeding of cattle in drought, a variety of fodders including some not normally grown for feeding to cattle, such as sugar cane, have been used. However, only a limited number of feedstuffs is available in sufficient quantity to make a significant contribution to any feeding programme.

(b) Feedstuffs Available for the Complete Hand Feeding of Cattle in Drought

The available feedstuffs fall into four categories:—

Grains including wheat, oats, barley and sorghum.

Hays such as lucerne and cereal hay produced from arable land and those of pasture origin.

Silages usually made from forage crops.

Fodder trees and shrubs.

(i) Grain

Wheat is the most important grain crop produced in Australia giving a mean annual exportable surplus of approximately 5.3 million metric tons (Official Year Book of the Commonwealth of Australia 1966). From quantitative considerations, wheat occupies a unique position as a drought fodder, and Morley and Ward (1966) proposed that a national drought fodder scheme should be established utilizing the resources of the Australian wheat industry which has bulk storage facilities equivalent to 10.5 million metric tons (Official Year Book of the Commonwealth of Australia 1966).

Although the annual production of oats, barley and sorghum is quantitatively less than that of wheat, substantial proportions of these crops are grown solely for feeding to livestock. Furthermore, in the tropical and sub-tropical regions of Australia, which experience a greater variability of rainfall than the temperate regions (Leeper 1960), there is greater emphasis on the production of summer growing grain crops such as sorghum, than on the winter cereals.
A drought fodder scheme based on the cereal grains has the following advantages:

Grains are produced in the quantities necessary to meet the demands of a drought.

Availability could be assured by using and expanding the present extensive storage facilities.

Unlike hay, grain can be moved by bulk handling techniques which require a minimum of labour and only moderate capital outlay.

Bulk density and digestible energy values, important factors in determining "on property" cost per unit of energy, are greater than those of roughages.

It should be possible to constitute an authority responsible to the grain producer and stock owner which could co-ordinate storage and movement of grain.

Notwithstanding these advantages, the feeding of all-grain rations to cattle is not without risk, and requires more careful management than the feeding of hay or silage. It appears that, from practical considerations, some roughage is necessary, at least in the initial stages of introducing cattle to all-grain rations.

(ii) Hay

Although the annual production and stocks of hay held on farms in Australia is approximately 5 million metric tons, a large proportion of this is probably associated with the dairying industry.

In the 1965 drought, considerable quantities of hay were fed to beef cattle as a drought fodder, particularly in the early stages when prices were reasonable. However, as the drought progressed, the demand for lucerne hay exceeded the supply, and the mean price on the Brisbane Market for the month of July, 1965 rose to $108 per metric ton. Comparable prices per metric ton for grain were $59 for sorghum and wheat, and $87 for maize.

Lucerne and similar hays have the advantage of being readily accepted by stock, are safe to feed, and provide sufficient nitrogen to be useful as supplements for low protein roughage. However, there are no large scale facilities for the storage of hay such as are available for grain, and the limited storage available is, in the main, at the source of production. Morley and Ward (1966) have shown that where droughts are relatively infrequent, capital and storage costs of hay make this form of conservation expensive and that the fodder is subject to deterioration. However, when hay is given regularly as a supplement to weaners or breeders, the capital and storage costs may be at least partially debited against supplementary feeding, and the reserve would be continually turned over to reduce loss by deterioration.

(iii) Silage

Silage is a commodity that cannot be readily purchased or distributed. The Australian annual production of silage is only about 700,000 metric tons, which is similar to the total quantity of silage in storage. The production of silage has been demonstrated to be technically possible in areas of Queensland with a mean annual rainfall of less than 60 cm. However, in the beef cattle areas there has been poor acceptance of this method of conservation. This is probably due to the uncertainty of producing a crop due to variability of rainfall, and the low nitrogen content of most silages produced from sorghum. In the absence of specialised
equipment, silage is more difficult to feed than hay, and low protein silages are of lower nutritive value than many hays, such as those made from lucerne.

(iv) Fodder Trees and Shrubs

Comprehensive surveys of the “palatability” and chemical composition of edible native trees and shrubs or “top feed” have been prepared by the Australian Northern Territory Administration (1963), and for the sheep areas of Queensland by Everist and Young (1967). However, both papers present little information on either the extent to which fodder trees may be utilized as a drought fodder for cattle, or the performance of cattle fed various shrub types. There is clearly a need for quantitative data on the nutritive value of “top feed” for cattle.

V. EXPERIMENTAL STUDIES ON SURVIVAL FEEDING

Although experimental studies on the drought feeding of sheep in Australia commenced in the 1940’s, similar studies with cattle were not begun until 1956. By this time, due in large measure to the research of Dr. Franklin, a fairly comprehensive body of information on nutritional aspects of drought feeding sheep was available (Anon 1951, 1958). As Dillon (1962) has stated, “while these sheep results could not be directly applied to cattle, they did presage research strategies pertinent to the nutritional aspects of drought feeding of cattle”. These later studies on the survival feeding of cattle, which will be discussed under the broad headings of grain, hay and silage rations, can be regarded as extensions of Franklin’s earlier experiments with sheep.

(a) Grain

A summary of results of trials in which cattle of at least 18 months of age have been fed all-grain or high-grain survival rations are presented in Tables 1 and 2. It appears that steers and non-pregnant heifers in store condition (approximately 200-250 kg body weight) can survive for periods of 6 months on wheat or sorghum grain alone given at the rate of 1.4 to 1.6 kg per head per day. The requirements for the survival of adult non-pregnant, non-lactating cattle of similar body condition, for a period of at least 6 months, are less than 2.7 kg grain per day, and 2.3 to 2.5 kg per day appears to be adequate.

The allowance required for a high rate of survival (> 90%) of pregnant cows in good condition over the last third of pregnancy and early lactation appears to be somewhat in excess of 2.7 kg grain per head daily. Cows in poor condition require more feed, and 3.5 to 4.5 kg grain per head daily appears necessary. As the critical period for the pregnant cows is at parturition, it is desirable to increase the allowance of feed at this time.

Cattle commonly experience digestive disturbances when fed all-grain rations, particularly while being introduced to the ration. These disturbances are generally limited to temporary inappetence, but transient or permanent laminitis may occur (Morris, unpublished data). Cattle can readily be introduced to all-grain rations if these are fed on a daily basis. Experience indicates that one of the safest methods of introducing cattle to all-grain rations is to feed initially a grain-rougahage mixture, e.g. equal parts grain and low quality milled roughage, and gradually reduce the percentage roughage in the ration. However, even with careful management, deaths have occasionally occurred with this method. The rate at which the proportion of grain in the ration can be increased will depend
### TABLE 1

**Summary of trials in which non-pregnant heifers and steers less than 2 yr of age have been fed predominantly grain or all-grain survival rations**

<table>
<thead>
<tr>
<th>Trial No. and Ration</th>
<th>Level (kg air dry matter/head/day) and Frequency of Feeding</th>
<th>Length Experiment (weeks)</th>
<th>Animals</th>
<th>Mean Body Weight</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sorghum (crushed)</td>
<td>1.4 daily</td>
<td>27</td>
<td>heifers</td>
<td>15-18</td>
<td>256</td>
</tr>
<tr>
<td>2. (a) Sorghum (crushed)</td>
<td>1.4 daily</td>
<td>26</td>
<td>heifers</td>
<td>17</td>
<td>10 (1)*</td>
</tr>
<tr>
<td>(b)</td>
<td>1.4 twice weekly</td>
<td>26</td>
<td>heifers</td>
<td>10</td>
<td>10 (1)</td>
</tr>
<tr>
<td>(c)</td>
<td>1.4 weekly</td>
<td>26</td>
<td>heifers</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>(d)</td>
<td>1.4 daily</td>
<td>26</td>
<td>heifers</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>3. (a) Wheat (whole)</td>
<td>0.8 daily</td>
<td>21</td>
<td>steers</td>
<td>yearling</td>
<td>10</td>
</tr>
<tr>
<td>(b) Wheat (whole)+</td>
<td>1.3 daily</td>
<td>21</td>
<td>steers</td>
<td>yearling</td>
<td>10</td>
</tr>
<tr>
<td>Cereal hay</td>
<td>0.8 daily</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. (a) Wheat (whole)</td>
<td>1.6 daily</td>
<td>16</td>
<td>steers</td>
<td>22</td>
<td>10 (1)</td>
</tr>
<tr>
<td>(b)</td>
<td>1.6 weekly</td>
<td>16</td>
<td>steers</td>
<td>22</td>
<td>10 (2)</td>
</tr>
<tr>
<td>5. (a) Wheat (whole)</td>
<td>1.6 daily</td>
<td>19</td>
<td>mixed</td>
<td>16-22</td>
<td>10</td>
</tr>
<tr>
<td>(b)</td>
<td>1.6 weekly</td>
<td>19</td>
<td>sexes</td>
<td>16-22</td>
<td>10 (2)</td>
</tr>
<tr>
<td>6. (a) Sorghum (cracked)</td>
<td>1.4 daily</td>
<td>28</td>
<td>heifers</td>
<td>19</td>
<td>8 (1)</td>
</tr>
<tr>
<td>(b)</td>
<td>1.4 (whole)</td>
<td>28</td>
<td>heifers</td>
<td>19</td>
<td>8 (3)</td>
</tr>
<tr>
<td>(c)</td>
<td>1.4 (whole)</td>
<td>28</td>
<td>heifers</td>
<td>19</td>
<td>8</td>
</tr>
<tr>
<td>(d)</td>
<td>1.4 (cracked)</td>
<td>28</td>
<td>heifers</td>
<td>19</td>
<td>8</td>
</tr>
<tr>
<td>(e)</td>
<td>1.4 (whole)</td>
<td>28</td>
<td>heifers</td>
<td>19</td>
<td>8</td>
</tr>
</tbody>
</table>

*Deaths.
### TABLE 2

*Summary of trials in which pregnant cattle have been fed all-grain rations for survival*

<table>
<thead>
<tr>
<th>Trial No. and Ration</th>
<th>Level (kg air dry matter/day) and Frequency of Feeding</th>
<th>Length of Experiment</th>
<th>Class of Animals</th>
<th>Mean Body Weight</th>
<th>Cumulative change over last 100 days pregnancy and first 70 days lactation (kg)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. (a) Sorghum (cracked)</td>
<td>2.7 daily</td>
<td>24 weeks</td>
<td>171 days</td>
<td>367</td>
<td>-245</td>
<td>-103</td>
</tr>
<tr>
<td>(b)</td>
<td>2.7 twice weekly</td>
<td></td>
<td>Pregnant</td>
<td>385</td>
<td>-331</td>
<td>-117</td>
</tr>
<tr>
<td>(c)</td>
<td>4.5 daily</td>
<td></td>
<td></td>
<td>377</td>
<td>+389</td>
<td>-30</td>
</tr>
<tr>
<td>2. Sorghum (crushed) and Wheat (ground)</td>
<td>1.8 to 3.6</td>
<td>19 weeks</td>
<td>3.4 months pregnant</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

**n.a.** Not available.
to some extent on the number of 'shy feeders', which will be minimal if the cattle have previously had experience of feeding from a trough.

A number of comparisons have been made of the performance of cattle fed all-grain rations on a daily and on an intermittent basis. In one experiment, Southcott and McClymont (1960b) reported that cattle fed whole wheat grain at the rate of 1.6 kg per head per day at weekly intervals were livelier, had shed their winter coats to a greater extent and showed more advanced eruption of their incisor teeth than comparable animals fed the same quantity of wheat at daily intervals. Although there was no significant difference between the groups in body weight, the animals fed weekly had higher values for haematocrit, haemoglobin and red cell counts than the animals fed daily. In another experiment, the same authors found no significant difference in favour of weekly feeding.

The performances of heifers fed crushed sorghum grain either daily, twice weekly or weekly were compared by Ryley, Gartner and Morris (1960). The loss of body weight of heifers fed twice-weekly was less than that of those fed weekly, but not significantly different from that of those fed daily. The general appearance of heifers indicated that those fed twice weekly were stronger than those fed weekly, which in turn were stronger than those fed daily. Haematological values in general were higher in heifers fed twice weekly than daily.

In a comparison of daily and twice weekly feeding of whole and cracked sorghum grain to heifers, Morris (unpublished data) found a greater weight loss in the daily than the twice weekly fed heifers for both whole and cracked grain. The decrease in volume of plasma, blood and red cells was not significantly different between animals fed daily or twice weekly (Payne, Morris and Gartner, unpublished data). Similarly, no significant differences between the body weight change or haematological measurements of pregnant cows fed daily or twice weekly were reported by Ryley and Gartner (1962a).

Although the available evidence is not conclusive, it suggests that the performance of cattle fed grain intermittently is similar to, or better than, that of those fed daily, and that intermittent feeding of grain at twice weekly intervals is preferable to weekly feeding. From the practical aspect, intermittent feeding requires less labour and may result in better distribution of feed amongst the group. On the debit side, it appears that the incidence of digestive disturbances is more frequent in the introductory phase of intermittent than in that of daily feeding, and that there is the possibility of greater loss of grain from depredations by the local fauna.

The processing of sorghum grain considerably increases its digestibility for cattle, but not for sheep. Morris (1966b) reported organic matter digestibility coefficients of 77 for whole sorghum grain fed daily to cattle at a survival level, whereas the same grain, either cracked or finely ground, gave values of 91 and 90 respectively. The apparent digestibility of whole, cracked and finely ground sorghum grain by sheep at survival levels of intake was 92, 90 and 93% respectively. In another trial, steers were fed whole or cracked sorghum grain at a level equivalent to 2 kg per head daily at either daily, twice weekly or weekly intervals. The mean apparent digestibility for all components measured was less when steers were fed at weekly intervals than when they were fed at daily or twice weekly intervals, and the differences approached significance at $P = 0.05$. 28
The observed differences in the digestibility of whole and cracked sorghum grain have been supported by a group feeding experiment (Morris, unpublished data), in which the rate of body weight loss was greater for groups fed whole, than for groups fed coarsely cracked sorghum grain at daily and at twice weekly feeding intervals. Increasing the allowance of whole grain to give digestible organic matter intakes comparable with that of cracked grain, reduced the loss of body weight of heifers to a level which was not significantly different from that of heifers fed cracked grain. Southcott and McClymont (personal communication) also found significantly higher digestibility coefficients for the organic matter of crushed wheat (87.7 ± 0.5) than of whole wheat (81.1 ± 1.7).

Although the above experiment with sorghum grain gave no indication of a greater incidence of digestive disturbances in heifers fed cracked rather than whole grain, there are reports of low acceptance of finely ground grain, in particular wheat. Sparke and Lamond (1966). Grinding, in particular fine grinding, may increase the susceptibility of cattle to digestive disturbances, which is probably due to the resultant increased surface area, and in consequence the rate of digestion of the grain. From practical considerations, it would also appear preferable to crack grain coarsely to minimise both wastage and the possibility of digestive disturbances. The survival feeding of grain to cattle, unlike the case with sheep, appears to be impracticable without the use of feed troughs to prevent wastage.

Coprophagia and geophagia have been recorded frequently in cattle fed all-grain rations in pens (Southcott and McClymont 1960a,b; Ryley, Gartner and Morris 1960). The practice of coprophagia could result in drought fed animals obtaining nutrients from undigested grain voided in the faeces. Hair balls are frequently found in the gastro-intestinal tract of cattle fed all-grain rations, which is probably a consequence of the nature of the diet rather than an alteration in the behavioural pattern of cattle. It is suggested that when cattle ingest rations containing roughage, hair becomes associated with particles of roughage and is thereby carried along the digestive tract. Grain rations lack these carriers for the ingested hair. A factor contributing to the production of hair balls may be an increased ingestion of hair by excessive coat licking, but cattle fed all-grain survival rations do not shed their winter coats as readily as “normal” (healthy) cattle.

The performance of calves weaned at an early age from dams in two simulated survival feeding trials was reported by Ryley and Gartner (1962b). Calves from one of these trials were weaned at a mean age of 62 days and fed a ration of equal parts of crushed sorghum grain and lucerne chaff ad libitum. All calves then survived for six weeks and had a mean daily feed intake and body weight gain of 2.3 and 0.5 kg respectively. In another similar trial, calves of a mean age and body weight of 70 days and 48 kg respectively were weaned and fed an all-sorghum grain ration ad libitum. The mean daily feed intake and body weight gain were less than those resulting from the grain-lucerne ration, being 1.5 and 0.2 kg respectively. Two of the 18 calves in the trial died.

It appears from studies on dairy calves and field experience with early weaned beef calves (Onley 1962; Weller 1966) that performance on rations which contain some roughage is superior to that on all-grain rations. This is possibly partly related to the effect of roughage on enhancing the development of rumen function.
In the trial of Ryley and Gartner (1962b), the low intake of nitrogen from the all-grain ration would appear to be a factor limiting feed intake and growth. For early weaned beef calves, it would appear advisable to supplement grain so the ration contains about 2.5% nitrogen. Lucerne hay is of particular value for this purpose, as it is a roughage and makes an appreciable contribution to the fulfilment of the nitrogen and calcium requirements of the calf.

(b) Silage

Although high protein silages can be conserved, the majority of crops which have been grown specifically for ensiling and for use in survival feeding have been based on the forage sorghums. When harvested for silage in the early dough stage or later, forage sorghums generally contain less than 1% nitrogen in the dry matter (Animal Research Institute, Yeerongpilly, unpublished data). Harvesting before the early dough stage results in higher nitrogen levels but marked depression of total yield.

Published results summarised in Tables 3 and 4 are available for only two feeding trials (Morris 1958b; Ryley 1961), in which sorghum silage was fed as a survival ration for cattle. In both experiments, supplementation of such silage with urea increased the voluntary intake and either reduced or reversed the body weight loss which occurred in the groups not given urea.

The available information indicates that sorghum silage supplemented with urea is an adequate ration for the maintenance of body weight of dry mature cattle. However, for cows in the latter stages of pregnancy, sorghum silage with

<table>
<thead>
<tr>
<th>Trial No. and Ration</th>
<th>Length of Experiment (weeks)</th>
<th>Animals</th>
<th>Mean Body Weight (g/day)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. (a) Bush hay ad lib.</td>
<td>26</td>
<td>22-28</td>
<td>6</td>
<td>237</td>
</tr>
<tr>
<td>(b) ad lib. + 0.6 kg lucerne</td>
<td>6</td>
<td>238</td>
<td>+54</td>
<td></td>
</tr>
<tr>
<td>(c) ad lib. + 1.4 kg lucerne</td>
<td>6</td>
<td>241</td>
<td>+215</td>
<td></td>
</tr>
<tr>
<td>(d) ad lib. + 0.7 kg meat meal</td>
<td>6</td>
<td>339</td>
<td>-101</td>
<td></td>
</tr>
<tr>
<td>2. (a) Bush hay ad lib.</td>
<td>21</td>
<td>18-24</td>
<td>6</td>
<td>209</td>
</tr>
<tr>
<td>(b) ad lib. + lick</td>
<td>6</td>
<td>210</td>
<td>-156</td>
<td></td>
</tr>
<tr>
<td>(c) ad lib. + lick + 0.5 kg sorghum grain</td>
<td>6</td>
<td>216</td>
<td>-45</td>
<td></td>
</tr>
<tr>
<td>(d) ad lib. + lick + 0.5 kg sorghum grain + 57 g urea</td>
<td>6</td>
<td>211</td>
<td>+194</td>
<td></td>
</tr>
<tr>
<td>3. Sorghum silage</td>
<td>28</td>
<td>16</td>
<td>7</td>
<td>174</td>
</tr>
<tr>
<td>(a) Ad lib.</td>
<td>7</td>
<td>176</td>
<td>-74</td>
<td></td>
</tr>
<tr>
<td>(b) Same intake as (a) + 43 g urea</td>
<td>7</td>
<td>172</td>
<td>+162</td>
<td></td>
</tr>
<tr>
<td>(c) Ad lib. + 43 g urea</td>
<td>7</td>
<td>177</td>
<td>+271</td>
<td></td>
</tr>
</tbody>
</table>
Summary of daily body weight changes of pregnant cows fed all-roughage rations over last 100 days of pregnancy

<table>
<thead>
<tr>
<th>Trial No. and Ration</th>
<th>Intake (kg D.M./head/day)</th>
<th>At Approx. 180 days Pregnant (kg)</th>
<th>Change over last 100 days Pregnancy (g/day)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorghum silage</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. (a) Ad lib.</td>
<td>2.9</td>
<td>382</td>
<td>−636</td>
<td>Kyley (1961)</td>
</tr>
<tr>
<td>(b) Ad lib. + 43 g urea/head/day</td>
<td>4.1</td>
<td>371</td>
<td>−332</td>
<td></td>
</tr>
<tr>
<td>(c) Ad lib. + 71 g urea/head/day</td>
<td>4.6</td>
<td>382</td>
<td>−180</td>
<td></td>
</tr>
<tr>
<td>2. (a) Lucerne chaff</td>
<td>3.3</td>
<td>335</td>
<td>−67</td>
<td>Morris (Unpublished data)</td>
</tr>
<tr>
<td>(b) &quot; &quot;</td>
<td>3.3</td>
<td>331</td>
<td>−87</td>
<td></td>
</tr>
<tr>
<td>(c) &quot; &quot;</td>
<td>6.5</td>
<td>348</td>
<td>+546</td>
<td></td>
</tr>
<tr>
<td>(d) &quot; &quot;</td>
<td>6.5</td>
<td>351</td>
<td>+565</td>
<td></td>
</tr>
</tbody>
</table>

added urea does not maintain body weight. This appears to be due to the inability of the pregnant cow to increase the intake of silage to meet the energy demands for pregnancy (Lamberth 1967). The deficiency in energy intake could presumably be overcome by the addition of grain to the silage, as Morris (1965) reported that rations of sorghum silage, sorghum grain and urea were capable of promoting body weight gains of the order of 1.3 kg per head per day in steers. The combination of silage and grain would probably result in fewer digestive disturbances than grain alone, and less silage would have to be conserved as a drought fodder.

(c) Hay

Although hay has been extensively used as a drought fodder, only a few feeding trials with hay as a survival ration have been published. In two of these trials, summarised in Table 4, native pasture hay ("bush hay") was fed either alone or in conjunction with supplements of lucerne chaff, meat meal, grain, and grain plus urea to groups of maiden heifers. Relatively large quantities of these hays, which were of low digestibility (51%) and contained approximately 0.75% nitrogen in the dry matter, had to be ingested to maintain body weight.

Progress results of a long term trial, in which a mixture of Rhodes grass (*Chloris gayana*) and lucerne chaff was fed individually at rates of 2.4 and 3.2 kg per head per day to steers of either high or low body weight, are summarised in Figure 1. At both levels of feeding, body weight progressively declined in all steers, but the rate of decline was greater for steers of high than for those of low initial body weight.

In another trial (Table 4, trial No. 2), body weight changes of four groups each of 10 pregnant cows fed lucerne chaff were recorded. The mean daily changes in body weight (180 days post mating to parturition) were -77 g and +555 g for intakes of 3.6 and 7.2 kg respectively of lucerne chaff (air dry) per
head per day. However, there was a mean loss of 45 kg body weight at parturition. This resulted in a mean net body weight change of the dams over the last 100 days of pregnancy of -541 and +59 g per day respectively.

VI. ENERGY REQUIREMENTS FOR SURVIVAL

The relationship between the body weight of cattle fed sub-maintenance rations and time tends to be asymptotic rather than rectilinear. The degree of departure from linearity appears to depend on the difference between the energy intake and the maintenance requirement, which in turn is a function of initial body weight. This is illustrated in Figure 1, which depicts the body weight change with time of high and low body weight steers fed “high” (3.2 kg/day) and “low” (2.4 kg/day) sub-maintenance rations of Rhodes grass-lucerne hay.

In almost all the experimental studies on survival feeding, cattle have been fed as groups, resulting in considerable variation in energy intake between animals within groups. This results in individual body weight-time relationships of low precision. In summarising the experimental data from group feeding trials, group mean changes in body weight have therefore been used, and linear relationships between body weight and time have been assumed. Linear regressions have been computed relating daily change in body weight (y), g per head per day, to digestible energy (D.E.) intake in kcal/W^0.75/day (x), where W is body weight in kg at the commencement of drought feeding. In cases where digestibility data for
the feeds used were not available, digestible energy values given by the National Academy of Sciences (1964) were used. When digestibility values were expressed on an organic matter or dry matter basis, these were converted to an energy basis by the use of the regressions of Minson and Milford (1966). Table 5 presents the regression equations for the various classes of cattle and fodders used, and the values for energy equilibrium predicted at zero change in body weight. The relationship between daily change in body weight and D.E. intake was significant \( P < 0.01 \) in all four cases.

The predicted D.E. intakes for zero change in body weight of non-pregnant cattle fed all-grain or Rhodes grass-lucerne rations from Figures 2 and 3 were approximately 115 kcal/W\(^{0.75}\)/day, which are considerably less than the values for maintenance given by the Agricultural Research Council (1965). The Agricultural Research Council (A.R.C.) values are expressed in terms of metabolisable energy (M.E.)/day, but these may be equated to D.E. by the factor 1.22 or \( \left( \frac{100.0}{82.1} \right) \) and then to a W\(^{0.75}\) basis. For growing cattle of 300 kg body weight, the A.R.C. maintenance requirements for rations containing 3.4 and 1.8 kcal M.E./g are 154 and 178 kcal D.E./W\(^{0.75}\)/day.

The dejected appearance, reluctance to undertake unnecessary movements, and an observed reduction in rectal temperature are probably expressions of the low rate of metabolism of cattle fed survival rations. For example, under the same environmental conditions other than nutrition, the rectal temperature of the steers fed sub-maintenance rations (Figure 3) was 0.77°C less than that of steers of a similar age maintaining body weight. The Carnegie Nutrition Laboratory

### Table 5

<table>
<thead>
<tr>
<th>Figure</th>
<th>Ration and Method of Feeding</th>
<th>Class of Cattle</th>
<th>Values for ( x ) (kcal/W(^{0.75})) W in kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>All grain and 50/50 grain and roughage — group fed</td>
<td>Steers and Non-pregnant heifers</td>
<td>(-9.4) 8.3 1.3 114</td>
</tr>
<tr>
<td>3</td>
<td>Rhodes grass-lucerne — individually fed</td>
<td>Steers</td>
<td>(-9.20) 8.0 1.8 115</td>
</tr>
<tr>
<td>4</td>
<td>All roughage rations bush hay and silage — group fed</td>
<td>Non-pregnant heifers</td>
<td>(-6.51) 3.8 0.5 171</td>
</tr>
<tr>
<td>5</td>
<td>All grain, silage and lucerne — group fed</td>
<td>pregnant cows 180 days to parturition</td>
<td>(-12.82) 9.0 1.3 142</td>
</tr>
</tbody>
</table>
Experiment (cited by Keys et al. 1950) also showed a reduction in rectal temperature of men fed a sub-maintenance diet. However, Benedict and Ritzman (1923) and Ritzman and Benedict (1938) were unable to demonstrate a similar decline of rectal temperature in their experiments with cattle.

The predicted D.E. intake at which zero change occurred in body weight of non-pregnant cattle fed low quality roughage rations of bush hay and sorghum silage (Figure 4), was 171 kcal/W^{0.75}/day, which is higher than the values found for all-grain and Rhodes grass hay rations (Figures 2 and 3). The difference may be due to several factors. Firstly, energy requirements for maintenance are inversely related to the concentration of D.E. in the ration (A.R.C. 1965). Secondly, the values used in Figure 4 are derived from three experiments which include an equal number of groups which gained and lost body weight. As the efficiency of utilization of energy for body weight gain (k_f), is less than that for maintenance (k_i), the values for groups which gained weight would tend to distort the regression, to cause an over-estimation of the energy intake for zero change of body weight.

The D.E. intakes of cows from the 180th day of pregnancy to immediately before parturition in relation to their daily body weight change is presented in Figure 5. Values were derived from three experiments listed in Tables 2 and
4, which included all-grain, silage and lucerne rations. The predicted D.E. intake for zero change in body weight was 142 kcal/W°.75/day which is in close agreement with that of 146 kcal/D.E./W°.75/day which can be calculated from the mean data of van Es (1961) for cows two months before parturition. For cows two weeks before parturition, the value rose to 176 kcal/D.E./W°.75/day. In the regression of D.E. intake on daily body weight change of pregnant cows 100 to 0 days before parturition (Figure 5), the maternal body weight change was not corrected for the products of conception. Taking the mean weight of 45 kg for the foetus, membranes and fluids at parturition (found in trial No. 2, Table 4) the corrected daily D.E. allowance for zero change in “true” body weight of the dam was approximately 200 kcal D.E./W°.75/day.

Jakobsen (1957) has shown that the requirements for pregnancy rise in an exponential manner described by the equation:—kcal in uterine contents = 416.2 e0.0174t (t = number of days from conception). In estimating the energy allowances for pregnancy of cattle, the A.R.C. (1965) suggest a value for the penultimate month of 1200 kcal M.E./day, rising to 2400 kcal M.E./day for the last month. Expressing the estimated requirements of the pregnant cow as a percentage of the non-pregnant allowance gives the following values—8 to 4 weeks...
before term, 129%; 4 to 2 weeks before term, 163%; and 2 to 0 weeks before term, 178%. The marked rise in energy deposition in the foetus near the termination of pregnancy, and the stress of parturition, at least partially explain the frequently observed mortalities in pregnant cattle at or around calving.

There is only limited information available on the milk production of beef cows under drought conditions. Ryley and Gartner (1962a) found that for cows at a mean of 72 days lactation, daily milk production of groups varied from a mean of 1500 g to 3500 g, depending on nutritional plane. If production averaged 2.5 kg of 4% butterfat milk/day, the A.R.C. (1965) estimates that the additional energy required above maintenance would be approximately 4 Mcal D.E./day. This is approximately half the D.E. intake of cows in trials la and lb in Table 2, and trials la, 2a and 2b Table 4.

Because of the large demands for energy in lactation, the cow which maintains milk production even for a short period after calving jeopardizes her chances of survival in a drought. For survival of the reproducing cow, it therefore would appear advisable to increase the allocation of feed in the last month of pregnancy, and make a further increase at parturition to meet the large demands of lactation. However, as only a fraction of the energy ingested by the cow is recovered as milk, it would appear good practice in drought to wean calves as early as practicable, and to feed cows and calves separately.

Although the regressions which have been presented relating D.E. intake to daily change in body weight are only in reasonable agreement with A.R.C. requirements, their main value lies in the demonstration that survival feeding can have a predictable outcome, that there is an inverse relationship between the level of energy intake below maintenance of body weight and rate of loss of body weight. Therefore, the level of survival feeding is dictated by the length of the period of stress, and the amount of tissue available to be catabolised to meet the energy deficit for that particular class of animal.

An estimate of the feed requirements of different classes of cattle of varying body condition for survival for approximately six months is presented in Table 6. The values given in the table have been derived from experiments under simulated drought feeding conditions. Allowances additional to those listed may be necessary under adverse climatic conditions, or where there is disproportional intake of feed between individuals in a group.

VII. VITAMIN AND MINERAL SUPPLEMENTS FOR SURVIVAL

(a) Vitamin A

Cattle grazing dry pasture herbage in a drought could be expected to have a low daily intake of carotene. However, under these conditions there is a concomitant low intake of energy, and there appears to be little evidence that vitamin A actually becomes a limiting factor for the survival of adult cattle. It would appear that once cattle have experienced a season of green pasture, their liver reserves are adequate for periods of at least 6 months on rations with a negligible content of carotene, (Morris 1958a; Ryley, Gartner and Morris 1960; Ryley and Gartner 1962a; and Gartner and Alexander 1966). The high hepatic vitamin A reserves reported by Gartner and Anson (1966) in sheep fed for periods varying from 3 to 16 months on mulga (Acacia aneura) scrub indicate that cattle are also unlikely to experience vitamin A deficiency when fed edible scrub.
Estimated survival requirements for the complete hand feeding of various classes of cattle on either grain or hay for a period of approximately 6 months

<table>
<thead>
<tr>
<th>Class of Cattle</th>
<th>Body Condition or Weight (kg)</th>
<th>Survival Rate</th>
<th>Grain(^*) (kg/day)</th>
<th>Hay(^+) (kg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cows 1st 2/3rd pregnancy or</td>
<td>&gt; 350</td>
<td>high</td>
<td>2.3</td>
<td>or</td>
</tr>
<tr>
<td>Cows non-pregnant &amp; dry</td>
<td>&lt; 300</td>
<td>high</td>
<td>2.7</td>
<td>or</td>
</tr>
<tr>
<td>Cows last 1/3rd pregnancy and first 2 mth. lactation</td>
<td>good &gt; 350</td>
<td>medium</td>
<td>3.0</td>
<td>or</td>
</tr>
<tr>
<td></td>
<td>poor &lt; 300</td>
<td>medium</td>
<td>3.5–4.5</td>
<td>or</td>
</tr>
<tr>
<td>Non-pregnant heifers or Steers</td>
<td>200–250</td>
<td>high</td>
<td>1.4–1.6</td>
<td>or</td>
</tr>
<tr>
<td>Calves</td>
<td>50</td>
<td>moderate growth</td>
<td>1.5</td>
<td>or</td>
</tr>
<tr>
<td></td>
<td></td>
<td>good growth</td>
<td>1.1 plus</td>
<td>1.1</td>
</tr>
</tbody>
</table>

\(^*\)Grain 3.5 Mcal. D.E./kg air dry.
\(^+\)Hay 2.2 Mcal. D.E./kg air dry.

Calves at birth normally have low hepatic reserves of vitamin A (Moore 1957) which are subsequently increased by the transference of vitamin A from the dam to the calf by colostrum and milk. When cows are fed drought rations low in carotene, both the quantity of colostrum and milk produced and the concentration of vitamin A in them are depressed (Gartner and Twist 1968), and calves may become deficient in vitamin A. Ryley and Gartner (1962b) found low liver reserves and low plasma vitamin A levels and nystagia in calves from dams fed drought rations of all-grain.

(b) Minerals

In all experimental studies on survival feeding of cattle on all-grain rations, 1% ground limestone has been added to prevent calcium deficiency. This practice is a direct consequence of the experiments of Franklin, Reid and Johnstone (1948) and Franklin (1950) with sheep. The addition of limestone to grains before feeding can be achieved simply with feed mixing facilities, but these are generally not available on the farm. The necessity for adding calcium to all-grain rations for the survival feeding of adult cattle has not been examined.

Although grains contain little sodium, sorghum grain approximately 19 p.p.m. (Gartner and Twist 1968), the limited evidence available (Ryley, Gartner and Morris 1960) would suggest that the addition of sodium chloride to all-grain survival rations is not beneficial and may produce undesirable side effects such as oedema.
VIII. MANAGERIAL CONSIDERATIONS ASSOCIATED WITH THE SURVIVAL FEEDING OF CATTLE

Although survival feeding is an important means of mitigating the effects of drought, it constitutes only one of the managerial techniques which should be employed. As the success of a survival feeding programme and the general nutrition of cattle in a drought is dependent on managerial factors, it is proposed to list the salient ones and to briefly comment on them.

(a) Property Development

Sub-division fencing and watering facilities are a necessity for the segregation of the various classes of cattle for survival feeding and efficient utilization of pastures. Introduction of improved pasture species and fertilization of pastures, if accompanied by judicious stocking, may reduce the risk of cattle losses in drought. Installation of irrigation for the sole purpose of providing feed in a drought does not appear to be an economic proposition.

(b) Herd and Property Management

Various herd management practices such as controlled mating, pregnancy diagnosis, early weaning and feeding of calves greatly facilitate the implementation of any survival feeding programme. The integration of cropping and beef production may provide an economic avenue for the building of fodder reserves and the utilization of crop residues for survival feeding.

(c) Intensive Finishing of Cattle in Drought

This technique provides in times of drought a method of reducing stock numbers and providing working capital to buy feed for the breeding herd. The input-output relationships and nutritional aspects of finishing cattle on simple rations of sorghum grain and low quality roughages have been examined by Morris and O'Bryan (1965), Morris (1966c), Morris and Gartner (1967) and Morris, Gartner and Pepper (1967).

IX CONCLUSIONS

1. The management of cattle in drought requires the formulation of a series of decisions for which the main basic information with one exception, the length of the drought, is available.
2. The survival of cattle in a drought is determined by the age and class of the animal, the body condition, the level of feed intake, the duration of the drought and environmental conditions. The energy requirements for survival can be related to these factors so that survival feeding can have a predictable outcome.
3. Managerial factors are an important component of any drought mitigation programme.
4. The pioneer studies on the survival feeding of sheep made by the late Dr. M. C. Franklin and his role as a teacher have contributed greatly to our present concepts on the survival feeding of cattle.

X. REFERENCES

AUSTRALIA, Northern Territory Administration, Animal Industry Branch (1963).

Extension Article No. 5.


