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Nutrition and management of goats in drought

A report for the Rural Industries Research and Development Corporation

by B. A. McGregor

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Foreword

The mohair, cashmere and goat meat industries are establishing industries exporting products valued at approximately $40 million pa. While the infrastructure and supply-chains exists for considerably larger industries, the long-term viability and resource sustainability is threatened by periodic long-term droughts. Inappropriate drought management will seriously damage the land and natural resources of farms, can bankrupt farmers, lead to serious social and personal problems and may lead to a loss of breeding stock which in turn reduces the capacity of goat producers to recover after a long-term drought. Application of inappropriate drought strategies may endanger the welfare of significant numbers of goats.

This report provides the most comprehensive manual ever produced of techniques to manage and feed goats during drought. The report builds on the interim manual that was produced under tight time-lines. This manual incorporates outcomes from previous RIRDC projects, new research data on nutrition and water requirements of goats and a review of developments during the 2001-2005 drought. Feedback has been sought from industry organisations, commercial producers and Departments of Primary Industry in all states of Australia. Two industry workshops were held to evaluate the manual and to identify new practices and deficiencies in our knowledge.

The key areas in this report are:
- the energy and water needs of goats;
- appropriate feeding systems and ration formulation; and
- the welfare of goats.

This project was funded mainly from industry revenue that is matched by funds provided by the Federal Government. The Victorian Department of Primary Industry also provided funding.

This report, a new addition to RIRDC's diverse range of over 1500 research publications, forms part of our *Rare Natural Fibres* R&D program, which aims to facilitate the development of new and established industries based on rare natural fibres.

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- downloads at www.rirdc.gov.au/reports/Index.htm
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Peter O'Brien
Managing Director
Rural Industries Research and Development Corporation

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I also thank the goat producers who provided detailed information on their experiences of drought management of goats including: Ian Firth, Alan Hoppe, Denise Cunningham, Mick Doak, Trevor Bunce, Rowena Doyle, Roger Clarke, Andrew Mosley, Helen Darlington, Tim Ferguson, Steve Grey, Dawn O’Neill and Dr. Doug Stapleton.

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About the author

As a Senior Research Scientist, Dr. Bruce McGregor has specialised in improving the production and quality of speciality animal fibres and goat meat. He has designed and completed many research projects with fine Merino sheep, mohair, cashmere and meat goats. His research and on-farm development and extension programs have been aimed at overcoming constraints to the development of viable industries. He has published 350 research, technical and advisory articles on these subjects. Bruce has had a long interest in nutritional management of Australian goats. At the 6th International Conference on Goats, Beijing, he received one of four Gold Awards for his scientific paper on goat nutrition. He is a member of the Editorial Advisory Board of the international scientific research journal Small Ruminant Research. He is a past president of the Victorian Branch of the Australian Society of Animal Production.

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Executive Summary

Introduction

Drought is a feature of the Australian farming landscape. Until 2002 the Australian goat industry had not previously reviewed the requirements and practices needed during drought feeding of goats.

Research objectives and general approach

This project revises and updates the interim manual produced in 2002 (DAV 202A). This work now completes the objectives of the project "Objective drought feeding guidelines for caprines" that was divided into three stages:

1. Production of an interim technical manual and advisory bulletin on drought management of Australian non-milch goats;
2. Review of water provision and water quality needs for goats; and
3. Implement three of the strategic actions recommended in the report DAV 202A namely:
   - Canvass the wider goat industry to capture farmers recent learning and experiences from the 2002-03 drought;
   - Validate the suitability, implications and appropriate methods of feeding whole grain wheat to goats under simulated drought conditions; and
   - Revise and republish the drought manual for goats incorporating all relevant findings and the review of water provision and quality for goats.

Outcomes and implications of review

This manual has identified and developed information for the best practice of goats during drought. Wherever possible reference has been made to original scientific data. Where relevant data is available for goats, the recommendations provided often differ to those provided for sheep. This project has enabled the first determination of critical live weights for goats. Where relevant data for goats is not available, the information is based on research undertaken with sheep.

The review has updated and revised the energy requirements for goats for maintenance and growth based on published and unpublished research with Australian goats. A number of useful existing and potential practices for improving the nutritional management and welfare of goats during drought have been identified. The impacts of cold and heat stress on the energy requirements of goats have been reviewed. Research on water requirements of goats has been included based on new Australian data. Welfare requirements of goats during drought have been briefly reviewed. New information on the role, impact and assessment of body condition scoring in goats has been included.

The manual could never claim to be exhaustive but represents a comprehensive amount of technical information pertaining to the drought management of Australian goats. The manual has identified a number of deficiencies in knowledge regarding best practice and welfare of goats during drought that should be rectified.

Recommendations

On the basis of the findings the following recommendations are made:

1. That the manual be published and made available to goat producers and advisory agencies.
2. That industry associations are encourage to link their internet sites to the drought manual and advisory bulletin on the RIRDC and DPI Victoria internet sites.
3. Investigate a number of important areas impacting on drought management of goats.

1 Introduction

1.1 Preparing for drought

1.1.1 Major issues

The major issue with managing goats in drought is the deteriorating financial situation for the farmer. This occurs as the drought progresses and demand increases for purchased feed. Feedback from goat producers in the 2001-2005 drought included the following comments:

> **"People get in too deep before they realise. Some spend a fortune, far more than what the animals are worth."**
>
> **"I didn't realise how bad it would be. Should have really destocked."**

The key issues associated with drought management are:

- Planning ahead and forecasting; and
- Anticipating stock and pasture condition and water availability.

Key decisions that will need to be made by the farmer are whether to feed, agist or sell the stock. The interactions between economic viability, stocking rate, land degradation and animal welfare are complex and conflicting. The last resort "that it's cheaper to let them die in the paddock" contravenes cruelty legislation and Codes of Practice. It is unacceptable to let goats die or suffer during drought.

> **"The thing about a drought is that things get a bit emotional."**
>
> **"The best drought strategy is to sit down and think."**
>
> **(Producer of 5000 goats after 2001-2005 drought)**

1.1.2 Drought strategies

All farmers need to prepare for drought. For drought strategies to be successful, they need to be flexible. They need to be capable of being implemented and varied according to the severity and duration of the drought. Livestock producers have a range of drought strategies including:

1. Feeding all the stock on the property;
2. Culling and selling some stock;
3. Agisting stock on another property;
4. Selling all the stock.

Most goat farmers use option 2. Option 2 reduces the costs of feeding and avoids expensive purchases of replacement stock when the drought ends. The decision on drought strategy is a grey area, do you maintain, sell or feed to reproduce?

The answer requires a clear economic understanding based on knowledge of markets, feeding options and attitudes to hard work and risk. This means calculators, cash flow charts, knowledge of feed availability, normal liveweight patterns and of market trends. This manual provides much of the technical information needed to support decision making.

STOCKPLAN is a drought decision support package produced by New South Wales Agriculture. It allows producers to determine a breakeven budget by evaluating the impact of decisions over a 10 year period on herd structure. Other computer decision packages may also be suitable. A guide to assist wool producers determine which sheep to keep may also be of assistance (Anon 2004a).

1.1.3 Which goat to cull?

Goat farmers have reported a range of drought culling practices. These include culling:

- Non-breeding goats including wethers;
- Does with no kids, poor teeth, udder faults, feet faults etc;
- Shy feeders;
- Cross-bred and rangeland goat types;
- Saleable goats.

Most goat producers aim to keep their breeding flock substantially intact so they can recover their stock numbers as rapidly as possible when the drought breaks. Pregnancy testing is a valuable tool to enable identification of the most valuable breeding does to retain when facing drought.

1.1.4 Pastoral area issues

The incidence of drought in pastoral areas is 3 years in each 10 year period (Anon 2005). The greatest issue is to ensure that management during drought does not undermine the land's ability to recover post-drought.

Drought management strategies for goats in pastoral areas differ to the options available to cattle and sheep producers. The biggest problem is that goat producer cannot readily access agistment, usually because fencing is inappropriate. Goats cannot really use stock routes, in part because of fencing issues. This means that more planning is required compared with cattle and sheep, particularly with the feeding and exit schedules.

One experienced pastoral producer feels that the best strategy is to provide more feed early in the drought to finish and sell the goats rather than holding onto the goats for an unknown period.

"The reason to keep goats should be to have a marketable product – a breeding doe or finished meat goat – not just to keep the goat alive."

(Very experienced rangeland goat meat producer after 2001-2005 drought)

"If I run into another drought I will do it a lot smarter than the last one."

(Very experienced goat meat producer after 2001-2005 drought)

One option in pastoral areas when faced with drought is to fence additional areas for goats so the capital value of the property is increased while at the same time providing greater access to fresh browse for the retained goats. This type of investment provides long-term benefits compared with the purchase of feed that only provides a relatively short-term benefit.

1.2 Vendor Declaration

When goats are sold producers need to prepare the correct paper work prior to the arrival of livestock carriers. Requirements for various Declarations are changing and depend on State and buyer requirements. A current National Vendor Declaration (NVD) may be needed. Goat Health Statements are currently required in New South Wales for goats not consigned for slaughter.

The NVD is updated from time to time, so you should always check you are using the latest version by visiting the Meat and Livestock Australia internet site (http://www.mla.com.au), phoning 1800 683 111 or emailing lpa@mla.com.au. An example of a completed Goat NVD Waybill is shown in Appendix 2.

1.3 Project Objectives

This project aimed to produce the best possible technical manual on drought feeding and management for Australian goats.

1.3.1 Justification for investigation

Prior to 2002 drought feeding and water supply recommendation for goats in Australia were not based on scientific knowledge of the energy and water requirements of goats. Many goat managers were not in the industry during the last long-term drought (1981-1983). Since this time there has been many scientific investigations into the nutritional and management needs of Australian goats. It is appropriate that the application of this knowledge be directed to providing the best drought strategies to reduce the impact of the drought on the welfare of goats and the financial and social stress on families.

While goats have generally similar energy requirements to sheep of similar live weight under calm conditions, there is objective evidence that the appropriate ration formulation, performance under non-grazing conditions, responses to grain feeding, welfare needs, and requirements under adverse climatic conditions differ significantly from ovine and bovine species. This manual updates and expands on the interim manual produced in 2002 (McGregor 2003).

1.3.2 Current industry practices

Benefits from the application of this work should include: less resource damage during droughts as a consequence of more appropriate use of pastures, grain, and water resources; increased capacity of goat producers to rebuild herds and become more productive after a long-term drought; improved welfare of goats; and more confident and capable farmers using appropriate science based industry resource materials.

1.3.3 Project Methodology

The following was carried out:

1. Reviewing published material relevant to the nutritional needs, feeding systems, ration formulation and welfare of goats and bring the data together in a technical manual.
2. Canvassing the wider goat industry, agents, and State Government staff operating with the goat industries seeking their views and input on unique approaches to the drought management of goats in an attempt to capture and evaluate the learning of experienced goat producers.
3. Evaluation of unpublished scientific material known to contain relevant information. Analyse and prepare this information for scientific publication and use in this manual.

1.3.3.2 Literature review

Research databases have been searched in an attempt to find scientific and other publications on the subject. Databases searched include Agricola, Australian Bibliography of Agriculture and CAB Abstracts. Few relevant articles on drought feeding were found.

This review includes data available from previous research from RIRDC funded projects, a recent scientific review that summarises relevant work of other scientists, and other articles considered relevant to the topic. Relevant information from Government Departments of Agriculture has been included, particularly information on the strategies for managing animals and from the Victorian Department of Primary Industries publication on drought feeding (Court 2002). Chapter 7 is substantially taken from Court (2002).

This review does not claim to be exhaustive. The initial interim manual was prepared under tight deadlines at short notice. The production of this manual has enabled some reflection on the recent drought and inclusion of goat producers' experiences. Drought feeding and management are complex issues and so the reader is directed to other sources for information on many issues that are outside the scope of this work. It was not possible to cover the many articles in the literature on the drought feeding of sheep that may be relevant to this topic. I have used my research wherever possible, partly because much of it has been focussed on managing goats during dry summer and long-term droughts and secondly it was readily available and understood. Some of this research has not been published elsewhere and is included here to answer requests from goat producers.

2 Droughts

2.1 Introduction

2.1.1 Scope of review

The revised Australian Goat Notes (Simmonds 2001), provides a wealth of valuable information for potential and current goat managers. The advice it contains on drought feeding goats (McGregor 2001a) is outdated being based on a brief article published two decades earlier during the 1982 drought (McGregor 1982a). Indeed the international scientific literature on goat nutrition rarely mentions drought feeding requirements for goats. For example, a major international conference on Goat Nutrition, co-hosted by the Food and Agricultural Organisation, fails to mention the subject of drought (Morand-Fehr 1991). This contrasts with the authoritative textbook on Australian pastoral industries (Alexander and Williams 1973) that mentions drought on page 15!

Since the early 1980s there has been considerable progress in understanding both the nutritional requirements of Australian goats and on the best strategies for feeding and managing goats during drought.

This manual brings together scientific data relevant to the energy and water needs, appropriate feeding systems, ration formulation and welfare of Australian goats in relation to drought management. This manual replaces earlier reports (McGregor 2003) also draws upon other drought feeding and management recommendations provided by Government Departments for sheep (Court 2002) and goats (Scarlett 2002). This manual includes data available from previous RIRDC funded goat research projects, and on some unpublished experiments that are considered relevant.

2.1.2 Droughts and goats in other countries

A search of Agricola and CAB abstract databases revealed less than 15 articles mentioning goats and drought. Articles from South Africa, Morocco, Botswana, Kenya, Zimbabwe, Brazil and Trinidad and Tobago made a connection between drought and goat production. Few had any relevance to Australia. A report from Brazil was of interest. Gutierrez et al. (1985) studied the strategies of goat producers in a semi-arid region of northeastern Brazil for coping with drought. They observed that small-scale farms with cattle, sheep and goat herds performed relatively better during the drought period of 1981 to 1983 than farms with cattle and sheep only. Even though cattle production was the most important component of overall farm production and income, sheep and particularly goat production appeared to guarantee survivability to the producer by adding flexibility to the system when drought occurs.

2.2 What is a drought?

2.2.1 Many ways of defining drought

Goat producers indicated at workshops that they were uncomfortable with current definitions of drought. Clearly drought happens at different times of the year in wet/dry season climates, semi-arid pastoral regions, cold winter tablelands. The time of the year is really irrelevant, a drought occurs when feed quality and availability is much less than required to maintain the long-term livestock carrying capacity of the land. Lack of rain during the pasture growth phase is the biggest issue. The deficiency in feed could be a 50% reduction compared with “normal” seasons. In modern livestock systems a drought could be defined as a reduction in feed resources that prevents a system from reaching production targets for goats that would be reached in a typical season.

Droughts are re-occurring features of Australian climatic variation. Droughts have been defined as a “situation where the supply of water falls below critical demand; and as the demand is generally a function of man’s activities drought can be considered to be man made” (Gibbs and Maher 1967). There are many other definitions of drought and readers are referred to Anon (1990).

In Australia, the majority of farmed goat grazing occurs on grasslands, either improved or native, which exhibit very seasonal patterns of pasture growth (growing seasons commonly of 5 to 8 months). Mean annual rainfall in the wheat-sheep zone varies from 400 to 750 mm. Usually growing seasons extend from mid autumn to late spring although in northern parts of the wheat-sheep zone summer rainfall predominates.

Williams (1973) did not regard these extended periods of absence of rain as drought. The so-called "dry season" of the tropical north and the dry summer conditions referred to above are seasonal droughts at best, as the pasture system remains dormant until the next growing season commences. However few droughts are completely rainless. According to Williams (1973), "feed shortages which seriously disrupt animal production generally have their origins in the rainfall and pasture growth of the preceding season". For example, the drought of 1981 to 1983 in southern Australia, began with below average rainfall in the spring of 1981, restricting spring pasture growth. This was followed by below average rainfall during 1982, producing a "green drought" during winter and spring. Thus there was little feed in storage and reduced summer pasture residues. In this case there was also reduced water run-off leading to very low levels of water supply in the summer of 1982-1983.

Sturgess (1973) defined drought in a more management orientated way as "any period in which supplementary feeding at a defined level is necessary as a result of adverse seasonal conditions. The severity of the drought is indicated by the quantities of fodder it is necessary to feed, while the length of the drought is the period between the commencement and conclusion of hand-feeding".

Sturgess's definition of drought clearly includes seasonal droughts if supplementary feeding was considered necessary as well as the longer-term periodic droughts.

The biggest issue for many goat producers is how to identify the commencement of drought.

2.2.2 What is the "normal" seasonal pattern of goat live weight loss?

An unstated assumption in discussions of drought feeding is that animal live weight change and welfare is well understood. William's view is that normal seasonal changes are not classified as drought whereas Sturgess's view was that if supplementary feeding is necessary owing to adverse conditions then drought management is required. So what are the normal seasonal changes in goat live weight during summer?

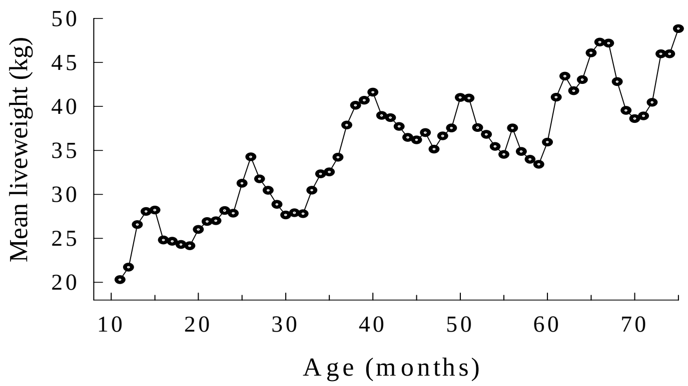


Figure 2.1. The changes in live weight of Angora wethers (castrated male) goats grazed on annual pastures in southern Australia and weighed every month from 10 to 75 months of age. Annual maximum live weights were reached at the end of spring or in early summer

Figure 2.1 shows the pattern of live weight change of Angora wether goats grazing annual temperate pastures near Melbourne, Victoria (37°54'S., 144°41'E., elevation 46 m, mean annual rainfall 520 mm, adapted from McGregor 1998). The peak annual live weight occurs at the end of spring, usually in early summer. The animals then experience live weight loss as the hot summers and autumns are characterised by declining quantities and qualities of mature dead pasture residues. It has been known for many years that these pasture residues are deficient in both energy and nitrogen resulting in loss of live weight and declining fibre production of sheep grazing such pastures (Donald and Allden, 1959).

In three successive years these goats experienced live weight loss during summer and autumn for periods of 5, 7 and 4 months, resulting in loss of live weight equivalent to 14%, 21% and 20% of the previous maxima respectively. These periods of live weight loss are typical unless supplementary feed is provided. In these environments there are no or few browse plants available as alternative feed sources. In this environment maintenance of live weight is rarely observed.

Figure 2.1 also shows the impact of a long-term drought that extended from 12 to 32 months of age. The first spring appeared normal enough but the following winter and spring exhibited poor animal growth. The second spring was shortened (months 24 to 26) followed by four months of rapid live weight loss. There was then a two-month period of constant live weight as the goats were removed from the pastures and fed to maintain live weight. Animals at higher stocking rates received significantly more feeding over much longer periods.

A brief review of sheep stocking rate experiments supports this experience with goats. This is to be expected as the main nutritional limitations are the same for goats and sheep. In southern and southwestern Australia and in the wheat sheep belt, seasonal droughts are usually experienced annually. Over a 12 to 16 week period in the summer, a 25 to 30% loss of live weight in sheep appeared to be normal (Brownlee 1973, Birrell et al. 1978, Egan et al. 1977, Davis et al. 1973, McGregor 1985b,c). Such a weight loss occurred before the critical live weight was obtained in sheep (see Section 3.2.1 for a discussion of critical live weight).

No Australian data was found on comparisons between goats and cattle on either improved pastures or in rangelands under normal or drought conditions.

2.3 Drought, stocking rate and grazing goats

2.3.1 Impact of stocking rate of goats and sheep

Drought is associated with stocking rate. In dry conditions a high stocking rate will lead to an earlier onset of drought compared with a lower stocking rate. A decision to increase stocking rate increases the severity and impact of drought, until, at very high stocking rates, drought can be continuous (Sturgess 1973).

In the study of McGregor (1985b,c) conducted on annual temperate pastures, goats and sheep were grazed at a range of stocking rates in separate goat and sheep pastures and when mixed together in equal numbers. During the course of this study a long-term drought was experienced (1981 to 1983). As expected, it was observed that when the stocking rate of goats and sheep grazing annual pastures was increased, the amount of supplementary feeding necessary was increased. However, separately grazed **sheep required significantly more** supplementary feeding than separately grazed goats, as the pasture grazed by the goats had significantly more herbage available at the start of the drought period. Indeed, sheep grazing with goats on the mixed grazed pastures required significantly less supplementary feeding, as they were heavier than separately grazed sheep and took longer to reach critical live weights than separately grazed sheep at the same stocking rate.

One of the reasons that supplementary feeding began later in the drought on the pastures grazed only by goats was also the ability of the goats to utilise more of the paddock feed (McGregor 1985c). Thus using the definition of drought provided by Sturgess, the drought period was less for separately grazed goats compared with the sheep.

2.3.2 Impact of mixed grazing and stocking rate of goats and sheep

In the study of McGregor (1985b,c), goats and sheep were grazed at a range of stocking rates in separate goat and sheep pastures and when mixed together in equal numbers. At the recommended stocking rate, goats grazed with sheep had similar requirements for supplementary feeding as the sheep but their requirements were greater compared with the goats grazed separately at this stocking rate. When the stocking rate was 25% above the long term recommended level, the drought feeding requirements of goats mixed grazed with sheep were 50% greater than the requirements of the sheep grazing these pastures. This increased requirement reflected the reduced ability of the goats to compete with the sheep under conditions of reduced herbage availability at this high level of stocking rate. As a consequence, these goats reached critical live weights earlier than did the sheep.

Producers who have grazed goats with sheep during the 2001 to 2005 drought reported that the sheep “ate everything under the goats feet” resulting in the goats needing feeding earlier than the sheep.

2.4 Drought and reproduction

2.4.1 Effect of drought on kidding performance

One of the costs of drought is the reduction in kidding performance. Reproductive performance of goats is affected by the live weight of does at mating time and the change in live weight at mating, see McGregor (2002c) for more details. Long-term drought results in depressed live weight and either falling or static live weight. This will result in reduced kidding rates. With rangeland goats Henzell (1982) reported that drought increased mean kidding interval from 221 days to 337 days.

Nutritional stress during the first 50 days of pregnancy will result in increased abortions in pregnant does. Furthermore, does fed to lose weight during mid pregnacy (day 50 to day 90), had a foetal loss of 21% (McGregor 1995).

In drought, does that conceive and kid late will have kids that are poorly grown by weaning time. The effect of late kidding on weaning weight are summarised for one flock that kidded during drought in 2002 (Table 2.1). Small kids at weaning will not grow over the dry summer period (McGregor et al. 1988). The acceptable kidding performance during drought depends on normal kidding performance and the decisions taken on mating or culling light weight does and the length of the mating season.

Table 2.1. The effect of time of kidding on mean live weight of kids (kg) at weaning when reared during drought conditions (Ferguson and McGregor unpublished 2005). Number of kids shown in brackets

Time of kidding	Single born	Twin born	Triplet born
First 12 days	17.9 (89)	13.6 (109)	12.6 (29)
Second 12 days	15.9 (89)	11.2 (62)	11.1 (19)
Last 3 weeks	12.3 (31)		

The impact of vermin control on kidding performance is briefly discussed in Section 6.4.

2.5 Occupational health and safety risks

There will be an increased risk of work place health and safety risks during drought. Increased manual handling of feed, livestock and equipment increases the risks of injury. Longer hours spent working outside increase the risks associated with sun exposure. The handling of hay, straw and equipment for feeding stock increases the risks of damage to the hands and eyes. The use of sunscreen, hats, gloves, boots and gaiters will reduce the risks associated with door work during drought.

Hat - sun protection and stops hay blowing down the neck

Gloves provide protection when handling hay bales, bins and troughs

Gaiters keep grass seeds out of socks

Safety boots protect against rough ground and animals standing on feet

Photo 2.1. This goat producer shows excellent health and safety precautions while feeding out on a very hot day

There are also risks associated with increased handling of sick or dead animals. Adequate precautions need to be maintained.

3 When and how to drought feed

3.1 Drought planning

The decision to begin drought feeding needs to be part of detailed drought planning. Some of the planning issues are discussed later in this report. Further details on drought planning can be found elsewhere (eg. Court 2002, Anon 2002a, AgNSW 2002, Anon 2003). This review is written on the understanding that the decision has been made to provide drought feeding to goats.

The commencement and cessation of feeding, the level of supplementation and the introduction strategy are important components of drought management. Feeding too early or for too long can waste feed while commencing too late or stopping too soon can result in stock illness or deaths. Often the largest stock losses occur after the drought has broken, especially if the weather turns cold.

3.2 When to start feeding

Feeding should be started well before the goats reach their critical weight related to when they become weak. It may take some time before they become accustomed to hand feeding and begin eating their ration. If goats have lost too much condition before feeding has begun, or before they readily accept grain, it may be hard to lift their live weight back to desirable levels. This is particularly applicable to kids or weaners that were not fed supplements when grazing with their mothers.

It pays to remember that, unlike fire or flood when goats may have to suddenly rely on hand feeding alone, the onset of a drought is usually gradual. Thus drought conditions rarely start when no grazing is available. Experience from previous droughts indicates that more paddock feed is available than would first appear. Goats can scavenge quite a bit of feed from sparse, dry pasture, weeds, dead leaves, low browse and buried clover or medic burr. However once the energy expended by goats to obtain this scavenged feed is greater than the energy gained, the goats will begin loosing body reserves. The presence of paddock feed early in a drought makes it easier to get the goats accustomed to the drought rations before they have to be fed full rations. The nutritive value of this scavenged feed is discussed later in this report.

3.2.1 Critical live weight and culling

The critical live weights for goat breeds have not previously been defined. This Section estimates the critical live weights for Australian fibre and meat goats. The results are summarised in Table 3.3.

3.2.1.1 Critical live weight - the concept

The idea of a critical live weight for drought feeding is based on observations of animals in a drought. Grazing animals can loose 20 to 30% of their peak spring live weight and still be active. However further live weight loss may endanger the survival of the animal by leaving them too weak to walk, graze or safely obtain drinking water. The concept of critical live weight was developed to indicate the minimum live weight that will enable an animal to survive. The critical live weight is also used when determining feeding level and for long term budgeting and purchasing of feed.

Oddy (1978) provided a guideline to the critical live weight for various breeds and strains of sheep. This critical live weight (Table 11 in Oddy 1978) is for fasted live weight and less the weight of fleece. Given that sheep may lose 2 kg in an overnight fast and making an allowance of 3 kg for greasy fleece weight (approximately the amount of wool grown between mid-spring shearing and late summer when drought feeding may commence), the information in Table 3.1 can be calculated.

3.2.1.2 Critical live weight and standard reference weights

Ideally, the critical live weight of goats would represent a proportion of the goats ultimate mature size. The concept encounters the problem of deciding when the mature size is reached and in accounting for the difference between sexes. The normal approach is to nominate a body condition score associated with the age and live weight of the animal. For sheep, SCA (1990) defined the concept of Standard Reference Weights (SRW, kg) as the live weight achieved when the animals skeletal development is complete and the empty body contains 250g fat/kg. For sheep this is achieved at a body condition score of approximately 3. Wether sheep have a SRW 20% higher and rams have a SRW 40% higher than ewes (SCA 1990).

The relationship between Oddy's (1978) suggested critical live weights (fleece free) and the SRW was calculated (Table 3.2) and the value ranged between 58 and 66% of the SRW. The variation in this ratio may be related to the mature live weight of the breed and perhaps some disagreement between the sources as to the mature weight of the sheep. The average value of this ratio was 63%.

Table 3.1 Guideline to critical live weights for various breeds and strains of sheep [#]. These live weights are off pasture with an allowance for fleece growth equal to half of a shearing interval. Values for sheep from Oddy (1978)

Breed or strain	Average, kg	Bottom ¼ of mob, kg
Small-framed Merino	35	32
Medium-framed Merino/Polwarth	40	37
Large-framed Merino	45	42
Corriedale	45	42
Border Leicester-Merino cross	50-55	48

[#] All values are provided for guidance purposes only. It is the responsibility of owners to ensure that sheep are managed in accordance with the Code of acceptable farming practice for sheep

Table 3.2 Comparison of critical live weights of sheep (Oddy 1978) with Standard Reference Weights for castrated males (SRW) or different breeds or stains of sheep (SCA 1990). Critical live weights (CLW) equal critical fasted fleece free live weight plus 2 kg (Oddy 1978)

Breed or strain	SRW, kg	CLW, kg	CLW/SRW, %
Angora goats	47	30[#]	
Small-framed Merino	48	32	66
Medium-framed Merino/Polwarth	60	37	62
Large-framed Merino	72	42	58
Corriedale	66	42	64
Border Leicester-Merino cross	66	42	64
Average value for sheep			63

[#] CLW calculated from SRW of wethers using the average ratio of 63% derived from sheep

3.2.1.3 Critical live weight of goats – seasonal peak method

McGregor (1985c and unpublished) calculated a critical live weight (CLW) of Angora goats as:

> CLW = 70% of the peak live weight at the end of the spring plus 1 kg for each year of age of the goats plus estimated greasy fleece weight.

The use of a 30% reduction in peak spring live weight was based on the typical changes observed in annual live weight patterns with sheep (Section 2.2.2). In this instance the goats were 2½ years of age and the calculated critical live weights ranged from 20 to 24 kg depending on the stocking rate during the previous spring. The use of 20 kg as the critical live weight was practical and enabled the Angora wether goats to survive the drought.

3.2.1.4 Critical live weight of Angora goats – standard reference weight method

The maximum mature live weight that the Angora wether goats reached in this grazing experiment was 54 kg (McGregor 1989 unpublished). The live weight when these Angora wether goats reached a total body fat content of 250 g fat/kg was approximately 47.5 kg if an allowance for the fat content of all non-carcass tissues is made (McGregor 1992a).
Applying the average ratio of CLW/SRW for sheep from Table 3.2, provides an estimated CLW for adult Angora wethers of:

CLW = 0.63 x 47.5 kg ≈ 30 kg.

An allowance must then be made for fleece weight (assuming 2 kg). Thus does have a CLW of 27 kg, wethers of 32 kg and bucks of 37 kg.

3.2.1.5 Critical live weight of other goat breeds – standard reference weight method

Cashmere goats

There is insufficient information about the total body fat content for cashmere goats to enable an estimate of the live weight when this breed would reach 250 g fat/kg of total body weight. Cashmere type goats are regarded as being leaner than Angora goats but there is no carcass composition evidence to support any determination. Five-year-old Australian cashmere wethers have reached a mean live weight of 60 kg at a body condition score of 3 (McGregor 1990b). Using this live weight a CLW can be estimated for these wethers as:

CLW = 0.63 x 60 kg ≈ 38 kg.

However cashmere benchmarking data (Figure 3.1, McGregor 2005a and unpublished) has shown that the typical peak live weight for adult cashmere does (4, 5 and 6 years of age) under reasonable seasonal conditions was 45 kg. This is a more likely value to use as wethers would be culled during drought. Using this live weight a CLW can be estimated for cashmere does as:

CLW = 0.63 x 45 kg ≈ 28 kg.

Using an allowance for fleece weight (assuming 0.5 kg) and adjusting for the sexes provides a CLW for does of 28 kg, wethers of 33 kg and bucks of 38 kg.

Critical weights need to be determined by each producer as the live weight of cashmere does varies significantly between age groups and between properties as shown in Figure 3.1.

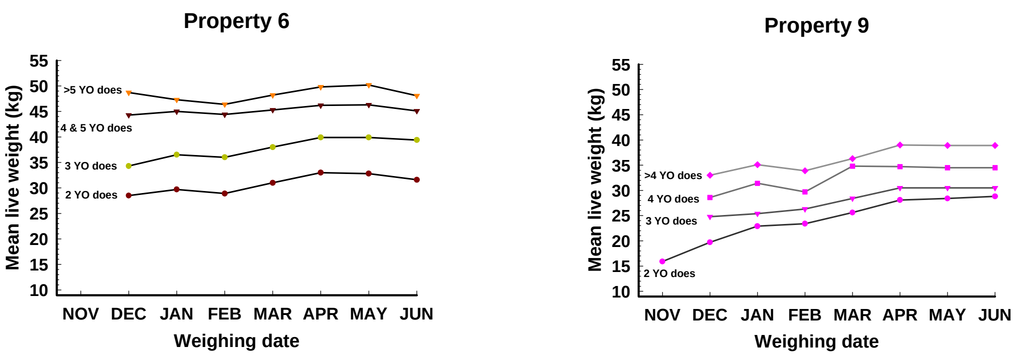


Figure 3.1. Changes in the mean live weight of various aged cashmere does from late spring until June on two properties (McGregor 2005a)

Boer goats

Campbell (1981) regarded the mature live weight of the improved Boer goat as 100 kg for males. These animals are likely to have had a body condition score in excess of 4. The body composition of 12 well fed Boer goat does between the live weights of 18 to 59 kg were reported by Viljoen et al. (1988). An analysis of the data for this review indicated that at about 55 kg live weight a total body fat composition of 25% was reached. This is in general agreement with field work (McGregor unpublished 2001), where in a flock of Boer goat does the mature weight for Boer females at a condition score 3 was approximately 60 kg. Using the former live weight, a CLW can be estimated for does as:

CLW = 0.63 x 55 kg ≈ 35 kg.

With no allowance for fleece weight and adjusting for the sexes provides a CLW for does of 35 kg, wethers of 42 kg and bucks of 50 kg. Clearly there are larger individual Boer goats, but the reader must remember that the CLW is derived to assist management of a large herd of these animals and the critical live weight is used to a guide as to the minimum weight to be reached during a drought. Several producers reported that Boer does should be at least 35 kg to enable them to reproduce.

Table 3.3 A guideline to critical live weights# for breeds of goats based on estimates of standard reference weights or by the use of the seasonal peak live weight method. These live weights are off pasture with an allowance for fleece growth equal to half of a shearing interval. Adjustments need to be made for small or large strains of goats.

Breed of goat	Critical live weight, kg		
	Does	Wethers	Bucks
Standard reference live weight method			
Angora goats	27	32	37
Cashmere goats	28	33	38
Boer goats	35	42	50
Seasonal peak live weight method			
All breeds	30 % less than previous peak live weight plus 1 kg for each year of age plus estimated fleece weight		

All values are provided for guidance purposes only. It is the responsibility of owners to ensure that goats are managed in accordance with the Code of acceptable farming practice for goats.

3.2.1.6 Culling based on live weight

Removing the “tail of a mob” for feeding or disposal enables more appropriate feeding and management for the remaining heavier and better conditioned goats. Commercial examples are provided in Table 3.4 and Figure 3.2. How the different groups of goats classified in Figure 3.2 could be assessed is illustrated in Table 3.5.

Table 3.4. The live weight and condition score of the average and the bottom quarter of a mob of Australian goats at different ages and in different seasons (McGregor unpublished 2005)

Mob and Age	Mob average	Average of bottom ¼ of mob
Live weight (kg)		
Mob A, 9 months of age	16.9	13.5
Mob A, 14 months of age	24.2	20.0
Mob A, 2 years 9 months of age	36.8	30.8
Body condition score		
Mob A, end of drought	1.8	1.1
Mob A, six months after end of drought at end of good spring	2.7	2.0
Mob A, 1 year after end of drought in mid winter	2.2	1.6

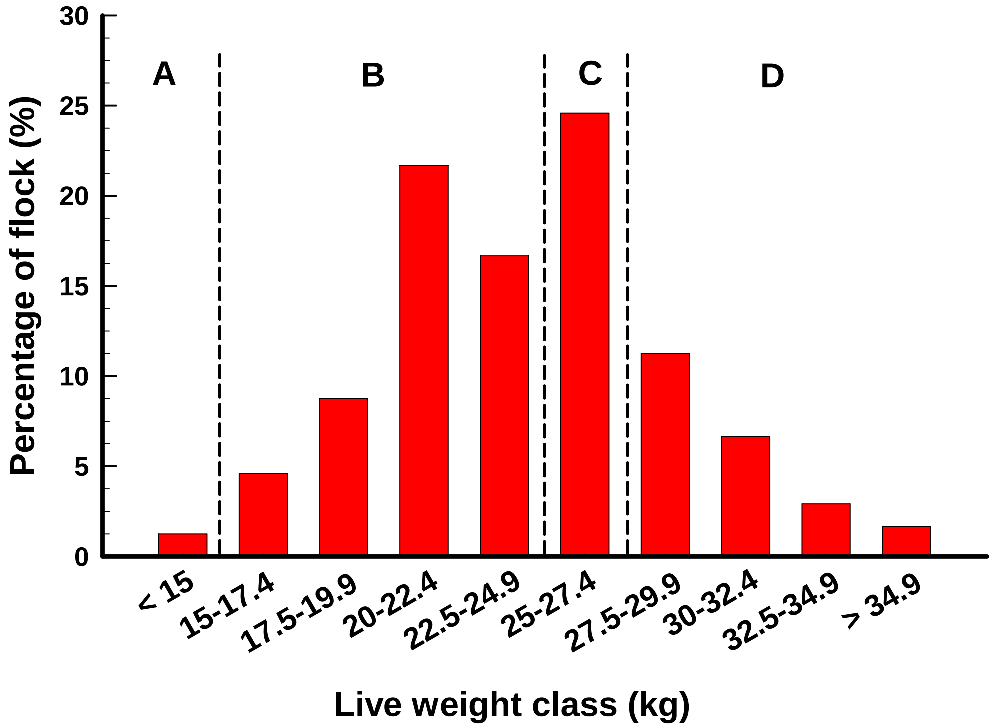


Figure 3.2. The percentage of maiden does in different live weight classes from a large flock of commercial Angora goats during the 2003 drought (Ferguson and McGregor unpublished 2005). The flock has been placed into four groups for assessment (see Table 3.5)

Table 3.5. An example of how a flock of maiden does could be assessed at the onset of a drought. See Figure 3.1 for details of the live weight range of each group.

Flock group	Action	Typical animal	Reason for action
A	Cull	Late born twin or orphaned kid.	Unlikely to respond to feeding. Problem kids.
B	Sell immediately or grow out for market	Twins and late born single kids.	Will not breed this year. Can sell easily for kid meat if in good condition. Can handle short-term feedloting but must be economic.
C	Evaluate	Well grown twins or singles born to maiden does.	Put best does in Group D and remainder in Group B.
D	Keep	Best grown potential breeding kids.	Likely to mate and rear a kid.

"The drought made me look very hard at my does"

"Made tough decisions. Improved the herd a lot"

(Mohair producer of 15 years experience on culling during the 2001-2005 drought)

3.2.2 Critical body condition for goats

3.2.2.1 The concept

Body reserves of goats are an important source of energy during critical stages of production and during drought. An accurate assessment of body reserves is therefore important for optimising nutritional management (SCA 1990) as live weight alone can be difficult to interpret owing to differences between the mature size of animals and strain of animal. Goats can also use body energy reserves and maintain live weight (McGregor 1988) by retaining increased amounts of water. In the paddock it is easy to condition score animals without weighing them.

In a drought the body condition score of goats must be taken into account when deciding feeding and management strategies. Using the body condition scoring techniques first described for sheep by Jefferies (1961), recommendations have been made about its application for goats (McGregor 1983, 1984a, 1988, 1992a, 1995, Mitchell 1986). Further details about body condition scoring can be obtained in more recent publications (Anon 2001, McGregor 2002a). The information on goats has been further updated. Conventions regarding the use of body condition scoring for sheep have recently changed and so the descriptions for goats has been edited to be compatible with the current usage with sheep.

Scientific studies have shown that body condition scoring to be reliable in predicting carcass weight when used with the live weight of goats (McGregor 1990b). Generally, goats have less fat under their skin than sheep. It is therefore easier to gain a more reliable estimate of the body condition and carcass yield of goats using body condition scores than it is with sheep.

3.2.2.2 How to body condition score

Body condition scoring is a “hands on” method of estimating.

(a) The animal must be standing on all feet and "relaxed", not tensed up or pushed into a corner. It is not possible to score if an animal is crouching or jumping over other animals.

(b) Use the "balls" of your fingers and thumb rather than the tips.

(c) Feel the body along the backbone just behind the last long rib in the loin area. Feel for the prominence of the spine, its sharpness and the amount of flesh on each side of the spine (see Figures 3.3 and 3.4).

(d) Now span the loin with your hand with fingers and thumb extended. Feel the ends of the spinal processes and press the fingers gently under the ends to assess the amount of flesh present (see Figures 3.3 and 3.4).

(e) Finally feel the eye muscle by feeling the thickness and coverage of flesh between the backbone and the spinal processes. The more flesh present the higher the score.

(f) For animals with a dense fleece, you will need to part the fleece to feel the skin more easily.

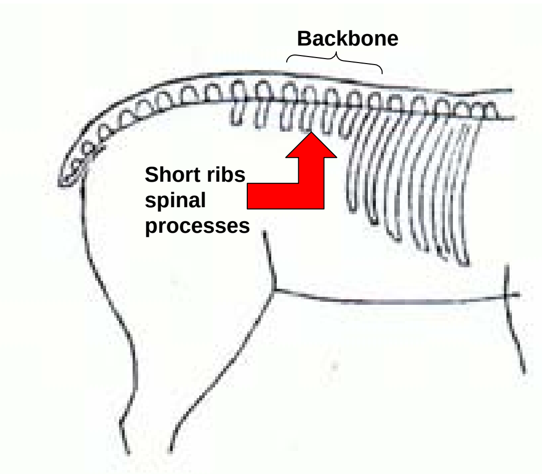


Figure 3.3. The position of the short ribs

Figure 3.4. The relationship between body condition scores, appearance of goats and the tissue reserves in the loin area of the short ribs. To be read in conjunction with Table 3.6 and Figure 3.3. Redrawn and modified from Mitchell (1986).

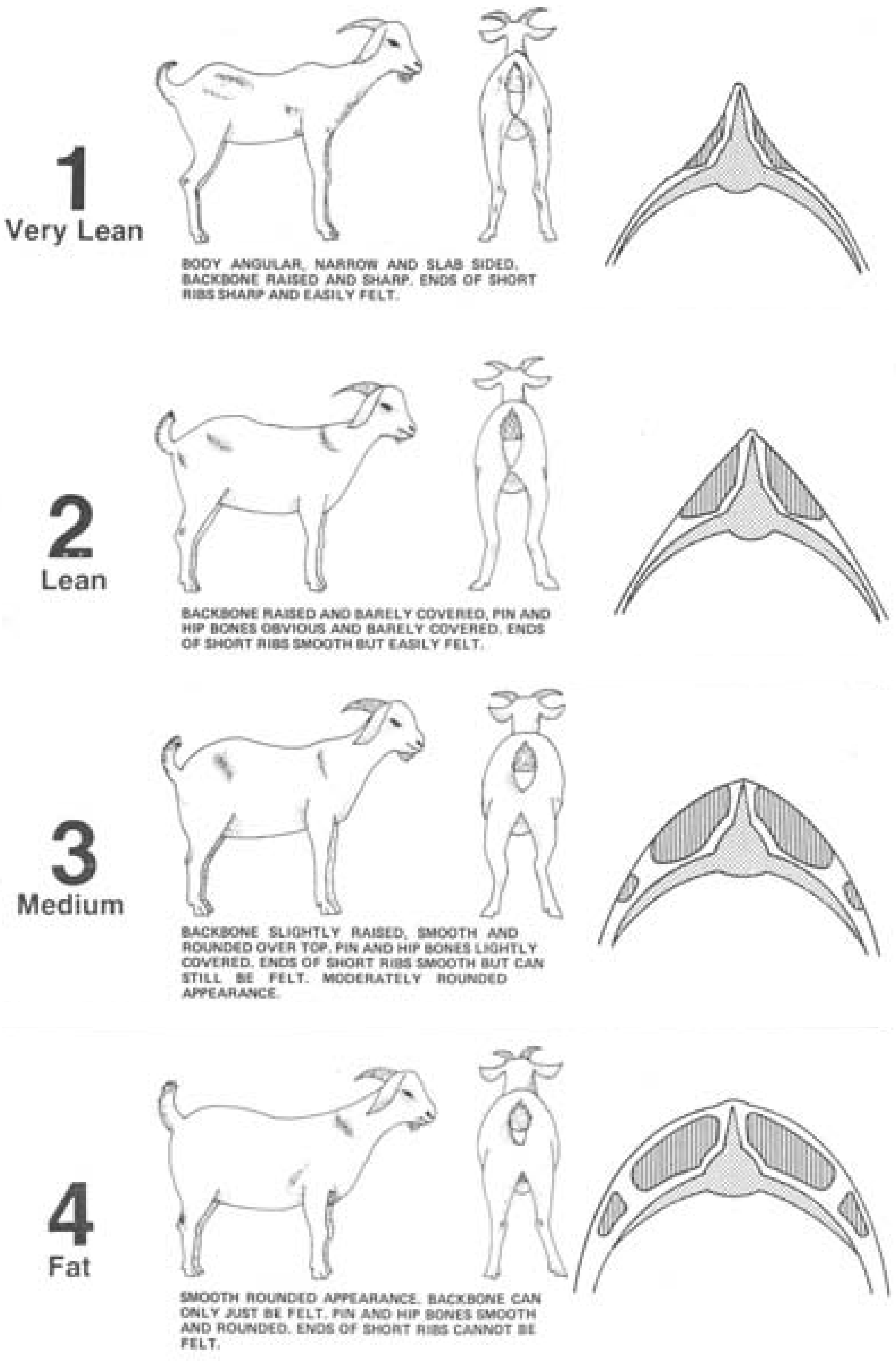


Table 3.6. What body condition scores feel like on a live goat

Body condition score	What you feel at each site			What the score means for meat production
	Backbone	*Spinal processes*	*Eye muscle*	
1	Prominent and sharp.	Sharp ends. Fingers easily pass under ends.	Very thin and feels hollow.	**Very lean**. Poor meat yield. Should be fed more. Further weight loss may result in death.
2	Prominent but smooth.	Smooth and rounded. Fingers pass under ends.	Some tissue present. Feels flat.	**Lean or Store**. Moderate meat yield for adults. Too low for prime kids.
3	Smooth and round over the top but still elevated.	Smooth. Need pressure to feel ends.	Full coverage to end of spinal processes. Feels rounded.	**Medium**. Ideal for prime kids. May be too fat for adult goats for lean meat.
4	Only detected with pressure.	Cannot be felt.	Well rounded.	**Fat**. Too much feed has been used. Fat has to be cut off meat when processed.

The reliability of your body condition scoring improves with practice. Skilled assessors can assign body condition scores that are intermediate between the main scores. For example, scores can be assigned such as: backward store (2-) which equates to a score of 1.7; forward store (2+) which equates to a score of 2.3 and so on for scores 2.7, 3.3, 3.7.

3.2.2.3 Relationship between body condition score and tissue reserves in goats

The fat and other tissue reserves of Australian cashmere and Angora goats with low body condition scores are lower than goats with higher body condition scores (McGregor 1990b, 1992a). There is an association between live weight and body condition scores in goats (see Figure 3.5). As goats increase in live weight, their body condition scores tend to increase and as goats lose live weight their body condition scores tend to decrease. For cashmere and Angora goats a body condition score equates to a live weight change of about 6 to 8 kg (McGregor unpublished as cited by SCA 1990 and unpublished data).

Over a period of years a goat may experience an increase and a decrease in its body condition score. Within a mob of goats, it is usual to observe a range in body condition scores.

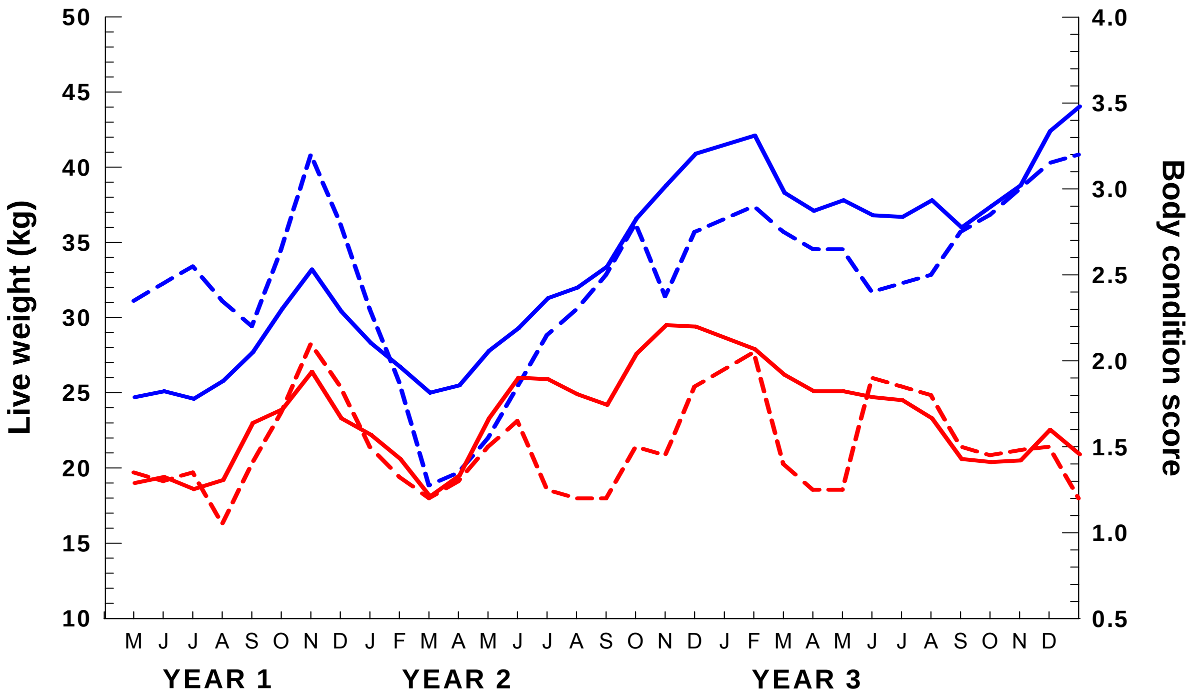


Figure 3.5. The changes in mean live weight (solid lines) and mean body condition score (dashed lines) of goats grazing at two stocking rates in southern Australia and measured each month (McGregor unpublished data 2005). The live weight data has been adjusted to remove fleece growth effects. Body condition scores determined as discussed in this paper.

Some goat producer's report that the vigour of a goat, as shown by the position of its tail, can be related to body condition score as follows:

- Tail down = condition score 1.7 or below;
- Tail up = condition score 2 or above.

3.2.2.4 When to start feeding based on body condition scores

Supplementary feeding should begin when more than a quarter of the goats in a flock have fallen to a body condition score of below 2 (equal to the old score of 2-, or backward store) or below. Feeding should be increased until half a maintenance ration is fed (see Chapter 4). If body condition continues to fall, the feeding rate should be increased until body condition is maintained. After a drought has broken reduce feeding when goats are growing and less than a quarter of the stock remain at a body condition of below 2.

In regions with very cold winters the loss of live weight and body condition increases the chances of death of goats due to cold stress. It is very hard to regain body condition during winter when pasture is in short supply as illustrated by the high stocking rate (red lines) in Figure 3.5, or if very cold and wet conditions prevail. These risks are discussed further in Section 4.3.

3.2.3 Implications for drought management

Many goat producers may not normally weigh their goats but frequent weighing and body condition scoring before and during drought is essential in order to make the correct culling, feeding and management decisions. Section 3.2 has provided examples of how to use and interpret live weights and body condition scores. Frequent monitoring will also allow benchmarking between years, improve pasture management and ultimately improve marketing decisions.

3.3 How to start feeding goats

3.3.1 Containment areas or droughtlots

Containment areas are yarded areas where stock are lot fed for survival or maintenance. Feeding in stock containment areas provide an opportunity to take the pressure off susceptible parts of the farm before they become too bare (Photo 3.1). Containment areas are recommended during drought feeding for several important reasons:

- To reduce soil erosion and loss of nutrients and topsoil;
- Save pastures allowing them to recover faster when drought breaks;
- Results in more pasture after drought breaks as plants survive better;
- Reduces energy expenditure by animals;
- Ease of mind as producers can easily inspect animals;
- Rapid feeding as less labour is required;
- Can provide shade for all animals;
- Easier to provide feed and mineral supplements in above ground troughs;
- Easier to provide a clean water supply;
- Reduces the impact of any weed seeds imported with purchased feed.

Photo 3.1. These drought-affected goats have reduced the pasture to a level where soil erosion and nutrient loss will increase. Confining these goats to a containment area will provide long-term resource benefits

Producers have identified some management problems with containment areas including:

- Increased requirement for direct labour input as animals are not getting any feed from pasture;
- Increased costs as all feed requirements have to be supplied;
- The containment area must be securely fenced to be goat proof;
- The need to rehabilitate the area after the drought;
- High levels of dust which increases pink eye problems;
- Feeding of pellets and grain can increase shy feeder problems;
- Animals can get heads caught under equipment;
- Potential for rapid disease spread, especially with kids and in wet conditions;
- Odour.

There is little direct experience of using containment areas for goats and particularly for goats of rangeland origin. Producers who have used containment areas emphasis the need to control kid bucks with adequate offset electric wires. Another producer emphasised the need to clean the water up to three times daily. Several goat producers reported fox problems around containment areas and recommended an electric outrigger 10 cm above the ground. More details are provided in Section 3.4.3.6.

3.3.2 Controlled live weight loss

Adult goats above the critical live weight, can be allowed to lose some weight and condition at the start of a drought. This weight loss should be controlled. A drop in weight of 4 kg over a number of weeks and a drop in store condition can save a lot of feed over the drought feeding period.

In drought feeding situations it is best to start feeding animals before they reach the critical live weight. If you start feeding when the average live weight of the goats is 3 kg above the critical live weight, the goats can lose weight during the introductory period without drastically altering their chances of survival. This period of controlled weight loss can coincide with the feeding of introductory rations. The flock can safely lose an average of 1 kg a week for this period (McGregor 1985b,c).

3.3.3 Introduction to grain

3.3.3.1 Gradual introduction method

Goats have to be brought gradually onto cereal grain such as wheat, barley, triticale, maize, sorghum and commercial pellets or “sheep nuts” or any ration that is high in starch and low in fibre. The gradual introduction is required as a sudden change in diet can cause grain poisoning or acidosis. This disease is discussed in Chapter 7. It is best to introduce goats onto cereal grain while there is still reasonable paddock feed available.

Train goats that have not been fed grain before by including previously fed goats in the mob to encourage the inexperienced goats to feed. Untrained goats are best educated in small paddocks. It is likely that 10 to 20% of goats will be shy feeders when wheat is introduced (McGregor et al. 1994). The feeding of whole grain lupins to goats without experience of lupin grain resulted in a high incidence of non-eaters and in these circumstances the feeding of wheat for rapid intake of energy appeared more desirable than rapid introduction of lupins (McGregor et al. 1994). Gherardi and Johnson (1994) examined rangeland goats fed in a feedlot and introduced to pellets that had been made for live sheep exports. They observed that the replacement of hay with pellets over a three-day period resulted in an incidence of shy feeders of up to 30%. Many goats lost more than 20% of their entry live weight within 7 to 14 days.

New kids can be taught to accept supplementary feeding before weaning by learning from their mothers to accept grain. This means that in non-drought years, does with kids at foot should be fed grain before the kids are weaned at least twice and preferably more often.

When starting to feed inexperienced goats, use good-quality hay and spread it over a large area so it is accessible to all the goats at the same time. This is best done in a small paddock or large yard that has good shade and water but no available grazing (Scarlett 2002). When the goats are used to eating the hay, begin grain feeding by pouring measured amounts of grain over newly fed hay. Gradually increase the grain ration at each feeding as discussed below. Hay feeding can stop when the goats are used to eating the grain.

The cereal grain ration should be started at the rate of 50 grams per head per day for adult goats, (25 grams for weaners) and increased slowly until the required ration is reached (see Table 3.7). This feeding and introduction program has been successfully used without problems for the feeding of wheat, barley and oats with a variety of Australian goats (McGregor 1995, 1998 and unpublished, McGregor and Hodge 1988, 1989, McGregor and Howse 1996, McGregor and Umar 2000).

More rapid introduction of cereal grains can induce acidosis. For example, when ground barley (73.5%) and crushed lupins (24.5%) and mineral supplement (2%) was fed as pelleted diets and introduced to full feeding over a 10 day period, acidosis was exhibited by 80% of goats in the first week as shown by bouts of feed rejection (McGregor 1994, see also McGregor and Howse 1996). Norton (1982) reported that 20% of rangeland goats offered a concentrate diet with 18% crude protein showed persistent diarrhoea but the feeding method was not described.

Once the required feeding rate is reached (Table 3.7), the introduction program can stop. So, if the target is feeding 300 g of cereal grain per day, this will be reached on day 11.

Table 3.7 A guide to the introduction of cereal grain to goats fed daily

Feeding days	**Amount of grain per feed**		**Amount of ground limestone per feed**
	gram per goat per day	kg per 100 goats per day	g per 100 goats per day
1, 2	50	5	75
3, 4	100	10	150
5, 6	150	15	225
7, 8	200	20	300
9, 10	250	25	375
11, 12	300	30	450
13, 14	350	35	525
15, 16	400	40	600
17, 18	450	45	675
19, 20	500	50	750
21, 22	550	55	825
23, 24	600	60	900
25, 26	650	65	975
27, 28	700	70	1050

Oats and lupins have a higher fibre content than the other grains and the full rations recommended may therefore be built up more quickly over a period from 14 to 21 days with less risk of causing digestive upsets. However it is suggested that the more cautious approach be applied for the introduction of all grains by following the guidelines for cereal grains unless more pressing welfare needs have been identified. One reason for this suggestion is that the energy content of oats varies throughout the cropping districts in Australia. If you are unsure of the energy content of your oats confirm the energy content by testing (see Section 5.1). Until you know the energy content of any grain, you must adopt a cautious approach.

3.3.3.2 Modification during the introduction period

In the early stages of grain feeding it is unwise to progress to higher levels of feeding until nearly all of the goats have taken to the ration or shy feeders have been drafted off. In group feeding situations, gorging is likely to occur (McGregor et al. 1994), especially since a substantial proportion of animals (10 to 20%) could be non-eaters. This is more likely to occur at the 2 to 3 week stage when the total amount of grain being fed is becoming more substantial.

If many cases of grain poisoning occur, particularly at the 2-3 week stage, the program should be modified by not increasing the ration for a few days and providing roughage (hay). For example McGregor (1984b) found when 20 kg goats were introduced to whole barley (75%) and whole lupin (25%) grain, that signs of graining poisoning appeared (as shown by rapid loss of appetite) during week 3 of the program. The provision of a small amount of hay was associated with a rapid return of appetite.

3.3.4 Provision of hay or roughage

3.3.4.1 Quantities of roughage to feed

Goats can be adequately fed to maintain live weight on diets of barley (75%) and lupins (25%) without additional roughage. McGregor (2005b) has examined the feeding of whole grain wheat in simulated drought conditions when roughage may be unavailable or its use limited by its high cost. Only one third of the goats fed whole grain wheat without roughage adapted rapidly to the wheat diet following the recommended introductory period and consumed this diet without further problems. A further one quarter adapted to the whole wheat ration after an extended period. The remaining goats exhibited cycles of rejection of whole wheat and required on average about 350 g roughage per kg of total ration in order to consume a maintenance diet. Even with a diet of 800 g/kg whole wheat plus 200 g /kg roughage some goats required an average intake of 350 g/kg hay in order to maintain live weight, with the average intake of hay being 236 g/kg of dry matter. From a budgeting point of view during drought, when whole wheat was to provide the major energy source to goats, managers would need to provide an average of approximately 250 g/kg (as fed) of feed intake as hay.

In practical terms, some goats can be fed diets consisting only of wheat grain without signs of illthrift or acidosis (McGregor et al. 1994, McGregor 2005b). Thus when roughage may be unavailable or very expensive, it may be more cost effective to draft off the shy feeders and provide them with a ration of 35% roughage or sell them. The remaining goats may be fed less roughage. If higher nutritive value feeds are provided such as lucerne hay and or barley/lupin rations then the quantity of roughage can be reduced to as low as 12% (McGregor 1998). The use of ricehulls as a roughage source for goats is ineffective (McGregor 1991, McGregor and House 1996). However, one must be vigilant that acidosis does not occur in the animals consuming 100% wheat grain (see Section 3.5).

In southern Australia during a dry winter, the feeding over four months of a supplement of 600 g/goat/day of lucerne hay in addition to the grazing allowance of sparse annual pasture did not increase the mohair growth of does. There was a slight increase in mohair growth to the feeding of barley grain at levels of 375 and 500 g/goat/day compared with the feeding of barley grain at levels of 250 g/goat/day or less, but the response was less than 10% additional mohair (McGregor 1995). The feeding of barley grain at 250 to 500 g/goat/day to does significantly improved the mohair style and mohair character scores and mohair length compared to does fed no grain or fed 125 g/goat/day of barley. Provision of roughage is also discussed in Section 4.4.3.

3.3.4.2 Fleece contamination from feeding roughage

When feeding hay, straw or grazing stubbles, the fleeces of Angora and cashmere goats can become contaminated with vegetable matter and dust (Photo 3.2). Severe price penalties exist for mohair and cashmere when VM levels exceed 2% (McGregor and Butler 2004). Stapleton (2002) reported he sometimes observed a large build up of fine straw particles and chaff in the fleece and soil penetrated the back-line of the fleece when Angora goats grazed stubble. While dusty mohair is not necessarily a problem it does show the kemp and there is a greater chance of classing fleeces into kempy lines. The dust content increases the wear of shearing equipment resulting in the gear running “hotter”. Consequently shearers have to work harder as the goats may squirm more. For Angora goats it is advised to have an early shearing if you intend to graze stubble extensively.

Photo 3.2. Feed roughage in a way that minimises the opportunity for goats to contaminate their fleece

3.4 Supplementary feeding and behaviour

3.4.1 Substitution

When grazing animals are offered supplements of grain or hay, the intake of pasture is usually depressed. The extent of the depression divided by the weight of supplement eaten is called the substitution rate (SCA 1990). Substitution rates of 1.0 occur with high quality supplements on abundant high quality pasture, but the rate may be as low as 0.65 on pastures with a digestibility of 50%. Substitution rates of 0 to 0.50 are predicted when pasture availability is less than 0.5 tonne DM/ha and will remain at about 0.45 when the digestibility of the pasture is less than 50% and the digestibility of the supplement is 80%.

In Texas, the intake of digestible dry matter (DDM) of Angora does grazing low quality range was increased by low levels of energy supplementation but as energy supplementation increased, forage DDM intake decreased at an increasing rate (Huston 1994). Total intake of DDM reached a plateau from supplementary feeding levels of 10 $g/kg^{0.75}/d$. Thus as supplementary feeding level increased, complementary, additive and substitutive effects on forage intake were observed. The implications are that when grain feeding typical 35 kg does grazing low quality forage, introduce 150 g/d and then evaluate by monitoring the does, as to the need for further supplements.

Allden (1969) examined the response of 27 kg Merino weaner sheep during summer drought in South Australia when grazing low quality herbage (> 2000 kg DM/ha) with a digestibility of 45 to 49%. For each 100 g of supplementary oat grain fed, the intake of herbage decreased by 65 to 69 g.

3.4.2 Feeding frequency and goat behaviour

The drought feeding strategy for sheep fed cereal grains is to change from daily feeding to feeding every second or third day (Court 2002) after following the routine in Table 3.7 for 2 weeks. Such a strategy is designed to reduce labour and to provide a mechanism to reduce the incidence of shy feeders (SCA 1990). The SCA concluded (SCA 1990, p. 229) that these advantages outweigh nutritional disadvantages for sheep and cattle. The practice of drought feeding sheep less frequently than daily originates from research conducted during the 1940s and early 1950s (Anon 1951, 1958) as Hewitt (1940) makes no reference to the practice.

When Farrell and Watson (1973) investigated the effects of feeding wheat daily or a similar amount in one feed per week, they found that the net availability of metabolisable energy (ME) was reduced with the once a week feeding regimen. This agrees with earlier theories and observations about the increased efficiency of utilization of the ration because of the reduced heat increment with daily feeding. Associated with the reduced feeding frequency of wheat were increases in water consumption (Watson et al. 1975), and a range of other changes in rumen and blood metabolites (Watson 1975). It would appear that for efficient use of feed ME and water resources, that once daily feeding is preferred over less frequent feeding regimens. When hay (dry matter digestibility of approximately 60%, crude protein 13.9%) was offered to Romney Marsh wethers, the frequency of feeding affected wool production (Birrell and Bishop 1970). Increasing the frequency of feeding had the effect of reducing wool production. Sheep fed weekly grew 10% more wool than those fed daily.

Experience has shown that when feeding full drought rations of cereal grains to goats when there is little or no roughage available it is best to feed each day. For example, attempts during the 1981-1983 drought to feed whole wheat to flocks of Angora goats indicated that the behaviour (dominance) of some goats contributed to grain poisoning (McGregor 1983 unpublished, McGregor et al. 1994). Attempts to feed less frequently than once per day were not successful, with some goats gorging wheat, resulting in subsequent severe acidosis.

Daily feeding can be achieved with a self-feeder or by feeding hay and grain on alternative days. Frequency of feeding can be determined by the state of the goats, type of feed, availability and capacity of troughs, and risk of feed losses through rain, birds and other animals.

It is possible to feed goats less frequently than 7 times per week when less than a full ration of cereal grain is fed and dry standing pasture residues are available or when low energy oats or other non cereal rations are being provided. For example, no problems were experienced when a ration equivalent to approximately 50% of maintenance energy requirements (equal to about 200 g/day per goat) was provided as five feeds each week (Monday to Friday) equal to 280 g/day per goat (McGregor 1992c). The introduction program indicated in Table 3.7 should be followed.

Stapleton (2002) introduces his goats to oats by starting with about 30 kg per 100 does twice a week and over 2 weeks building up to about 40 kg every second day. This is the equivalent to 300 g/goat at the start. Stapleton noted that some animals get a reaction to oats especially if they have run some distance to the grain. This response appears to be mild grain poisoning.

3.4.3 Feeding method, behaviour and fencing

Holst and White (1997) discuss a range of supplementary feeding systems and their efficiency.

3.4.3.1 Trails

A grain ration may be fed out in a thin trail so that it can be eaten along with paddock feed. When forced to feed in confined spaces, goats invade the approach distance between animals and displays of butting and bullying are common, particularly when most of the feed has been eaten. In poorly managed situations, some shy goats and less dominant animals will not receive any feed. Using very long thin trails providing at least 1 m per goats will reduce this problem (Photo 3.3).

One farmer reported that when feeding in trails the goats crowded around their vehicle with the constant risk of running over animals. There are several tactics to minimise this problem including:

- When entering a paddock do not be tentative, get moving with laying the trail;
- Feed over a fence so that the vehicle in not in the paddock with the goats;
- Vary start time and entry gate;
- Alternate feeding paddock. Lay out the trail and then open the gate to allow entry of goats. Close the gate after goats enter;
- Use a containment area so that the above ideas are easier to manage and damage to paddocks is minimised (see Section 3.3.1).

Photo 3.3. Long trails provide plenty of access for all goats to access grain. In the distance there are two shy feeders standing back from the trail.

Feeding in trails may increase feed wastage. Holst (2000) reported that 16% of lupins could be wasted when fed in trails. Trails of self-sown crops clearly demonstrate that grain is lost into the soil with trail feeding. If a ration has been carefully calculated then an increased allowance must be made to replace grain lost into the soil. Esson (2005) found that goats grew better when troughs were used compared with the feeding of cereal grain on sandy or wet ground, presumably as more grain was lost in the sand. Feeding on hard dry ground is less likely to waste cereal grain than feeding on wet muddy ground or on sandy ground.

Photo 3.4. Using guttering laid on the ground keeps the feed clean but does not stop all wastage. Troughs mounted 40 cm above the ground stop animals tramping in or kicking the feed about.

3.4.3.2 Behavioural problems, shy feeders and fences

Shy feeders are usually seen on the fringe of the general mob. Shy feeders lose weight rapidly because they are not eating the ration provided. Shy feeders will not survive for long unless remedial action is taken. Experienced goat producers reported that stockmanship is the only effective solution to managing shy feeders, in other words careful observation and quick action. See Photos 3.3 and 3.5 for examples of shy feeders.

Scarlett (2002) suggested the following approach to minimise the number of shy feeders:

- Draft goats into groups of uniform size, weight and condition. Keep young goats separate.
- Limit the number in each mob, with full-grown goats in groups of 1000 or less, and kids and weaners in groups of 400 or less.
- Feed in areas that are visible to all goats. Paddocks with hills, gullies and patches of dense timber are unsuitable.
- Make the feeding trail as long as possible. A circular trail is preferable to a straight trail. If you are using troughing, make sure there is enough space for all goats to eat at once.
- Remove shy feeders and feed them separately with good legume hay. As consumption increases, gradually introduce grain until they are on the same routine as the main mob.

During drought feeding, a days ration of grain or even hay can be consumed in 15 to 30 minutes. Given that goats usually spend 8 to 9.5 hours grazing each day (McGregor 1982b and unpublished) and a similar amount of time ruminating, the provision of a days ration can lead to goats having plenty of time for exploration and misadventure. Growers have reported that does in good condition and receiving enough grain would still attempt to escape to the next paddock. The implication is that good fencing is required at all times, even during a drought. The authors experience of Angora and cashmere goat responses to fences is described elsewhere (McGregor 1990a). These observations include periods of intensive drought feeding (1981-1983) and numerous periods of supplementary feeding during dry summers and drought. No case of goats escaping from one paddock into the next paddock to consume supplements was seen.

The most dangerous influence of fences during periods of feed shortage (any time of the year) is when goats push their heads through narrow spaces in prefabricated wire fences and are unable to withdraw their heads thereby becoming entrapped (McGregor 1990a). The most risky fences have vertical wire spaces at 15 cm, such as pig wire. However most common prefabricated wire fences are erected with droppers or star posts that can halve the distance between the vertical wires spaced at 30 cm resulting in 15 cm spaces. The implication is that goat producers need to inspect their fence lines regularly or suffer increased mortality of goats.

The use of “play equipment” such as logs, rocks, etc to reduce the boredom of goats in confinement areas or feedlots may offer potential to reduce behavioural problems during drought feeding. Some goat shy feeders do not like contaminated feed so daily cleaning of water and feed troughs is essential.

Photo 3.5. These Angora goats were fed throughout the 2002-2004 drought. When most of the grain mix was eaten some goats began to wander away. These animals are not shy feeders.

3.4.3.3 Super spreader

Feed can be distributed by using a super spreader, particularly for larger sized grain such as lupins and beans (Bell 2002). This approach will encourage foraging and is particularly useful when there is still pasture or crop residue available for animals.

3.4.3.4 Troughs, self-feeders and hay racks

Rations can also be provided in metal troughs such as modified roofing or spouting as a way to minimise loss of grain into the soil caused by trampling etc. Troughs can become wet and any feed residue rapidly becomes mouldy. Troughs need to be cleaned prior to each feeding and emptied of any faecal matter, feed residue, water and urine. To minimise fouling the troughs are best raised from the ground. Troughs made of guttering and roofing and placed on the ground will need to be fixed as they will be blown away in strong winds. However using heavy “C” channel is too heavy for regular moving and turning during cleaning. Plastic roll-up troughs are being developed. These minimise fouling effects as they can be easily moved and cleaned.

The amount of feed intake can be more easily controlled by the use of a grain self-feeder designed with adjustable channel widths to control the delivery of grain, pellets, meal and hammer milled mixes. The Cowra Lick Feeder (Lachlan Steel Fabrications, Cowra) is one example of such a controlled feeder. The Cowra sheep feeder is 2.3 m long, double sided, built on skids, contains 17 bags of feed and retails for $968 inc GST. Clearly advantages of such a feeder include the reduced need to feed each day, less wastage, reduced disease transmission, reduced loss of feed from rain or birds but the disadvantage is the cost, especially if a number of feeders are required.

Does can easily be fed whole grain oats using large, silo type self-feeders. One producer modified the feeders to allow access by younger animals and were able to use the ‘skirts’ around the feeders to limit the amount of grain consumed each day. The goats licked up grain through a small opening and did not appear to “over eat”. Various types of hay feeders and racks are available. These reduce the ability of goats to contaminate the hay, of camping under the bales and contaminating their fleeces. An example is shown in Photo 3.6.

The introduction to full feeding from grain feeders needs to be done gradually. One grower reported that when a mob of 400 does, that were familiar with using a grain feeder, were introduced to full feeding five goats were trampled to death in the rush. This grower warns against using feeders unless there is enough access so that all goats can stand and feed at the same time.

Photo 3.6. An example of a round bale feeder. This design prevents goats from climbing over the bale and stops a half-eaten bale from collapsing onto goats. The amount of wasted hay can easily be seen.

3.4.3.5 Using salt to limit intake

If supplements are provided in feeders without adjustable channels, feed consumption by goats can be limited by the addition of common salt (sodium chloride). Huston et al. (1971) reported that in rangelands in Texas the use of 20% by dry weight of salt or 10% gypsum limited consumption of Angora goats. Huston et al. (1971) noted that the effects of feeding high levels of salt were still in question. They also noted that producers should experiment with other levels of salt in order to determine what level will satisfactorily limit supplement consumption under their conditions. If the pasture forage contains high levels of salt then the levels added to supplements could be reduced.

In South Africa, Van der Westhuysen et al. (1988) advised Angora goat producers that adding salt was an effective method of controlling the intake of supplements. They claimed that by gradually decreasing the salt content the intake of the supplement could be increased to the desired level. Thus in week one the salt content was suggested as 20%, declining to 10% by week three. This approach limited the intake of a supplement to about 200 g/goat/day. For kids and weaners a level of 10% salt was suggested providing 50 to 100 g/goat/day.

One problem may be the "top dressing" of the pasture by spreading salt over a property. Several goat producers have opted not to use salt to reduce intake for environmental reasons.

3.4.3.6 Design of containment areas (droughtlot)

A containment area is a place where goats are fed for maintenance. The design of containment areas for goats and sheep is constantly improving as new materials, approaches and experiences are evaluated. Anon (2004b) provides a best practice guide based on case study examples of managing sheep in droughtlots during the 2001-2004 drought. If constructing a containment area is really the start of a feedlot it is very important to check with the local government authority to determine whether any planning permits are required.

Holst (2000) and Flint and Murray (2001, 2004a,b) discuss the design and management of feedlots for goats. Good site selection is important. Consideration should be given to proximity of waterways and dams, neighbours and the management of any odours that may cause nuisances. Site selection should include consideration of topography, all-weather road access, electricity and water supply and manure management. Design points to consider include:

1. Prior to lot feeding, rangeland goats should be habituated to the facilities they will encounter on introduction to the feedlot. Rangeland goats should be trained with 7 or 9 strand plain wire electric fences during the pre-feedlot habituation process.
2. Feedlots fencing for rangeland goats should be at least 1100 mm high (100 x 50 mm mesh) weld mesh topped with fabricated wire netting to create a 1500 mm high goat proof fence.
3. The goats should be stocked at 64 goats per hectare in pre-feedlot habituation. In a feedlot, goats can be stocked at 1667 goats per hectare as long as a pre-feedlot habituation stage has been undertaken. This stocking density is the equivalent of 5.9 m^2 per head. Pen size should be rectangular and approximately 42 m by 60 m to create manageable groups and to mimic 'natural' flock sizes of around 400 goats per pen.
4. A laneway system connected to yards to allow easy movement, weighing and treatment of goats.
5. Isolation pens for sick goats with separate water and feed sources, loading ramp and drainage system to avoid any contamination of healthy goats in other pens.
6. Water and feed troughs should be similar to those used by goats in the paddock. Feed and water troughs should be easy to clean. Feed troughs should be fixed 400 mm above the ground with a cover to prevent goats from standing in and contaminating the feed. A minimum feed trough length of 5 cm per head is recommended. Hay racks should be elevated to goat head height.
7. Shelter (running in a north-south direction) from the wind, rain, direct sun and cold should be sufficient to cover all goats in the yard at the same time. Shelter should provide 1.0 $metre^2$ of space per goat. Wind breaks can be provided wooden barriers and corrugated iron.
8. Pens should be enriched with "toys" to help alleviate boredom and disruptive behaviours in the goats. Toys may take the form of a pile of stacked railway sleepers and old car tyres or mounds of soil to climb on, or suspended plastic milk bottles and pipes to mouth and butt.
9. Feed storage facilities. In an emergency a feed dump should be considered, particularly if the access to the site may be limited by heavy rain.

3.4.3.7 Feeding method and disease transmission

There may be an association between feeding method and disease transmission. Evidence with sheep has shown that the mortalities of sheep fed on the ground (trails) exceeded those of trough fed sheep when mob size was greater than 2000. At small mob sizes the mortalities of trail fed sheep was lower (Anon 2004b). Other disease issues are discussed further in Chapter 7.

3.4.3.8 Feeding and mis-mothering during drought

During drought the mis-mothering of kids is likely to be increased. Mis-mothering will be worse in a paddock with timber belts or gullies or other areas where does (especially the maiden does) simply "forget" that they have planted their kids. One grower reported that they adopted a strategy of feeding out in early morning thereby maximising the time left for does to re-unite with their kids.

3.4.4 Breaking routine or changing feed

Experience with sheep suggests that if a break in the normal feeding routine occurs for more than 2 to 3 days through delay in the availability of supplies or other matters, feeding should not be resumed with the full ration when supplies become available. Begin feeding again daily on about half-rations, and build up to the full ration over a few days before returning to your previous routine (Court 2002).

It is especially important to avoid sudden changes in the ration. Goats that have become accustomed to one type of grain cannot immediately adjust to another. Deaths can result from a sudden switch of feed. Even the same grain type obtained from a different source has caused losses with sheep, presumably a consequence of higher digestible starch content in the new cereal grain (Court 2002). Hence, it is desirable to estimate early in the program how long supplies will last. This will allow time for planning of a gradual changeover from one feed to another.

In the 1982-83 drought, digestive problems often occurred when a new batch of sheep nuts was fed, even when the sheep had been well accustomed to the previous batch. Manufacturers sometimes change the major grain ingredients, or change the processing procedure, from one batch to the next (Court 2002). The list of ingredients on commercial sheep nuts can be used as a guide to what is in the feed but generally not the relative amounts of each ingredient.

If it is necessary to use a different grain, arrange the supplies early and mix the old grain with the new, gradually increasing the concentration over at least a week. Gradually changing the supplies of cereal grain and processed pellets or nuts fed to a range of goats has not caused any problems (McGregor 1984c, 1995). Goat have also successfully eaten large cattle cubes (30 mm x 30 mm x 40 mm) made with 20% milled barley, 70% straw and 10% molasses when their normal supply of sheep nuts was unavailable.

Additions to the ration of 2% sodium bentonite or 1% salt may reduce the risk of grain poisoning during the change. Other approaches are discussed in the Section 3.5.

3.4.5 Feeding processed grain or hay

Feeding processed grain to goats can increase the incidence of grain poisoning and significantly reduce appetite (McGregor 1994, McGregor et al. 1994). When whole grain barley and oats are fed to goats there will be some loss of grain in the faeces (McGregor and Whiting 1990 unpublished). However the cost of processing by hammer milling, cracking, popping, rolling, grinding, or pelleting the grain are usually greater than the value of the “lost” grain. In addition, the increased risks of grain poisoning make processing of grain unattractive for drought feeding adult goats. For early weaned kids it may be necessary to process grains to enable kids to consume and digest sufficient amounts of grain. For example, during introduction to grain, barley may be cracked and lupins milled for creep feeding to weaners. Finally, animals that are on a reduced feed intake during drought conditions generally digest feed more efficiently than fully fed goats and the appearance of whole grains in faeces generally appears to be greater than it truly is.

Processing of hay and straw by hammer milling, pelleting or chaff-cutting are also generally unnecessary. The ME value for fodder can be increased slightly by these processing systems (SCA 1990) but the costs usually outweigh the benefits. One goat producers followed the grain harvester to immediately make chaff from residues of wheat, barley and lupin crops as a method of collecting “processed” feed for later use.

Processed dry feed based on copra and cottonseed meal can be conveniently fed out using feeders designed for the purpose. Feeders usually result in 100% consumption of these mixes and pellets. Sometimes with loose cottonseed meals about 10% is wasted as the goats sift through the mixture. Lots of waste can arise if the cottonseed pellets are spilt onto the ground. One producer reported that they fed a mix of 75% cottonseed with urea, salt and other minerals (Darlington 2005). The initial feed consisted of 5% urea and 10% common salt. Extra salt was added to reduce intake. For does, 10% urea was found to be satisfactory in using the dry pasture residues (see Photo 3.7). In this self-feeding activity, does ate about 200 g/day and the cost equated to 10c/goat/day. For weaners, if they were not eating enough, extra copra was added. At the season break the salt content was increased to 15%. No problems were reported and a feeding frenzy was avoided. The extra cost of purchasing a prepared mix compared with using whole grain or mixing the ration was worth it as there was less labour and the goats didn't annoy the person filling the feeder.

Photo 3.7. A feeder manufactured for cottonseed-urea mix pellets enabled the use of extensive areas of dry grass. The feeder was lightweight and easily moved to new areas.

3.4.6 Silage for goats

There is limited experience in using silage in Australian goat rations. The quality of silage will be important so producers considering silage are recommended to undertake a FeedTest prior to the purchase of silage. As goats can be very selective, poor quality silage will be wasted if better feed is on offer. Some producers reported their goats playing on wilted silage, feed that was apparently readily eaten by cattle. Silage can also be contaminated with disease organisms (see Section 7.2.9).

Silage is fed to goats in other countries. For example, silage is becoming more important as a feed in China, where it is frequently used during the severe winter "drought" experienced in northern and western China. In China, silage is commonly made using maize although other forages are used.

3.5 Using additives to limit acidosis

3.5.1 The potential use of slaked lime

3.5.1.1 Twice weekly feeding of cereal grain

Wentzel (1982) described the use of caustic soda treated maize for supplementary feeding of goats and sheep to modify the process of rumen fermentation and limit rumen acidification. Subsequently Wentzel (1987) advised that the use of calcium hydroxide ($Ca(OH)_2$) treated maize with sodium monensin (Rumensin) for supplementary feeding cold stressed goats and for drought feeding small livestock was a safer and more cost effective approach. Owing to the brownish appearance of the end product, South African Angora goat and sheep farmers call such treated maize "chocolate mealies".

Van der Westhuysen et al. (1988) indicated that using maize treated in this way the supplementation of 300 g/goat/day could be provided as two feeds per week. They reported that the feeding of 900 g of chocolate mealies on Day 1 followed by 1200 g on Day 4 (2 feeds per week) provided good results.

3.5.1.2 Very rapid introduction of cereal grain

Goats may require rapid introduction to high-energy cereal grains during adverse weather following shearing and after fires or flooding destroy pastures. In these circumstances there is no opportunity for a gradual introduction and the need to feed a maintenance or double maintenance energy ration significantly increases the risk of severe or fatal acidosis. In one experiment where individually fed Angora goats (mean live weight 40 kg) were offered 500 g/day of wheat without an introduction period, no mortality was reported over a five day feeding period and the average intake was 465 g wheat/goat/day (McGregor et al., 1994). This study recommended that the wheat be treated with slaked lime to increase rumen pH and so reduce the potential for acidosis.

An alternative strategy of using rice hulls as a cheap form of roughage with wheat (McGregor and Howse 1996) showed that:

- Goats showed a strong discrimination against rice hulls fed in a variety of loose forms. In the loose form rice hulls did not assist the adaptation to wheat diets. Intake of rice hulls was only 3 to 5 g/d.
- When rice hulls were incorporated into pellets with wheat at the rate of 30, 40 or 50% and the diets rapidly introduced, the pellets resulted in depressed feed intake compared with slaked lime treated wheat and a large increase in the number of shy eaters. There was no evidence that rice hulls increased rumen pH or modified rumen pH changes.

3.5.1.3 Australian experience with slaked lime
Australian research with goats fed 300 and 500 g/d of whole grain wheat without an introduction period showed that inclusion of slaked lime in whole grain wheat diets increased rumen pH when compared with diets without slaked lime (McGregor et al., 1994, McGregor and Howse 1996). The size of the effect increased with time. It was likely that, if greater amounts of treated whole grain wheat were fed, greater benefits in rumen pH would be detected closer to introduction. These results suggest that treating wheat with 2% slaked lime for rapid introduction to goats is a practical method for rapid introduction to high energy grains (McGregor et al. 1994).

In group feeding situations, gorging is likely to occur, especially since a substantial proportion of animals (10-20%) may be non-eaters. The increase in rumen pH with the addition of 2% slaked lime could well prevent acidosis and even death. Based on Australian and South African experience it is suggested that in group feeding situations that wheat and corn should be treated with 2% slaked lime.

3.5.1.4 Treating wheat with slaked lime
To use molasses as the binder:
Use a paddle mixer, mix whole grain with 2% slaked lime (Limil, David Mitchell Estates Ltd, 90% $Ca(OH)_2$) and 1.9% molasses (McGregor et al. 1994).

To use water as the binder and to add urea:
First thoroughly mix together: 3.6 l water, 1.4 kg urea, 2.8 l molasses, 2.2 kg slaked lime (Limil) for each 100 kg of grain. Then using a paddle mixer, mix whole grain with the prepared premix (Van der Westhuysen et al. 1988). If this mix is being fed to bucks or wethers it is advisable to add 0.5 kg ammonium chloride (NH_4Cl) to each 100 kg of grain.

3.5.2 Other additives

Wentzel (1982) and subsequently Van der Westhuysen et al. (1988) proposed the use of sodium monensin (20 ppm) to modify the process of rumen fermentation and limit rumen acidification when maize was fed to goats and sheep as two feeds per week. When Rumensin (17 ppm) was included in whole wheat fed to individually penned goats at intakes of 300-500 g/day over 4 or 5 day periods, the rumen pH was no higher than that provided by slaked lime, and less stable feed intake was observed (McGregor et al. 1994). Thus Rumensin provided no additional benefits over that provided by slaked lime and appeared unnecessary.

Thorniley et al. (1996) reported that a single drench of the antibiotic virginiamycin, can control acidosis in sheep and cattle. A single drench of 2.5 mg/kg live weight prevented mortalities in weaner sheep fed wheat *ad libitum* in pen conditions by suppressing rumen L-lactate levels for 4 to 5 days after treatment. Further research indicated that a single drench of 160 mg of virginiamycin (Thorniley et al. 1998) can effectively prevent lactic acidosis in sheep fed wheat diets.

Additions to the ration of 2% sodium bentonite or 1% salt may reduce the risk of grain poisoning for sheep during the introduction of whole wheat (Court 2002).

It was advised that ammonium chloride (0.5%) should be added to cereal grain to prevent formation of urinary calculi in males if fed more than 500 g/day of slaked lime treated grain (Van der Westhuysen et al. 1988).

3.6 Monitoring the goats

The management of goats during a drought depends on knowing how the animals are faring. The only real way to know how they are going is to weigh and condition score them. Tag or brand 20 goats from each mob and monitor them regularly throughout the drought. Knowing weight changes can save the cost of unnecessary feeding as well as preventing deaths of goats that slip too far before being fed, or which are not getting enough to eat. To minimise animal movement during the drought, portable yards and live weight scales are required.

Producers are encouraged to body condition score their goats. It is possible for goats to maintain live weight but to lose body condition score during a long period of maintenance feeding (McGregor 1988). Cunningham (2005) reported that declining drought conditions are gradual and so a producers' goalposts alter over time. Regular body condition scoring can overcome the need to weight animals as often.

A variable proportion of goats and kids will not adapt to drought feeding. The proportion of shy feeders depends on age, previous feeding history, ration, mob size (in sheep, the proportion rises steeply once the mob size is above 400), but up to 10% is not uncommon. Shy feeders have different behaviour, they hang back from feeding troughs and trails. Shy feeders will lose live weight rapidly. Remove shy feeders from the mob and feed them separately with good quality hay or sell them. Many shy feeders eat some of the ration but not enough to maintain their weight.

3.7 Deciding when to stop feeding

Droughts end after enough rain has resulted in pasture germination sufficient for supplementary feeding to cease. Often heavy rains are associated with the end of a drought. Scarlett (2002) advised that it was essential, to confine goats to feeding sites that are accessible by vehicle after rain. The alternative is to establish an emergency feed dump at the feeding site, preferably including hay, so that goats survive the rain period. Feeding areas should be well drained, and located where floodwater will not isolate any of the mobs. After the drought breaks you will probably still be drought feeding the goats in a confined or restricted area for some weeks to protect the fragile germinating pastures. Goats will chase the first green pick (Gurung et al. 1994), expending considerable energy grazing over the paddock. Goats should be kept in confined areas until new pasture is well established and can provide worthwhile grazing. At that point they can be gradually weaned off drought rations and allowed some grazing.

When the decision has been made to allow some grazing, increase grazing time each day until full grazing is provided after 6 to 7 days. Does with kids should be fed a full ration for a few weeks to ensure the maintenance of lactation. Calcium may also be limiting so limestone and salt should be fed for a few weeks (see Chapter 4, Court 2002). Allowing immediate full grazing will lead to digestive disorders.

Once goats are released onto the pasture continue to monitor them. Using the rule of thumb based on body condition scores, sheep producers are advised to stop feeding when less than a quarter of the stock remain at a condition score below 2.

Unfortunately the period when most droughts break coincides with the time when Angora goats are normally shorn in autumn and with a period of uncertainty in weather predictions. Goats in poor condition and of light body weight are vulnerable to wet windy weather, particularly to periods of extended rainfall (McGregor 1985c, McGregor and Rizzoli 1991, McGregor 2001b and unpublished). High wind speeds and unpredicted intense storms can also cause deaths in all live stock species. Short duration intense storms have caused death in goats from exposure and suffocation resulting from crushing. Even if shelter is provided goats can be caught in open paddocks by unexpected intense storms (McGregor and Rizzoli 1991, McGregor 2001b). In previous droughts, many properties have experienced their heaviest sheep losses during the period immediately following drought-breaking rain (Court 2002). Thus goat producers should be prepared to feed goats after the drought breaks and take particular notice of weather conditions and the issuing of Grazier Weather Alerts from the Bureau of Meteorology. Weather stress is discussed further in Section 4.3.

Photo 3.8. A paddock based goat shelter build to provide protection during the 2003 drought

"The constant walking and the wind caused paddock erosion."

(Mohair producer of 25 years experience reflecting on their decision to let their goats roam the paddocks and not use a containment area during the 2001-2005 drought)

4 Nutrient requirements of drought fed goats

4.1 Introduction

4.1.1 Drought feeding objectives

The objectives of feeding goats during droughts are:

- Maintain the live weight of goats;
- Meet the requirements of does in late pregnancy and during lactation;
- Maintain the welfare of goats;
- Allow kids to grow to a target weight without suffering permanent setbacks.

You may also select other targets such as finishing goats for quick sale. Feed levels can then be adjusted for these aims.

One producer workshop concluded that the targets should be: to keep the goats alive and to maintain body weights.

4.1.2 Selecting drought feeds

Selecting the types and amounts of feeds to give goats during a drought involves six steps:

1. Determining total energy and protein requirements of each class of goat;
2. Determining the energy and protein content of available and suitable feeds;
3. Calculating which of the available and suitable fodders is cheapest;
4. Calculating the amount and cost of the selected feed;
5. Assessing the proportion of feed requirements that can be met from pasture and /or crop residues;
6. Monitoring the individual mobs and adjusting their ration up or down.

This chapter is concerned with step 1. Steps 2 to 4 are discussed in Chapter 5. There are various ways of reaching the same end point in calculating the preferred drought ration. Examples of approaches are provided elsewhere for sheep and other live stock (Court 2002, Scarlett 2000).

4.2 Energy requirements of drought fed goats

Energy is a major nutrient requirement and normally the first limitation during a drought. The energy derived from digested feed to maintain body functions and to produce fibre, foetal growth, milk or more body weight is termed "metabolisable energy"(ME). The energy value of feeds and the energy requirements are described in units of ME.

4.2.1 Maintenance energy requirements

4.2.1.1 Feeding standards

The National Research Council of the United States of America published a review of the nutrient requirements of goats and included recommendations for the provision of energy and protein (NRC, 1981). This publication has been the basis for goat nutritional advice over the past two decades. Unfortunately the NRC review included few experimental data derived from fibre producing goats.

In Australia, the Standing Committee on Agriculture published the Feeding Standards for Australian Livestock – Ruminants (SCA 1990). This work is based in the ME system of feeding and is the basic textbook for Ruminant Nutrition in Australia. The present review is to be read in conjunction with the Feeding Standards for Australian Livestock, Ruminants. SCA (1990) includes only a small number of references to goats and concluded that the maintenance metabolism of goats was similar to that of sheep (page 23). This review provides a new analysis based on new data including Australian research not available to the NRC or SCA.

4.2.1.2 Review of maintenance requirements for goats
Estimates of the maintenance energy requirement of goats in thermo-neutral conditions were first provided by Armstrong and Blaxter (1965) as 312 kJ ME/kg$^{0.75}$ per day. The one estimate for Australian goats in thermo-neutral conditions (Dunshea 1987, Table 4.1) is similar to that of Armstrong and Blaxter. In practice Australian goats are not kept in thermo-neutral conditions and so these values have not been included in the calculation of energy requirements.

The NRC review derived energy requirements for maintenance from the pooled means of experimental data from 10 published sources. The NRC mean value for maintenance was 424 kJ ME/ kg$^{0.75}$. The review by Ademosun et al. (1992) added two records. Ademoson et al. (1992) converted the data from Zemmelink et al. (1991) using 15.8 kJ/g digestible organic matter (DOM) (NRC 1981) but in the present review the SCA (1990) conversion of 17.5 kJ/g DOM has been used. The mean of these 12 values is 419 kJ ME/ kg$^{0.75}$ (range 365 – 482 kJ ME/ kg$^{0.75}$).

During the past 20 years, data has been derived for the maintenance requirements of Australian Angora, cashmere and rangeland goats managed under a range of environments, experimental conditions (Table 4.1) and fed either forage only or grain/forage diets. In addition, Holmes and Moore (1981) reported the maintenance energy metabolism for rangeland goats as 391 kJ ME/ kg$^{0.75}$ following calorimetric studies in New Zealand. The mean value for the maintenance of live weight of Australian goats was 382 kJ ME/ kg$^{0.75}$ (range 267 – 485 kJ ME/ kg$^{0.75}$). The mean value rises to 388 kJ ME/ kg$^{0.75}$ if the value for energy maintenance (McGregor 1988) is used rather than the value for live weight maintenance. The variation in values can be attributed to the type and size of goat used, the environment, the experimental set-up, the period of measurement and the accuracy of determination of changes in body composition.

Assuming that all reports are relevant to Australian conditions, the mean of these 22 estimates for the maintenance requirements is 404.7 kJ ME/ kg$^{0.75}$. This value has been used to provide estimates of the energy requirements for the drought feeding of goats under conditions of minimal activity (Table 4.2).

4.2.1.3 Maintenance energy requirements for goats during drought
SCA (1990) reports that the maintenance energy requirements for drought fed sheep and cattle may be at least 10% less than determined using various feeding systems. Whether this observation applies to goats is unknown, although data in Table 4.1 and unpublished data may provide evidence for this observation in goats. The observations referred to by the SCA may in part be a consequence of experimental conditions where animals were individually fed in pens or stalls. In practice during a drought, animals will have some activity that is likely to equal or exceed the 10% of maintenance value referred to by the SCA. The energy requirement for activity is discussed further in Section 4.2.3.5. It is concluded that no deduction be made based on the above observations of drought fed sheep and cattle.

4.2.2 Energy requirements for growth

4.2.2.1 Review of energy requirements for growth
The NRC (1981) review derived energy requirements for growth from the pooled means of experimental data from 3 published sources. The NRC mean value for growth was 30.3 kJ ME/g of growth. The review by Ademosun et al. (1992) added two records. Ademoson et al. (1992) converted the data from Zemmelink et al. (1991) using 15.8 kJ/g DOM (NRC 1981) but in the present review the SCA (1990) conversion of 17.5 kJ/g DOM has been used. The mean of these 5 values is 34.2 kJ ME/g of growth (range 22 – 42 kJ ME/g of growth).

During the past 20 years data have been derived for the growth requirements of Australian Angora, cashmere and rangeland goats managed in four experiments (Table 4.1). The mean value for the energy requirements for growth of these Australian goats was 39.8 kJ ME/g of growth (range 24 - 54 kJ ME/g of growth). Further calculations are possible using the data from McGregor (1988, 1995).

Assuming that all reports are relevant to Australian conditions, the mean of these 9 estimates for the energy requirements for growth is 36.7 kJ ME/g of growth. This value has been used to revise the estimates of the energy requirements for growth provided by the NRC (1981), see Table 4.2. For maximum growth of kids it is suggested that the ration contain at least 10 MJ ME/kg.

A compendium of recorded growth rates of all breeds and age classes of Australian goats provides a guide to the potential growth of goats being fed to target weights McGregor (2005c).

4.2.3 Energy requirements during pregnancy and lactation

4.2.3.1 Provision of metabolisable energy

The NRC (1981) indicate that up until day 85 of pregnancy that does be fed at maintenance and that for the last 8 weeks of pregnancy that energy provision be increased by 5.94 MJ ME/day. NRC has included in these values an allowance of 20% for does carrying twin pregnancies. SCA (1990) suggest that based on evidence for sheep and assuming a birth weight of 4 kg, that from day 66 of pregnancy energy provision be increased by initially 0.4 MJ ME/day rising gradually to an allowance of an extra 5.3 MJ ME/day. They suggest a *pro rata* adjustment for energy requirement based on different total birth weights. For example, twin goats with a total birth weight of 5 kg would need a 25% greater allowance. It is unclear what triplet goats weighing a total of 4 kg would require. The practical application of these recommendations is considered to be too complex during drought feeding operations on farms and Section 4.2.3.2 suggests a different approach.

Experimental evidence with Australian goats indicates that feeding below maintenance (from 0.8 to 0.5 of maintenance) from day 50 to day 85 of pregnancy will substantially increase the risk of reproductive failure whereas feeding at maintenance will provide no penalty in terms of kid birth weight (McGregor 1995).

The NRC (1981) and SCA (1990) provide data to estimate the energy requirement for lactating goats. The SCA (1990) recommendations for sheep were used as the basis for the energy provision from day 85 of pregnancy during a large experiment conducted with pregnant and lactating Australian Angora goats (McGregor 1995). These goats were housed in small outside pens where the activity was minimal and so provide a good model for the energy requirements of typical drought fed does. The milk production and quality of these goats was determined. For an average 12 week lactation producing an average of 1.5 kg of milk with 9.5% fat, the actual energy intake over maintenance was 9.0 MJ ME/d (McGregor 1995). This value has been provided in Table 4.2 along with other nutrients as suggested by NRC (1981).

4.2.3.2 Feeding reproducing does using maintenance requirements as the benchmark

The risks of adopting the SCA (1990) recommendation for sheep of using set allowances for pregnancy in goats assumes that the reproductive performance is similar and that farmers know the pregnancy status of their does. Often farmers do not accurately know the date of conception or the number of foetuses being carried and this is particularly so in extensive pastoral rangelands. The practical consequence of being one oestrus cycle in error is that feeding provisions during drought could be up to 17 days in error. During mid to late pregnancy a delay of 17 days in increasing energy provision may lead to wide spread abortion in goats at about 100 day of pregnancy.

Table 4.1. Some estimates of the energy requirements for maintenance and growth of Australian Angora, cashmere, dairy and rangeland goats

Goat breed or strain	Age years	Sex[A]	Weight kg	Season	Fleece at start	Housing and length of study	Ration composition	Maintenance kJ ME/$kg^{0.75}$	Growth kJ ME/g	Authority
Australian Angora	2	CM	29	Spring	Shorn at start	Indoors, 12 weeks	Oaten chaff and 150 g/d barley	267		McGregor and Hodge, 1989
Australian Angora	1-2	CM	11-35	Spring	3 weeks fleece	Indoors, 26 weeks	Pellets 63% barley, 25% lucerne meal, 10% lupins, 2% minerals	391	34.6	McGregor, 1982 unpublished
Australian Angora	2 - 6	F	35	Winter	4 months fleece	10 weeks pregnant. Outdoor pens, 6 weeks	Pellets 73% lucerne, 25% barley, 2% minerals	390		McGregor, 1995
Australian Angora	1.5-2	CM	20	Autumn - Winter	Shorn at start	Indoors, 23 weeks	Whole wheat grain or 80% whole wheat and 20% hay	428		McGregor, 2005b
Australian cashmere	2	CM	28	Summer - Winter	Shorn at start	Indoors, 7 months	Persian clover (*Trifolium resupinatum*)	312[B], 267[C]		McGregor, 1988
Australian cashmere	2.5	CM	33-40	Spring	3 months fleece	Indoors, last 14 days of 47 day study	Base diet 75% barley, 25% lupin pellets with six levels of hay, 0 to 27%	385[D]		Derived from McGregor, 1994
Australian cashmere	5.5	CM	37-50	Summer Autumn	6 months	Indoors, last 7 weeks of 9 week study	Senescent summer pasture with 5 levels of barley and lupin grain	485[D]	45.4[D]	Derived from McGregor and Umar, 2000
Australian rangeland	0.5	M, F	14-17	Summer Brisbane	Not shorn	Indoors, 18 weeks		376	24.8	Ash and Norton, 1987
Australian rangeland	0.5	M	14-28		Not shorn	Indoors	Concentrate diet	455[D]	54.4[D]	Derived from Norton, 1982
Australian dairy Saanen	4-6	F	38-62	Thermo-neutral	Not shorn	Indoors, last 9 weeks of 13 week study	50% lucerne chaff, 50% oat grain	310		Dunshea, 1987

[A] CM, castrated male; F, female; M, male
[B] Maintenance of body energy based on stable body condition scores
[C] Maintenance of live weight
[D] Derived using conversion factors from SCA (1990).

Table 4.2 Guide to the daily nutrient requirements for maintenance of goats during a drought under stable dry conditions with minimal activity. If some grazing is provided then requirements increase by 25%. Under cold, wet and windy conditions energy provision should be doubled. Data are based on the review of maintenance energy requirements of goats (see text) and NRC (1981)

Live weight kg	Energy requirement MJ ME[A]	Total crude protein g	Calcium g	Phosphorus g
Maintenance during drought feeding in intensive feedlot type management				
10	2.27	33	1	0.7
20	3.82	55	2	1.4
30	5.18	74	3	2.1
40	6.43	93	4	2.8
50	7.60	110	4	2.8
60	8.71	126	5	3.5
70	9.78	141	6	4.2
80	10.81	156	6	4.2
90	11.80	170	7	4.9
100	12.78	184	7	4.9
Requirement for does in last 8 weeks of pregnancy				
30	11.12	156	5	3.5
40	12.37	175	6	4.2
50	13.54	192	6	4.2
60	14.65	208	7	4.9
70	15.72	223	8	5.6
80	16.75	238	8	5.6
Additional requirement above maintenance for milk production during lactation. For a 12 week lactation averaging 1.5 kg milk at 9.5% fat				
	9.0	180	7.5	5.3
Additional requirement above maintenance for growth at 50 g/day				
	1.84 [B]	14 [B]	1	0.7
Additional requirement above maintenance for growth at 100 g/day				
	3.67 [B]	28 [B]	1	0.7
Additional requirement above maintenance for growth at 150 g/day				
	5.51 [B]	42 [B]	2	1.4
Additional requirement above maintenance for growth at 200 g/day				
	7.34 [B]	56 [B]	2	1.4

[A] Mega joules of metabolisable energy

[B] For maximum performance of kids it is suggested that the ration contain at least 10 MJ ME/kg and 16% crude protein.

Note: These macro nutrient guidelines are suggested guidelines and should be used as a starting point. The guidelines need to be modified based on regular monitoring of the live weight and body condition score of goats. During feeding in severe weather the energy requirement may be two or more times those listed.

For practical farmers with larger group feeding situations during a drought it is easier to determine the maintenance requirement for does during mid pregnancy and then use adjustment factors to increase the provision of energy at the appropriate stage of pregnancy. The suggested guideline for feeding pregnant and lactating does is given in Figure 4.1 (modified from McGregor 1995). The assumptions underlying the data are:

1. The mean live weight of a flock of does during a drought will be 35 ± 0.5 kg.
2. During a drought, does in the early stages of pregnancy should be fed at maintenance.
3. Energy provision should be increased from day 66 of pregnancy (SCA 1990) in progressive steps.
4. It is unlikely that farmers know the pregnancy status of their does. This data includes 20% of does with twins, similar to that seen in practice. Frequently 5 to 10 % of does are dry.
5. When ration provision is increased the rate of increase is 50 g/day every second day.
6. From about day 120 of pregnancy until kidding feed provision is *ad libitum*.
7. During a drought, energy provision during lactation may be restricted. Thus the feeding level shown during lactation is 60% of that consumed by does fed *ad libitum*.

As a rule of thumb, feeding from day 140 of pregnancy and during lactation could be maintained at 2.5 times maintenance.

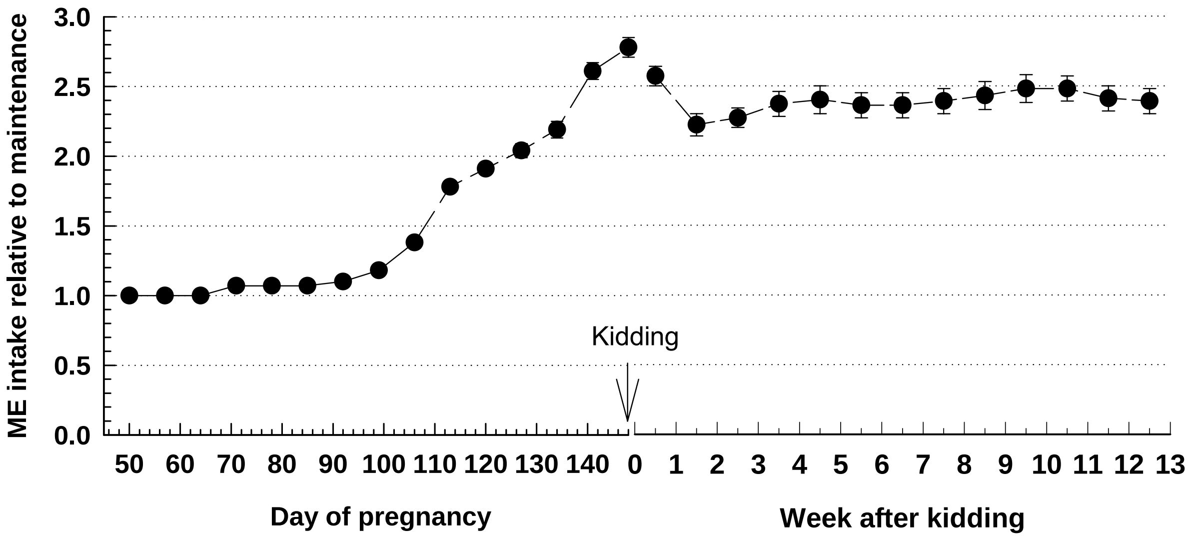


Figure 4.1 Suggested drought energy feeding for pregnant and lactating does. The graph shows mean (± se) intake of metabolisable energy (ME) relative to maintenance ME requirements of pregnant and lactating Angora does kept in outdoor pens with minimum activity (modified from McGregor 1995). The energy requirements are increased from day 66 of pregnancy in accordance with SCA (1990) recommendations. Energy provision during lactation is 60% of that consumed by does fed *ad libitum* and was achieved without ill-effect

To determine the level of energy provision from Figure 4.1:

1. Determine the energy required to maintain the pregnant does in early pregnancy;
2. At any given stage past day 66 of pregnancy, read from the vertical axis the relative ME intake required for the doe;
3. Multiply the relative intake by the energy required for maintenance feeding.

For example: a 40 kg doe would require 6.43 MJ ME per day for maintenance (Table 4.2). At day 130 of pregnancy the relative intake should be 2.0 times maintenance (Figure 4.1). Thus the energy requirements would be 2.0 x 6.43 = 12.86 MJ/day.

Fibre growth is maintained when pregnant Merino ewes (Williams and Butt, 1989) and pregnant Angora does (McGregor 1995) are fed adequate energy to maintain maternal live weight.

4.2.3.3 Feeding twins

Clearly the energy requirement for does rearing twins will be greater than that for single rearing goats. The requirements are discussed in Section 4.2.3.1. Australian cashmere/rangeland does have performed similarly to the Angora does described when fed diets designed for drought feeding. When fed whole oats (97.1%) treated with urea (1.4%) plus minerals (1.5%) or oats (69%) with lucerne chaff (29.5%) plus minerals (1.5%) rangeland does raised kids at 106 to 171 g/d (Table 4.3). The data have been derived from McGregor and Hodge (1988) and the digestibility determinations provided by Hodge et al. (1980) have been used to determine ME intake as the experiments were conducted simultaneously using the same feed stuffs. The use of oats and urea is discussed in Section 4.4.

Table 4.3 A comparison of the energy intake, growth and milk production of twin rearing rangeland goats fed oats and lucerne (OL) or oats and urea (OU) diets (adapted from McGregor and Hodge 1988)

Treatment	Doe live weight, kg	Doe ME intake, MJ/d[A]	Kid live weight gain, g/d	Doe live weight change birth to 4 wk, kg	Milk production, kg/day	Milk fat %
OL	45.6	18.1	171	-1.3	3.4	6.3
OU	46.1	13.6	106	-2.6	2.2	6.6

[A] Determined from feed intake, digestibility data (Hodge et al. 1980) and conversions SCA (1990)

"If the does are not strong enough to rear kids then the whole drought feeding exercise is a waste of time."

"Nobody wants runty kids."

(Producer of 700 goats after 2001-2005 drought)

4.2.3.4 Early weaning and rate of feed intake

Early weaning has been suggested as a strategy to reduce total energy expenditure (Anon 1958, McInnes and Briggs 1964, Oddy 1978). When Anon (1958) weaned lambs at 7 kg, mortality was 16%. McInnes and Briggs (1964) weaned Merino x Border Leicester lambs at 27 to 59 days of age (mean 46 days) and 13.1 kg live weight and compared their growth with unweaned lambs suckling ewes in yards or when grazing at pasture. When fed oat grain and chaff diets with or without protein supplementation, the lambs weaned and fed high protein diets (17.8% crude protein, CP) grew 132 g/d, as fast as lambs suckling ewes confined to yards and fed the same diet, 117 g/d. Lambs in both these treatments grew significantly faster than lambs weaned and fed a low protein diet (10.4% CP), 71 g/d, or who suckled ewes fed the low protein diet in yards, 94 g/d, or who suckled ewes that grazed mature dry pasture 91 g/d. As grazing ewes lost 6 kg and the hand fed ewes gained 0.5 to 2.2 kg during the 10 week trial, it was concluded that it is sufficient to feed the ewes and let the lambs suckle. As only one lamb died, it appears that weaning at 13 kg live weight can be achieved.

Oddy (1978) suggests that lambs be weaned at about 10 kg. At this age, young ruminants need very careful management and highly digestible rations. It is suggested that early weaned kids should be fed *ad libitum* rations of about 10 MJ ME/kg DM and 16% crude protein.

Oddy (1978) suggests a maximum rate of feed dry matter intake for sheep of about 3.5% of live weight and up to 5% in rapidly growing animals. He cautioned that these values be used as a guide for groups of animals being fed good quality mixed feed. The NRC (1981) provides a range of maintenance intake values as a % of live weight, for different feeds and live weights. No appropriate data on the food intake of goats expressed as a % of live weight is available for Australian goats. It would be possible to calculate such values from existing published data but it is better to determine the ME requirements using the information in this manual.

Producers who had tried early weaning of kids during the 2002-2005 drought reported that a minimum age of 6 weeks and minimum live weight of 8 to 10 kg with access to pasture helped the kids reach target weights for sale. One producer who fed Boer goat weaners from 19 kg live weight for ten weeks before intended sale found they ate about 1 kg/day (about 30 c/head) plus barley straw but reported it was not financially worthwhile unless a good premium was obtained. The goats gained 151 g/d from an initial live weight of 19 kg.

Little scientific information is available about feeding early-weaned kids. The performance of cashmere kids that did not grow out well and were weaned at 13 kg in the middle of summer was reported by McGregor et al. (1988). These kids were kept in bare 0.2 ha yards and fed 400 g whole grain per day of 77.5% barley, 20% sweet lupin grain and 2.5% crushed limestone in metal troughs with 10 cm trough space/goat. Grass hay (9.6 MJ ME/kg DM) was fed *ad libitum* in hay racks. Bucks were separated from does to avoid harassment. Following weaning and after 2 days of rain, 15% of kids had diarrhoea. Male and wether kids grew at 78 g/d and doe kids at 57 g/d. When slaughtered at 23 kg live weight, these kids provided excellent 10 kg carcasses. This supplementary feeding resulted in an increase in the number of these weaners reaching puberty and in being available for mating (Wolde-Michael et al., 1989).

Stapleton (2002), Bell (2002) and Cunningham (2002a) have reported success in weaning straight onto stubble. Cunningham reported no problems with kids weaned onto wheat stubble. Stapleton (2002), a very experienced goat farmer in NSW, favours leaving kids on their mothers for as long as possible. He argues that during a drought, the does are better converters of rough feed to protein. He suspects that during drought many kids are weaned early anyway. Many eventually grow out but there is always a tail of about 5% that never grow out. Oldfield (2002) noted that during dry seasons, once kids were weaned the does stop losing live weight. She feeds her does with barley for six weeks before and after kidding. In this manner the kids are well used to grain that is required after weaning. Stapleton (2002) tries to supply lucerne to weaned kids, either as grazing or in bales. Oldfield (2002) usually provides peas. Both of these feeds have high protein contents and are usually readily eaten.

4.2.3.5 Containment areas reduce energy expenditure

The energy expenditure of grazing animals at pasture was reviewed by SCA (1990). Calorimetric studies with ruminants have established the energy costs of walking and standing as follows:

1. Walking horizontal component, 2.6 kJ/kg live weight/km;
2. Walking vertical component, 28 kJ/ kg live weight/km;
3. Standing compared with lying, 10 kJ/ kg live weight/day.

For each hundred 35 kg does that are allowed to wander around a large hilly paddock, assuming 10 km per day with a vertical climb of 100 m, compared with being confined to a suitable yard or small paddock, the additional energy expenditure approximates to 100 MJ ME per day, equal to the energy content of about 8 kg of wheat. Confining does and their kids will reduce total energy expenditure.

4.2.4 Energy and adaptation requirements for mating bucks

Toerien et al. (1999) reported that the energy requirements of working bucks were 460 kJ ME/kg$^{0.75}$. The energy expenditure of the 57 kg bucks was associated with the number of does marked. It is concluded that the energy requirement of working bucks is 15% greater than the maintenance requirement calculated on the basis of live weight only.

Australian producers have reported that using two-year-old Boer bucks in score 2 to 3 condition during drought periods on semi-arid range pastures resulted in good performance during the first three weeks of mating but after this time the bucks have “crashed” with some deaths reported. Bucks need to be familiar with grazing conditions in rangelands. It is inadvisable to move bucks reared on improved pastures or in intensive lot-fed conditions onto browse conditions and expect rapid adaptation and high levels of performance. Bucks need to be conditioned and imprinted when young to range conditions and also need to know where the water supplies and supplementary feeding (if any) are located in range conditions.

4.3 Impact of cold stress on energy requirements of goats

4.3.1 Susceptibility to cold stress

4.3.1.1 Critical conditions

The impact of cold stress on the energy requirements of grazing animals is discussed in detail in SCA (Anon 1990). This discussion is largely taken from the recent review of cold stress on goats (McGregor 2002b). Grazing ruminants such as goats try to maintain a near-constant body temperature of approximately 39°C, and this is not a major issue when an animal is in the "zone of thermoneutrality". The lower limit of the zone of thermoneutrality is the lower critical temperature (T_{lc}). T_{lc} varies with the thermal insulation and the rate of heat production of an animal. Thermal insulation is the resistance to heat loss and is provided by tissues, fleece, the boundary layer of air trapped in the fleece, and is affected by air temperature, rain fall and windspeed.

An animal will increase its heat production if the air temperature falls below the T_{lc}. The maximum attainable heat production is called the summit metabolism. In sheep, the summit metabolism is approximately 2.16 MJ/kg $W^{0.75}$ per day, where W is live weight (SCA 1990). The summit metabolism cannot be maintained for more than a few hours although a sheep can maintain half the summit metabolism for a number of days. Some examples of T_{lc} are provided in Tables 4.4 and 4.5. For a 40 kg doe, at the summit metabolism, the total energy usage in 4 hours is equivalent to 5.7 MJ, similar to the metabolisable energy content of about 500 g of wheat or barley grain.

As can be seen from Tables 4.4 and 4.5, the critical temperature in wet and windy temperature when a sheep or calf has a 10 mm coat can be as high as 27 to 32°C. The information available for goats is limited. The data for calves are provided as their coat more closely resembles that of many goats (eg rangeland and Boer types and Angora and cashmere goats in the 6 weeks after shearing) although the body shape of calves is different to that of goats.

Holmes and Clark (1989) reported that the T_{lc} of cashmere goats, weighing 14 to 22 kg, was increased by 3 to 5°C when wind speed was increased from 0.7 to 6 km/h. At 16°C, following 4 hours of simulated rain, the metabolic rate of the cashmere goats increased 90% over that of the goats in dry conditions.

Table 4.4 Estimated lower critical temperatures (T_{lc}) for sheep as provided by SCA (1990) and for rangeland and cashmere goats (Holmes and Moore 1981, Holmes and Clark 1989)

Animal	Air and feeding conditions	Coat depth	T_{lc}, °C
Sheep, Adult	Still air, fasted	Shorn, 5 mm	31
	Still air, maintenance	Shorn, 5 mm	25
	Still air, full fed	Shorn, 5 mm	18
	Still air, maintenance	50 mm	9
	Still air, maintenance	100 mm	-3
Rangeland goat, 21 kg	Still air, maintenance	57 mm	9
	Wind 7 km/h, maintenance	57 mm	12
Cashmere goat, 18 kg	Still air, 1.25 times maintenance	4 mm	16-22
	Still air, 1.25 times maintenance	8 mm	11-15

Table 4.5. The lower critical temperatures (°C) at thermoneutral conditions for a 50 kg live weight adult sheep and a 40 kg live weight calf fed at maintenance (SCA 1990)

Coat depth mm	Wind km/h	Calm			10			20			30		
	Rain mm/d	0	10	30	0	10	30	0	10	30	0	10	30
Adult sheep 50 kg													
10		16	16	20	22	24	25	24	26	26	26	27	27
30		5	8	11	15	17	18	19	20	21	21	22	24
50		-5	-2	1	8	10	12	14	15	16	18	19	20
Calf 40 kg													
10		22	25	26	28	29	30	30	31	31	31	32	32

4.3.1.2 Saturation of fleeces and hypothermia

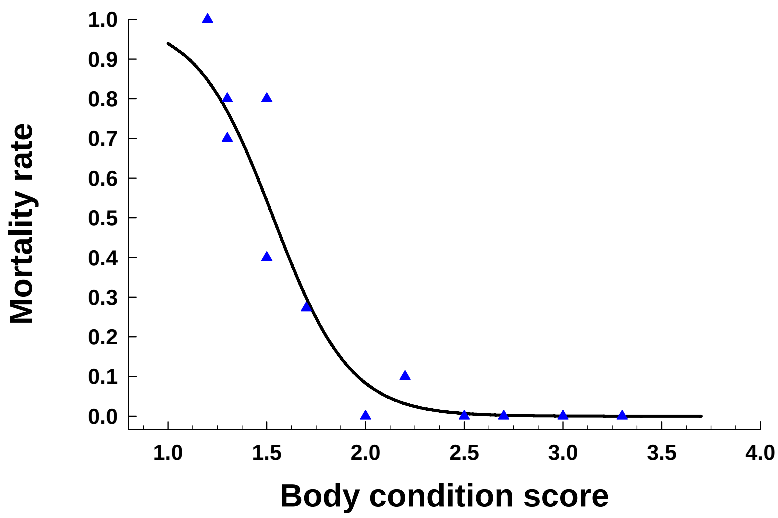
Relative to sheep, goats appear to be more vulnerable to continuous rain at low wind speed and to intense storms (Wentzel et al. 1979, Holmes and Moore 1981, Poolman 1984, McGregor and Presidente 1985, McGregor and Rizzoli 1991). Part of the increased vulnerability of goats is that less rain is required to saturate their fleece compared to sheep (>7 mm of rain is required to saturate sheep). Rainwater displaces the warm insulating layer of air within the fleece. The reasons for this are discussed elsewhere (McGregor 2002b).

Holmes and Moore (1981) demonstrated that goats have a higher critical temperature than sheep when their coats were the same depth. In Holmes and Moore's study, for sheep to have the same critical temperature as goats with a 60 mm deep fleece, the wool fleece needed to be only 30 mm deep. Signs of physiological stress increase and heat production of goats increases rapidly as the air temperature falls below 15°C and under wet and windy conditions the heat production can increase at 27 to 29°C (Wentzel et al. 1979, Poolman 1984).

Research in South Africa concluded that Angora goat deaths could occur as soon as minimum temperatures dropped below 10°C with 15 mm rainfall and a simultaneous wind run of 7.5 km per hour. These criteria had a 73% correlation to goat death rates (Rowswell 1986).

In southern Australia, high stocking rate, low body condition score and low live weight were all positively correlated to deaths of Angora goats from hypothermia (McGregor 1985c). Reanalysis of that data showed that the between paddock mortality was best explained by body condition score alone (McGregor unpublished 2005). Mortality increased substantially at body condition scores below 2 (Figure 4.2).

Figure 4.2. The between paddock relationship of body condition score and mortality rate for Angora wether goats six weeks off shears exposed to a severe weather event in southern Australia (McGregor unpublished 2005)



4.3.1.3 Shearing practice

Shearing removes the external natural insulation of the goats and leaves them exposed to the elements. Shearing practice also reduces the total amount of insulation found on Angora goats compared with Merino sheep. Angora goats are shorn twice each year, usually in autumn and spring. As a result of shearing, the thermal insulation provided by the fleece of Angora goats during the coldest period of the year is significantly less than that of spring shorn Merino sheep. During winter for example, autumn shorn Angora goats may have 1 to 1.5 kg of fleece, whereas spring shorn Merino sheep have at least 3 to 3.5 kg of fleece (McGregor 1985b).

Birrell (1989) determined the influence of pasture and animal factors on the consumption of pasture in Corriedale sheep shorn annually and grazed on mixed perennial/annual species pastures at Hamilton, Victoria. Intake rate was elevated by 40-50% immediately after shearing and in 55 kg sheep intake rate took more than six months to fall to a steady state. In 75 kg sheep intake rate took only four months (120 days) to fall to a steady state.

Farrell and Corbett (1970) provided evidence that the fasting heat production of Merino sheep increased significantly after shearing and that the return to pre-shearing values in heat production was not observed until 135 days after shearing. They concluded that sheep at pasture had an increased energy requirement for maintenance for a considerable period after shearing.

On the basis of the data provided including the observations that:

- The fleece of the Angora goat is not as efficient an insulator as is the fleece of a Merino sheep;
- Angora goats are shorn bi-annually; and
- The mean live weight of Angora goats is less than 55 kg;

it is highly likely that Angora goats suffer the effects of exposure to cold stress throughout the year.

Cashmere goats shorn twice each year will be exposed to the same risks as Angora goats. The shearing of cashmere goats in mid-winter exposes them to significant risks from weather stress. Provided adequate shelter and supplementary feeding are available, cashmere goats of low body condition score can survive snow, wet and windy conditions (McGregor 1988, 1996 and unpublished). Deaths from hypothermia will be reduced if cashmere goats are well grown by shearing time.

Following shearing the general industry advice to fibre producers is that the most susceptible time for death is: for sheep, the first 2 weeks; fibre goats, the first 6 weeks.

4.3.1.4 Grazier weather warnings

The methods by which sheep grazier warnings are predicted are described by the Bureau of Meteorology (Anon 1982). Warnings of wet, windy conditions are issued to enable graziers to take action to reduce losses among animals susceptible to hypothermia. The Bureau of Meteorology developed a nomogram based on research relating the physiological reaction of sheep to weather conditions. The nomogram is used as an aid in deciding whether or not an alert is warranted. Warnings are issued at a forecaster’s discretion and take into account the predictions for the lowest temperature, highest hourly mean wind speed, total rainfall, and preceding weather conditions.

Goat producers hearing sheep grazier warnings are advised to include themselves in the target audience and take appropriate action (McGregor 2001b). The South African Weather Bureau has used the criteria in Table 4.6 to determine if weather warnings are required for the Angora Goat Industry. It is suggested, in the absence of any further data, that goat farmers use these values.

Table 4.6. Cut-off values used by the South African Weather Bureau for warnings to the Angora goat industry (Poolman 1984)

Weather condition	Any two of the following conditions:
Rain	More than 5 mm of rain
Temperature	Less than 10°C minimum in wet conditions
	Less than 3°C minimum in dry conditions
Wind	Stronger than 18 km/hour

4.3.1.5 Pattern of live weight change and susceptibility to hypothermia
Hutchinson and McRae (1969) evaluated factors associated with the survival of newly shorn sheep at Armidale, NSW. Deaths in sheep were related to a high rate of body weight loss during the 4 weeks before shearing and the actual body weight and condition score at shearing was unimportant. This advice has been repeated by Scarlett (2002). However, deaths in goats following shearing have been associated with stocking rate and body condition at the time of the weather event (McGregor 1985, McGregor and Presidente1985, McGregor and Rizzoli 1991). As discussed in the previous section body condition score was the most important factor (Figure 4.2). However losses of unshorn meat and cashmere goats have also been reported in late summer and early autumn following the onset of wet weather (McGregor and Rizzoli 1991, McGregor unpublished reports from producers).

As one producer described "Given that within any mob there are those which do better than others, the poor ones didn't all die and the better conditioned ones didn't all live." The evidence is that goats with a body condition score of 2 or below are the most vulnerable to hypothermia. It is clear that during drought, many goats will have increased susceptibility to hypothermia.

4.3.2 Implications for energy provision

4.3.2.1 Summary of impacts
The implications of the susceptibility of goats to cold stress for drought feeding are:

- Goats with a condition score of 2 or below are the most susceptible;
- Shearing increases susceptibility to cold stress for 6 weeks as a minimum;
- Feeding goats at maintenance increases susceptibility to cold stress compared with when goats are fed to grow;
- During drought, goat managers need to constantly monitor the Sheep Grazier Weather forecasts issued by the Bureau of Meteorology;
- When wet and windy conditions are forecast producers need to increase energy provision prior to the arrival of the weather. Given the increasing reliability of weather forecasts, it should be possible to increase energy provision 3 to 4 day prior to arrival of bad weather;
- Susceptible goats should be moved to suitable shelter;
- Feeds suitable for rapid introduction need to be available.

4.3.2.2 Increased level of energy provision
In cold wet conditions the provision of energy should be increased at least twofold. Hay is the safest for such a sudden increase in the ration, but it can be gradually replaced by grain if the increase has to be sustained. Ideally begin to increase grain feeding if the onset of bad weather has been predicted. If grain alone is to be fed, then there are a number of options:

1. Increase the frequency of feeding rather than the amount offered at each feed. For example feed twice a day rather than feed a double ration once a day.
2. Feed "chocolate mealies" or slaked lime treated grain (see Section 3.5)
3. Feed a non-cereal grain such as lupins, faba beans etc.

The advice that when grain is trailed on muddy ground rations should be increased by 16% to make up for wastage caused by trampling needs to be used by goat producers (Holst and White 1997).

4.4 Other nutritional requirements

4.4.1 Other nutrients for drought feeding

While energy is usually the greatest requirement, other nutrients can become limited during a drought. Once an energy ration has been determined, other issues must be considered including:

- Is there adequate protein in the diet?
- Can goats eat enough of this ration to satisfy their needs?
- Will the supplement, plus paddock feed, provide adequate roughage?
- Are there enough minerals in the diet?
- Are water supplies sufficient and suitable?

4.4.2 Protein requirements

4.4.2.1 Provision of crude protein

NRC (1981) suggested daily provision of protein (see Table 4.1). Generally most hays, grains and purchased commercial pellets have adequate crude protein for adult non-lactating goats. It is common that dry grazed pasture and some browse plants and some poorer grass hays, straw and oaten grain in southern Victoria are below 7% crude protein (Hodge et al. 1980). If the crude protein falls below 7% the rate of rumen digestion will fall, as the diet is not ideal for rumen micro-organisms and appetite may drop. In response to this situation animals will catabolise (break down) their muscle protein to supply sufficient nitrogen for saliva production and rumen function but insufficient additional nitrogen for other body requirements. As a consequence, the animals will lose weight and may drop below their critical live weight. This situation is particularly dangerous for weaners and other stock below 20 kg.

For maximum performance of kids it is suggested that the ration contain 16% crude protein. Diets with more than 16% crude protein result in substantial losses of nitrogen caused by rumen degradation. Lactating does have higher requirements for protein (Table 4.1). Both kids and lactating does may need supplementation of cereal grain or hay diets with protein rich feeds such as lupins, faba beans or cottonseed meal. Cottonseed meal should not make up more than 20% of the diet. More detail about feeding cottonseed is provided by Leng (2002).

Results in the USA have shown that the most strategic use of protein is to enable young female goats to reach mating live weight by 17 months of age. Feeding both energy and protein from weaning, at 5 months of age, for 3 months increased live weight 3.6 kg, mohair growth by 20% and mohair fibre diameter by <1 μm. Forage quality was low (DMD 50%) and the supplements of both energy and protein were additive to forage intake thereby increasing total dry matter intake (Huston et al., 1993).

4.4.2.2 Using urea to supply nitrogen

Most protein consumed by ruminants is denatured during rumen digestion and is either used by rumen micro-organisms for their growth or converted into urea or ammonia (Harmeyer and Martens, 1980). Urea is a chemical compound containing a high percentage of nitrogen (46%) and is a normal part of the metabolism of goats. Although it has often been referred to as a ‘protein supplement’, this is not correct, urea does not contain protein.

In drought and semi-drought conditions, urea has been used to supplement poor-quality dry pasture and low-protein hay in order to speed up the rate of digestion, increase food consumption and stop animals losing weight (Clark and Quin 1951, Anon 1958). Such a strategy postpones the time when an energy supplement such as grain will be necessary.

However if consumed in excessive amounts, urea will poison sheep (McBarron and McInnes 1968). In most drought feeding situations a supplement such as molasses must be fed with urea to ensure that the supplement is effective. Urea is only effective if supplied to grazing goats while dry feed is still available or when fed with low nitrogen roughage or low nitrogen oats. Scarlett (2002) suggested that the use of urea be restricted to adult dry goats that are still in strong condition. Norton et al. (1994) found that the digestibility of the molasses when fed to rangeland goats was only 56.5%, so it is not a readily digested source of energy and is used mainly as a medium to feed urea.

In the past, there has been some confusion about the safe level and method of feeding urea to ruminants. In the study of McGregor and Hodge (1988) there was no evidence of urea toxicity even though some does consumed 29 g/day of urea. A range of experiments with sheep have shown that intakes of 20 g/day up to 100 g/day of urea can be safe when urea was fed in blocks or when sprayed onto low nitrogen herbage (McInnes and Mangelsdorf 1966, Coombe and Tribe 1963). Mortalities from urea toxicity have been reported in other studies with urea intakes as low as 8 g/day or when urea was rapidly ingested when urea was supplied by drenching or when fed as power with grain (McBarron and McInnes 1968).

Urea can be supplied in three different methods, each with its own costs and benefits. In summary:

1. Urea can be supplied in lick blocks or in drums as a liquid supplement with molasses. In drum feeders, the urea molasses mix can be toxic if too much urea is consumed in one meal, or the urea is not evenly mixed. Ideally each goat will consume 6 to 8 g of urea each day (Scarlett 2002). Norton et al. (1994) found that when rangeland goats were fed sorghum grain or molasses with urea as the major energy source that the goats consumed more dry matter and had higher live weight gains when the grain was fed. McInnes and Mangelsdorf (1966) found that performance of sheep fed low concentrate urea blocks (7.1% urea) was better than that of sheep fed a 30% urea block.

   Stapleton (2002) reported that he had no problem using 10% urea blocks with goats to make better use of standing straw. He reported that with wheat stubble, goats seem to be able to digest more of the straw than sheep. Wet stubble or stubble left in wet summers that goes grey in colour has been known to trigger Vitamin B1 deficiencies so producers need to watch for this problem when the season breaks. Another producer reported that rangeland goats fed straw based diets used 1 urea block/100 kids/week. Rates of urea block usage are also discussed in Section 4.4.4.1.

2. Urea can be sprayed onto straw when it is baled. Hadjipanayiotou (1984) demonstrated that treating straw with urea and feeding it to lactating does, increased the digestibility of the straw and consequently the ME content. Spraying urea onto straw evenly spreads the urea though the roughage. Obtain further advice from an Agricultural Department on the current best practice before undertaking a urea spraying activity.

3. Urea can be sprayed onto grain. In south-eastern Australia oats are commonly used as a drought feed, but they have a low nitrogen content (7 to 9% crude protein). If these oats are fed to lactating ewes, their milk production is much lower compared to ewes that are fed oats with urea (Hodge et al., 1981). Urea sprayed on to oats has been successfully used as a drought feed for does (McGregor and Hodge, 1988, see Table 4.3).

   Bogdanovic (1983) described a cost-effective method of supplementing oat grain with urea and minerals. To avoid segregation of the powdery supplements molasses was used as the binding agent. The method is to use a horizontal paddle mixer and mix the following (g/kg of air-dry grain): molasses 20 (diluted in water 2 : 1 w/w); ground limestone 14; urea 10 (diluted in water 1 : 1 w/w and added to the diluted molasses); common salt 5; potassium sulphate 4; trace mineral and vitamin premix 1. First slowly add half the molasses urea mixture, then add the mixed minerals and then add the remainder of the molasses urea mixture. Mix for 10 minutes and then store in hessian bags. The mixture can be stored for up to 12 months without separation but are best used within a few weeks.

Several producers reported that even if the urea blocks had little productive effect they regarded their use as something that was “cheap” which also made them “sleep better” because at least they had done something.

4.4.3 Roughage

Roughage is needed by weaned kids and does in late pregnancy or in lactation. Milk production of does (Morand-Fehr 1991) and of ewes (Oddy 1978, Kenny 1985) is improved if roughage is provided in the ration. For ewes, a minimum of 30% roughage is required (Oddy 1978) and this level of roughage in practice provides good results in ewes (Hodge et al. 1980, 1981, Watson and Egan 1985) and does (McGregor and Hodge 1988, see Table 4.3).

If the main source of energy during a drought is wheat or other low fibre grains, a supplement of roughage will be necessary. Roughage may come from hay, oats, lupins pasture or crop residue. Oat grain and lupin grain provides six or more times as much fibre as wheat grain. Kenny (1985) reported that ewes fed oat grain (crude protein level 10.5%) performed better than those fed wheat. In this study the feeding of poor quality hay (crude protein 5.0%) at rates of 150 g/ewe per day in pregnancy and 350 g/ewe per day in lactation, improved the performance of ewes fed oats or wheat with or without lupins. Provision of lupins in cereal grains improved ewe performance.

The roughage may only need to be supplied in a small quantity, about 10% of the ration. It will pay to buy or retain a small proportion of hay early in the drought so that you have some roughage in autumn when pasture or crop residue is scarce. Roughage is discussed further in Section 3.3.4.

4.4.4 Minerals and Vitamins

4.4.4.1 Minerals

The mineral requirements of goats have been reviewed by Haenlein (1992). Only two major minerals, calcium and sodium, are likely to be needed for sheep as additional supplements during a drought (SCA 1990, Court 2002). Phosphorus deficiencies may occur on some properties. In some districts goats have marginal supply of iodine, selenium, copper and cobalt. Experienced goat producers have reported phosphorus and sulphur deficiencies.

Dry pastures are likely to contain sufficient calcium. When diets consist mainly of cereal grain it is likely that calcium will become deficient (Anon 1958). When grain is fed for more than a few weeks, calcium should be added to the ration. To prevent calcium deficiency, add 1.5% of finely ground agricultural limestone ($CaCO_3$ calcium carbonate) to cereal grain (that is, for every tonne of grain add 15 kg of limestone). Do not use builders lime, burnt lime or slaked lime for this purpose. The lime should be spread onto grain when filling the feed-out bin. The fine lime particles stick to the grain. Do not add lime to stored grain when filling the silo as lime may corrode the lining of the silo. If grain is being treated with urea and trace minerals use the method of Bogdanovic (1983, see Section 4.4.2.1).

The first animals to be affected by a calcium deficiency will be lactating does, then suckling kids, weaners, pregnant does and then adult wethers. In sheep, calcium deficiency is associated with depressed appetite, loss of live weight, reduced wool production, lowered milk production, impared teeth development in weaners, and in severe cases, heavy mortality (Anon 1958).

In Western Australia, Morecombe et al. (1990) observed that when 27 kg lambs grazing dry wheat stubble were provided with *ad libitum* oat grain, those provided with 2% crushed limestone grew at 83 g/d compared with the lambs fed oats without limestone who grew at 39 g/d. The sheep fed oats with limestone consumed 700 g/d of oats while the other treatment consumed 550 g/d of oats.

Sodium is deficient in most grains. Common salt (NaCl, sodium chloride) can be provided at 0.5% if needed, but often water supplies have sufficient salt to alleviate the need to supplement.

Alternatively, both salt and calcium can be provided in a salt urea block. The percentage of each mineral can vary, but calcium levels above 30% start to limit uptake. You can mix your own blocks cheaply or buy commercial blocks. One difficulty with blocks is that some goats in a mob are shy feeders and will not eat any or enough and the intake of the others can be highly variable.

If phosphorus deficiency is identified it may be rectified by supplementation with monosodium phosphate (MSP). MSP will need to be fed out mixed with grain. For goats grazing dry grazed mature pasture, the use of a small amount of a commercial feed pellets that contain phosphorus mineral supplements may be sufficient and may be a cheaper and easier method of supplying phosphorus than using MSP.

Many goat producers find the provision of a suitable multi-mineral urea lick block is adequate in supplying the minerals discussed. My experience with multi-mineral urea lick blocks in southern Victoria is that Angora goats took between 21 and 107 days per 100 goats to consume a block with a mean ± SD of 32 ± 9 days (McGregor unpublished 2005). This use varied with season and it appeared that harder blocks, that had been stored, took longer to consume than new blocks. No scientific reference was found to substantiate the effectiveness of multi-mineral urea lick block in supplying minerals to goats.

4.4.4.2 Vitamins

Vitamins, A and E, are the only vitamins likely to be deficient as a direct result of drought feeding.

Vitamin A is obtained from green pasture, hay with a good green colour, green browse plants and yellow maize. Even a short green pick will supply adequate quantities of Vitamin A. Vitamin A is stored in the liver. Young goats may experience deficiencies when they have been without green pasture, green hay or yellow maize for six months. Symptoms include night blindness, eye discharges and ill-thrift. Treat with Vitamin A or supply a feed with Vitamin A.

An inter-relationship exists between Vitamin E and selenium. Grains and hays are usually fair to good sources of Vitamin E, although considerable variation does occur. A Vitamin E deficiency induces symptoms similar to selenium deficiency (that is, still born kids and older kids that suffer from a stiff, stilted gait, lameness and illthrift). During droughts, wheat and pasture hay that has been stored for long periods can be deficient in Vitamin E. Lambs born to ewes fed wheat based diets before lambing and during lactation can become deficient in Vitamin E and die (Watson and Egan 1985, Watson et al. 1988). Watson and Egan (1985) reported the sudden deaths of 5% of lambs as a result of Vitamin E myopathy. In wether goats fed drought rations of wheat over long periods (McGregor 2005b) the Vitamin E levels were much lower than the levels reported in ewes whose lambs had Vitamin E myopathy (Watson and Egan 1985). Plasma vitamin E concentration was significantly higher for goats grazing pasture than those on wheat, and those with access to hay had higher significantly concentrations than those on wheat only. McGregor (2005b) concluded that producers need to ensure an adequate provision of vitamin E and or selenium during long term feeding of wheat, particularly during pregnancy, and with goats fed complete diets in housed or confined feedlots and similar situations. The provision of adequate selenium or some green feed is likely to alleviate the need to supplement vitamin E. Vitamin E in mineral premixes can be added to grain using the method of Bogdanovic (1983).

If you suspect these or other vitamin deficiencies, seek veterinary advice for confirmation and instructions for treatment.

4.5 Water consumption, quality and supply

A good reliable water supply is extremely important in drought. In drought, goats will be fed diets very low in water content and therefore must be supplied with water at all times. Published books on water supply for goats are out of date (NRC 1981). This Section is based on McGregor (2004).

4.5.1 Water intake

Giger-Reverdin and Gihad (1991) reviewed the main factors affecting water metabolism and free water intake of goats. Goat are similar to other ruminants and water intake is related to:

1. Dry matter intake (water intake is about 3 times dry matter intake);
2. Composition of feeds and especially their water, salt and mineral contents; taste factors;
3. Live weight;
4. Level of milk production (water required is 1.28 kg/kg of milk);
5. Physiological status (maintenance water intake is 107 $g/kg^{0.75}$ for a dry and non-pregnant goat, 140 $g/kg^{0.75}$ at mid-pregnancy and 165 $g/kg^{0.75}$ at mid-lactation); and
6. Environmental factors.

4.5.2 Sources of water loss

In all ruminants so far studied, evaporative water loss exceeds faecal and urinary water losses combined. Evaporative water loss provides a cooling mechanism for goats in hot dry conditions that are prevalent during drought. Environmental factors affect the evaporative (insensitive) water loss by goats. The evaporative water loss for many goats and sheep is 60% breathing (respiration) and 40% sweating (cutaneous) under hot dry conditions (as cited by Wilson 1989). In desert adapted Bedouin goats the relative evaporative water loss is 33% respiration: 67% cutaneous. When environmental temperatures increase from 20°C to above 40°C, respiration rates in East African goats increased from about 20 to over 250 breaths/minute (Maloiy and Taylor 1971).

Goats and sheep show intermittent synchronous discharge of sweat from the sweat glands. In British Saanen goats exposed to 40°C conditions, the pattern of sweating shows discrete peaks at regular intervals but there was a rapid fall off in the amount of sweat produced due to fatigue in sweat glands (Robertshaw 1968, Jenkinson and Robertshaw 1971). Dehydrated goats sweat less than hydrated goats with maximum sweat discharge rates of 45 g water/m^2/hour being usual although the desert adapted Bedouin goat has a sweat rate of 140 g water/m^2/hour (see review by Wilson 1989).

Goats and sheep are regarded as having a more efficient renal system (kidney function) which reduces water loss compared with temperate and Zebu cattle (Wilson 1989). In the Rajasthan desert during summer, the adapted goats were considered to be more efficient at economising on water use than sheep from the same region (Khan and Ghosh 1982). Many authors who have studied goats, that have had access to shade, concluded that goats were better adapted to more arid conditions than sheep. However, the arid environments to which goats are "so well adapted" are characterised by low rocky ridges and scrubland plant communities. These environments allow goats to use shade during the hottest part of the day (McGregor 1986, Burke 1990). In environments where goats are derived from shade these conclusions may not be valid.

On dry annual pasture in southern Australia, particularly during drought, the moisture content of pasture is very low and much pasture and crop-lands have been cleared leaving little shade. Thus goats are more exposed to direct sunlight and must control their body temperature by panting and sweating, particularly on hot days with strong winds (McGregor 1986).

4.5.3 Sources of water

4.5.3.1 Metabolic water

Animals derive their water from three sources: water consumed by drinking; water that is present in or on food; and water formed during metabolism of food and body tissue, known as metabolic water. Different amounts of metabolic water are formed for each food type metabolised: for protein 0.396 g/g food; for fat 1.071 g/g; and for starch 0.556 g/g (Schmidt-Nielsen 1964). As a consequence of drought, animals produce metabolic water during periods of body weight loss. A goat losing 1 kg of body weight per week, a common live weight loss during seasonal summer droughts on annual pastures in southern Australia (McGregor 1984a, 1985b, 1998) will generate about 130 g of metabolic water per day.

4.5.3.2 Water consumption

Wilson (1989) observed that when water stress is imposed and animals become dehydrated, food intake is reduced whatever the temperature. Under conditions of heat stress and limited water there are further depressive effects on food intake, the reductions being particularly marked in the domestic species of goats, sheep and cattle. There is some evidence that East African goats may be able to maintain appetite under heat stress. In general, when goats are water stressed, they will eat less food so reducing their intake of water within the food. Under drought conditions, when animals are being fed to maintain body weight or to slowly lose body weight, the most important factors contributing to water turnover are the requirements for evaporative cooling (sweating, breathing) and to ensure an adequate intake of food (Wilson 1989).

Appleman and Delouche (1958) studied the response of housed Nubian goats when exposed to temperatures ranging from 0° to 40°C. Water intake increased at temperatures above 20°C and time spent eating and in ruminating fell as the temperature rose above 10°C. They also observed a decrease in aggressive behaviour as temperature rose above 10°C and a further decrease at 40°C.

Goats are able to consume a significant amount of water at a single drinking session (see review by Wilson 1989). In Black Bedouin goats, a species adapted to the arid deserts of the Sinai region, water intake can reach as high as 45% of body weight without haemolysis of the red blood cells. This response is related to the rumen acting as a water storage preventing water passing directly into the blood stream by reducing water flow into the lower gut thus allowing water to be absorbed over an extended period of time. This response also prevents unnecessary water and salt loss via urine. When saline water is consumed by goats, the outflow from the rumen was much greater than when fresh water was consumed. Choshniak et al. (1987) concluded that absorption of saline fluid from the rumen into the blood is responsible for an expansion of blood plasma volume. This process enables a rapid return of water to the body. In addition there was no chance of haemolysis of blood cells after drinking saline water as there is following the drinking of fresh water.

The water use by animals is related to the live weight of animals to the power 0.82, not the normally used power 0.75 as water is used not only for intermediary metabolism but also for evaporative cooling (Wilson 1989). Generally there is a log-linear relationship between body water turnover and body weight. Where possible, earlier scientific reports have been recalculated using the power 0.82.

Water consumption of adult Angora goats and adult Merino sheep has been measured when grazing dry unshaded summer pastures in southern Australia (McGregor, 1986). The findings were:

- For both goats and sheep, water intakes on the hottest days (> 33°C) were double the average (when the mean temperature averaged 25°C).
- Water intake of the Angora goats was 36% greater than intake of adult Merino sheep. The intake of the goats was 1.9 compared with the intake for sheep 1.4 litres/day.
- When allowing for the differences in live weight and removing fleece weight, water intake was 50% higher in the goats, Angora goats: 55.6 ml/kg/day; Merino sheep: 36.8 ml/kg/day or Angora goats: 104 ± 4 ml/kg$^{0.82}$/day; Merino sheep: 70 ± 3 ml/kg$^{0.82}$/day.

In east Africa a similar finding has been made when shade provision was low (King 1983). King found that the daily water intake of East African goats weighing 37 kg averaged 2.2 l/day (equvialent to 114 ml/kg$^{0.82}$/day) was higher than heavier Dorper type sheep.

Boer goats have also been recorded as having a lower water turnover rate than Merino and other southern African sheep breeds. Erasmus (1967) tested these animals at 21°C and 37°C but details of feed, housing and shade provision are not available. In this study the Boer goats drank 40% less tepid water per kg$^{0.82}$ than sheep when under heat stress. Goat faeces were also drier, the urinary volume declined at higher temperatures and was lower than that of the sheep.

Ferreira et al. (2002) measured the water intake of castrated Boer goat kids (26 kg) and castrated Mutton Merino lambs (32 kg) receiving either a low (8.9 MJ ME/kg DM) or high (10.9 MJ ME/kg DM) energy diet when fed indoors on slatted floors. Both diets contained 12.8% crude protein. On both the high and low energy diets the Boer goats had a lower water intake per kg of feed intake and per kg of live weight gain than the sheep. Both species had a lower water intake on the high energy ration compared with that on the low energy diet. In these shaded conditions the Boer goats had a daily water intake of 129 ml/kg$^{0.82}$ compared with the 237 ml/kg$^{0.82}$ of the Mutton Merino. The authors conducted the study during the spring and early summer but did not report environmental temperature.

It is unclear how much the water intake of goats is reduced by the grazing and browsing of Australian scrub. Goats grazing the greener material will ingest water but may have to excrete more water if the ash content of the material is high (SCA 1990). The provision of shade in such a situation may provide more benefit in reducing water intake than the actual intake of water from the drought affected plants.

The impact of direct sunlight on the water intake of the Boer goats is not reported. McGregor (1985a) reported suspected cases of heat stress in Angora goats that were associated with the increased intake of water following the rapid onset of hot weather. When Angora goats and Merino sheep were exposed to full sun, the goats had higher rectal temperatures than the sheep and the smaller goats had higher rectal temperatures than the larger goats. These findings suggest that the provision of shade during summer is more beneficial and more important for Angora goats, particularly smaller Angora goats, than is the provision of shade to Merino sheep.

4.5.3.3 Water deprivation

Under certain conditions where vegetation contains sufficient water goats (Blignaut 1966) and Merino sheep (Lynch et al. 1972) can survive without drinking. On the temperate pastures at Armidale, NSW, Merino sheep can graze all year round at high stocking rates without the provision of drinking water. At Armidale most of the water intake came from green feed but water intake from dew and guttation (water exuded by plants at night when humidity was high) was very important. During periods of dry pasture deaths of lactating ewes occurred during hot weather. The conditions that allowed the ewes to survive at Armidale are unlikely to be available during most drought.

In the arid conditions in the semi-desert regions of Sudan, the usual watering interval for goats and sheep ranges from three to seven days. Sudanese desert goats were better adapted to water deprivation for three days than Sudanese desert sheep (El-Hadi 1986). Silanikove (1992) concluded in his review of the effects of water deprivation on ruminants that breeds of goats which are well adapted to a desert environment demonstrate a greater capability than non-desert breeds to ameliorate the stressful effects induced by water deprivation. Silanikove and colleagues studied the Black Bedouin goat in the Sinai desert. When deprived from water for 48 to 72 hours Black Bedouin goats consumed on average 91% and 81% of the amount which was consumed when goats were allowed to drink once daily, while non desert Saanen goats consumed only 67% and 58% of that amount.

Misra and Singh (2002) reported that water deprivation of up to 48 hours in three Indian goat breeds did not affect food intake and nutrient digestibility in 4 year old bucks (mean live weight 36 kg). Increasing the level of water deprivation reduced average water intake from 178 to 148 ml/kg$^{0.82}$ and 2.77 to 2.33 litre/kg DM intake.

4.5.4 Water quality

4.5.4.1 Tolerance to solutions

The limited evidence available suggests that goats have similar or slightly greater tolerances to salt in water compared with sheep (Bell 1959, Goatcher and Church 1970). For salty, bitter, sweet and sour tastes, goats preferred dilutions of the taste solution over fresh water.

4.5.4.2 Intake of saline and seawater

All natural waters contain some dissolved salts. This is referred to as salinity. Salinity levels are measured directly by TDS (total dissolved solids) and indirectly by EC (electrical conductivity). The higher the values of TDS and EC the higher the salinity. According to Goatcher and Church (1970), laboratory tests showed that the intake of water by goats and sheep fell rapidly above sodium chloride concentrations of 0.6%. This does not accord well with Bell (1959), who reported peak water intakes when the salt levels were 0.08 to 1.25%, or with observations made of feral goats surviving on arid islands (Dunson 1974, Parkes et al. 1996) or with studies on Egyptian goats (Abou Hussien et al. 1994). In 1905, scientists in the Galapagos Islands observed feral goats apparently drinking from seawater (Dunson 1974). Observations have been made of goats on beaches apparently drinking seawater in Western Australia (Parkes et al. 1996), Queensland (Dunston 1974) and Lord Howe Island (McGregor personal observation 1992).

Drinking seawater by goats may be associated with:

1. Drinking fresh ground water or diluted seawater that has followed the water table to the tide mark;
2. Sodium deficient animals drinking some seawater for the salt content;
3. Eating seaweed as a source of food (Dunson 1974);
4. Drinking large volumes of seawater to obtain free water after salt excretion; or
5. Consuming small amounts of seawater to offset insufficient amounts of plant moisture.

Dunson (1974) cites Castro who reported that feral goats on Espanola Island in the Galapagos drank seawater for 10 months when fresh water was not available even though they often exhibited diarrhea. Dunson (1974) observed goats drinking from a seawater seep on Espanola Island and measured the sodium concentration at 470 mM (27,500 mg/l).

Burke (1990) investigated the seawater consumption of feral goats on Aldabra Atoll in the Seychelles. During the dry season, goats were seen drinking from tidal pools and the lagoon. The conductivity and thus the salinity was identical to that of water from the ocean (EC 51,000 μS/cm). These goats appeared to produce very dry faeces, drier than those reported for Bedouin goats. Burke calculated that these goats could produce urine more than twice the osmolarity of seawater, probably enough to allow them to realise a net gain of free water from drinking seawater. It is possible that by drinking seawater it allowed the goats to increase urine volume to enable them to excrete larger amounts of other solutes such as urea. These goats had access to a good supply of browse vegetation with a water content of 17 to 48%. The goats drank from temporary rainwater puddles when available. The goats remained relatively inactive during the day and fed primarily at dusk and dawn.

Macfarlane (1982) concluded that since most Merino sheep become partly intoxicated by salt at 1.3% (220 m mol/l) in water (Peirce 1968) and Turkana goats tolerate 1.5% (257 m mol/l) of salt in drinking water that these goats must be more adapted to higher salt loads by having slightly better sodium pumps than sheep. Macfarlane (1982) noted that within 4 days of being exposed to saline water there is an induction of enzymes in the ilium, liver and kidney. The main enzyme is NaK ATPase that increases the pumping of sodium out of cells and potassium return to the intracellular space. The induction of this enzyme is a powerful adaptive mechanism.

Abou Hussien et al. (1994) examined the response of Egyptian Zaraibi bucks (38 kg body weight), Rahmany rams (55 kg) and camels to three levels of drinking water salinity. Using dried sea salt, the TDS of tap water (260 mg/l) was increased to either 9,500 or 17,000 mg/l. The animals were fed good quality hay ad libitum indoors. Increasing water salinity to 17,000 mg/l increased total water intake of goats by 59% to 376 ml/kg$^{0.82}$ and that of sheep by 99% to 500 ml/kg$^{0.82}$. The increase in water intake was associated with greater urinary water loss and little change in faecal and insensible water loss (sweating, breathing).

Pickles (1994 as cited by Parkes et al. 1996) observed that in Western Australia, feral goats that had drunk seawater would die when chased or stressed.

In a survey of water supplied to Australian goats McGregor (2004) found that the responses from all but one contributor indicated that the goats survived on the saline water sources without any noticeable problems (Table 4.7). For example, the contributor of a sample of bore water with 11000 mg/l of TDS and 470 mg/l Mg, stated that “the rangeland goats walk past fresh ground water to drink this”. Similarly for another sample of bore water of 11000 mg/l of TDS and 400 mg/l Mg, the contributor stated that “sheep do well on this” as well as the rangeland goats. For another property sample which had 9100 mg/l of TDS and 370 mg/l Mg, the contributor stated that the goats “survived on this for 6 months”. These observations generally accord with scientific observations reviewed above. Despite prompting, no contributor reported any symptoms associated with salt poisoning (see also Section 4.5.4.7).

Table 4.7. Mean, median, SD and range in mineral content of water drunk by Australian goats (n=30, McGregor 2004)

	TDS	**EC**	**Hardness**	**Total Alkalinity**	**pH**	**Total P**	**Total N**	**NO_3-NO_2**
	mg/l	µS/cm	mg $CaCO_3$/l	mg $CaCO_3$/l		mg/l	mg/l	mg N/l
Mean	3600	5900	900	250	7.4	0.05	2.20	1.60
Median	2300	4200	540	240	7.5	0.03	1.1	0.25
Minimum	200	400	6	0	3.7	0.01	0.09	0.01
Maximum	11000	16000	3100	550	8.5	0.17	14.0	13.0
SD	3300	4900	860	190	0.9	0.04	3.10	3.00

	Al	**B**	**Ca**	**Cl**	**Cu**	**Fe**	**K**	**Mg**	**Mn**	**Na**	**S**	**SAR**	**Zn**
	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		mg/l
Mean	2.7	0.75	130	1600	0.10	2.10	32	150	0.19	950	150	14.0	0.12
Median	0.3	0.22	68	970	0.03	0.12	11	110	0.01	560	48	10.0	0.03
Min.	0.1	0.03	2.2	25	0.03	0.01	0.2	0	0.01	51	0.3	2.1	0.03
Max.	62	3.4	520	4600	1.8	19	160	470	2.60	3200	850	42	0.69
SD	11.0	0.96	140	1400	0.31	4.50	49	140	0.54	900	220	10.0	0.20

4.5.4.3 Growth and physiological responses by goats to saline water and restriction of water

It would seem clear that there are differences between breeds of goats in their ability to resist dehydration based on genetics and environmental history. Greenwald (1967) found that desert Hottentot goats from South Africa were more resistant to dehydration with lower water consumption, evaporative and urinary losses compared with Swiss-type milk goats.

The capacity of the kidney to concentrate urine and its ability to reduce urinary water loss during dehydration is directly related with the relative kidney medullary thickness (RMT). The greater the RMT, the longer the loop of Henle relative to the size of the kidney so the greater the ability of the kidney to reabsorb water. In Australia, Dunson (1974) found that the RMT of feral goats from Queenslands Esk Island was greater than the RMT of domestic Australian goats that in turn had a greater RMT than domestic lambs. Similar findings have been reported by Greenwald (1967) where desert adapted African goats had a greater RMT than Swiss-type dairy goats. Burke (1990) found no unusual morphological effects on the goats’ kidneys resulting from drinking seawater. These goats had RMT less than those measured by Dunson but greater than Greenwald’s Swiss dairy goats.

East African goats (Schoen 1968) and Turkana goats from Kenya (Maloiy and Taylor 1971) both reduced evaporative water losses and increased urine concentration with reduced urinary volume when faced with restricted water supply. With housed domestic goats, Dunson (1974) reported that one of the main mechanism for reduction of water loss during dehydration appeared to be a decrease in evaporative loss. When he fed seawater to domestic North American goats, all the goats drank seawater but consumption was low and variable. With Australian domestic goats, voluntary consumption of seawater of 3.6% of body weight per day for 24 days occurred with 15 to 20%

weight loss but consumption by one goat of 9.1% of body weight was associated with a 30% weight loss over 16 days.

Dunson (1974) concluded that seawater consumption can slow the rate of dehydration in goats provided consumption was less than 4% of body weight per day, maintenance of food consumption and sources of water loss, particularly evaporative water loss, were reduced. It is also clear that to minimise dehydration of goats, behavioural avoidance of environmental heat load would be critical as would be a reduction in activity.

In the study of Abou Hussien et al. (1994) described earlier, intake of water with 9,500 mg/l TDS reduced the dietary intake of sheep but not of goats. Increasing the salt content from 9,500 to 17,000 mg/l TDS reduced the dietary intake of both sheep and goats. The increase in urinary output of sodium and chloride and the decrease in urinary potassium associated with drinking water of 17,000 mg/l was evident with sheep and goats. The urea clearance rate of goats was higher than that of sheep. Drinking saline water had no effect on the urea concentration of urine of goats but decreased it in sheep and camels. Abou Hussien et al. (1994) concluded that the mechanism by which sheep and goats control salt load by drinking saline water is different to that of camels. Sheep and goats excreted more urine and increased the filtration rate to reduce the high salt load resulting from their high consumption of saline water. Camels consumed relatively less saline water to reduce salt stress.

El-Gawad (1997) studied the responses of 21 to 46 kg does fed tap water (TDS 1,050 mg/l) or saline well water (8,250 mg/l) for 6 weeks. Goats were individually housed in semi-open pens and fed on hay and a concentrate mixture. Body weight was not significantly affected, while feed and water intake increased in the group offered saline water. Respiration rate increased in goats drinking saline water, while rectal temperature and pulse rate were only slightly affected.

The impact of minerals in bore water on the health and productivity of goats is not known. The effect on health and production of goats by changing the drinking water from surface run off water (TDS 200 to 500 mg/l) to saline bore water (TDS 5,000 to 10,000 mg/l) as goats are grazed in different paddocks has not been documented.

No studies of the relationship between the growth of Australian goats and the salinity content of water have been found. SCA (1990) summarised some data for Merino sheep kept in semi-arid regions of Australia. In Western Victoria, Walkerden et al. (1976) found that there was no affect on the growth of weaned Merino lambs fed typical pasture hay (15% crude protein, 8.8 MJ ME/kg DM) when saline bore water of 3,720 mg/l TDS; 330 mg/l Mg was used instead of freshwater (120 mg/l TDS). Bore water should also be tested for other toxic minerals. Saul and Flinn (1978, p 736) reported that 370 to 500 mg/l magnesium had no harmful effect on young sheep.

4.5.4.4 Behavioural responses

Macfarlane (1982) concluded that dominant goats expend more energy maintaining their dominant position than lower rank goats and in return they obtain better shade and more access to water. When water supply was restricted to 2 m long troughs, dominant goats dominated supplies. Macfarlane provided photographic evidence of dominant bucks defending a 2 m water trough from rams and other subordinate goats so that these animals had no access to water during hot weather (40°C). He noted that similar behaviour occurs for shade and food supplies.

Henzell (1997) remarks upon the dependence of feral goats to drinking water leading them to gather at water points, where they can be trapped, a practice used for many years to capture feral goats. For many years Australian feral goats have been known to be highly dependent on drinking water (Harrington 1982, Parkes et al. 1996). During hot dry periods more than 80% of feral goats will drink daily. Similar observations have not been made on domestic goats. Feral goats have been recorded as dying at dry water holes when water was available within 1.5 km (Harrington 1982). This suggests that when water sources dry out or are changed during a drought, the manager must be vigilant in ensuring that goats are led to new sources of water.

4.5.4.5 Entrapment in muddy dams

Drying dams with deep muddy edges can cause entrapment of goats (NRC 1981). Goats tend to have longer legs than sheep and they may venture further into muddy dams thereby reducing the chances of an easy escape. Dams with deep muddy edges should be fenced to keep stock out, or inspected several times daily to prevent entrapment.

If goats have been stuck in dams they may need to be washed down as sticky mud can be a source of flystrike (Cunningham 2002a). Cunningham (2002a) noted that fly strike is not something most goat producers are used to dealing with and so they need to be prepared for fly strike if they have muddy dams.

4.5.4.6 Other water quality and supply issues

Algal growth in water supplies is aided by high temperatures and high levels of phosphorus and nitrogen (Cummings 2002). Blue green algae can poison stock. Advice on control should be sought from Government Departments working with water supply and or environment.

Allowing goats to camp on dam walls or nearby can lead to accumulation of manure in dams following strong winds or heavy run-off. Manure washed into dams may make the water unfit for consumption. Dams contaminated with manure may have to be pumped out. During drought it may be preferable to fence out dams and reticulate water to a temporary trough.

Budgeting for water supply must make allowance for the high levels of evaporation of water from dams and of seepage from dams. In most parts of Australia, about 1.5 to 2 m of depth is evaporated from a dam each year although this can vary with the depth and orientation of the dam. The depth of water in each dam should be measured early in the drought to assess how long supplies will last. Advice on determining the current capacity of dams and the impact of evaporation and seepage is provided by Government Departments working with water supply and or environment. During a drought Cunningham (2002a) noted that evaporation had been great, primarily because of the very strong winds. As a greater amount of water is lost from two shallow dams than from one deeper dam she decided to amalgamate the remaining water from two adjoining paddocks by siphoning (or otherwise transferring) the water into the one dam.

Evaporation over years and during droughts will lead to higher concentration of salts in the water. The quality of water in dams should be checked. As reported in the next section, salinity levels in dam water can reach the level of seawater and lead to goat mortality.

Farmers may need to mix mobs of livestock later in a drought when the shallower dams dry up. Troughs need to be checked daily and cleaned regularly.

4.5.4.7 Symptoms and an example of salt poisoning

Baxendell (1988) and Hungerford (1990) summarised the symptoms of salt poisoning in goats as rapid breathing, blindness, ataxia, high temperature, abdominal pain, diarrhoea, excessive thirst, weakness, head pressing and death. There is marked congestion of the mucous membrane of the omasum and abomasum. There is also oedema of skeletal muscles and hydropericardium. In one case, sheep placed in a paddock for three days without water suffered a 5% mortality rate when they broke a fence to gain access to a tidal creek. The sheep showed frothy discharge from the nostrils and walked with high stepping movements of the front feet. Reddened stomach and intestines in addition to the symptoms given for the goats were observed on post mortum.

Samples of water were taken following the death of some Angora goats as a post mortum indicated that saline water may have been associated with the cause of death (McGregor 2004). The water source was based on pumping water from a river, which had stopped flowing during 2002 as a consequence of drought. The water was then stored in a dam and reticulated to troughs via a header tank. Inspection of the waterhole by this author showed salt encrusted on the soil around the waterhole. The water test result (Table 4.8) shows levels of TDS and Mg well above recommended levels. Evaporation from the dam over a period of years would have contributed to increasing levels of salinity. Interestingly, prior to the deaths of the goats, laying hens had died and then a little time later some beef cattle died. This sequence of mortality fits exactly the suggested susceptibility of livestock to increasing levels of salt.

Table 4.8. Water test results for water associated with mortality of Angora goats (McGregor 2004)

TDS	EC	Hardness	Total Alkalinity	pH	Total P	Total N	NO_3-NO_2
mg/l	μS/cm	mg $CaCO_3$/l	mg $CaCO_3$/l		mg/l	mg/l	mg N/l
33000	49000	7100	20	6.7	0.06	2.0	1.0

Al	B	Ca	Cl	Cu	Fe	K	Mg	Mn	Na	S	SAR	Zn
mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		mg/l
2.7	2.3	710	18000	1.8	0.31	87	1300	5.2	11000	860	57	0.15

4.5.5 Suggested water provision for goats

It is likely that in grazing situations the water consumption of goats will increase as the salinity of the water increases. SCA (1990) reports that for each 1,000 mg TDS/l in excess of 2,000 mg/l water, allowances for sheep increase by 3%. For the last two months of pregnancy and during lactation the SCA (1990) suggest that water allowances increase by 30% and that a further 1 litre be provided for each 1 kg of milk produced. Water consumption will also increase if the feed has been treated with caustic soda or slaked lime and the SCA (1990) recommend that in this circumstance an additional 2 litres per kg of treated feed (sheep) be provided. A similar allowance is suggested for goats.

Budgets for water allowances should plan for average daily consumption (4 l/head/day). This can change dramatically with the weather. On very hot days, intake will be greatly increased so the supply system must be able to deliver up to 9 l/head/day. Allow enough trough space so that 10% of livestock can drink at any time, or 15 metres of trough edge for 500 goats.

With saline water, adapted goats are able to maintain food intake with salinity levels up to 9,500 mg/l. Salinity levels greater than this result in a decline in food intake. Goats adapted to saline water appear to be able to tolerate higher levels of salt than sheep and can live on seawater. The length of time required for goats to adapt to water of high salt content is not known. There is also no documented evidence of differences between the main breeds of goats in Australia (rangeland, Boer, Angora, cashmere and dairy).

Young sheep have difficulty thriving on water supplies with higher than 5,000 mg/l salt. Levels above 10,000 mg/l salt need to be treated with caution (Court 2002). There are differences between the salinity limits advised for sheep (Court 2002) and those provided by Scarlett (2002) for goats (Table 4.9). Scarlett provided no reference or evidence for his recommendations.

Table 4.9. Suggested maximum desirable level of salinity in water provided to stock consuming dry pasture, hay or grain

Class of animal	Sheep (Court 2002)		Goat (Scarlett 2002)[A]
	TDS, mg/l	EC units	TDS, mg/l
Young	5,000	8,300	7,000[A]
Dry adult	10,000	16,700	14,000[A]
Lactating female	5,000	8,300	10,000[A]

[A] When fed diets with salty plant material such as saltbush (*Atriplex spp)*, blue bush (*Maireana spp*) or copper burr (*Scerolaena spp*) these salinity levels should be reduced by 30%

During drought, goat producers should monitor the salinity of their water supply, particularly farm dams. Test results should be checked against the tables of recommended water quality and with the data in this report. When water is purchased or goats are transferred to an unknown water source, the water quality should be checked.

High levels of phosphorus and nitrogen (TP > 0.005 – 0.05 mg/l; TN > 0.1 – 0.5) coupled with high water temperatures will lead to algal blooms (Cummings 2002). Many samples of water supplied to Australian goats (McGregor 2004) had total N levels and total P levels greater than recommended and one third of samples had high levels of both N and P. This indicates that under typical drought conditions these waters may experience algal blooms.

The level of magnesium is recommended to be kept below 600 mg/l (Cummings 2002).

5 Feed quality and quantities

5.1 Determining the energy and protein content of feeds

To determine a drought ration the energy and protein content of feeds must be known. This is particularly the case for grass hays and oats. The only way to obtain this information is to have samples tested in a laboratory (eg. FeedTest). Average feed tables are available for use as a guide. Feed values (energy and protein) can be highly variable. Variations are due to district, variety, season and growing conditions.

5.1.1 FeedTest

Before finalising plans to feed any feedstuff, by-product or unusual feedstuff to livestock, it is advisable to have a sample analysed by a feed analysis service, such as FeedTest at the Department of Primary Industries at Hamilton, Victoria, telephone 1300 655 474, fax (03) 55 730 939. Email contact: feed.test@dpi.vic.gov.au

Most by-products and unusual feedstuffs should be used with caution and introduced into rations gradually, even when low prices favour their use. Factors to consider about unusual feedstuffs are: their nutritive value, palatability, possible toxicity or contamination with pesticides or heavy metals and the effects upon digestion and utilisation of the total ration. The use of by-product stockfeed needs to be declared when completing a National Vendor Declaration (see Appendix 2).

5.1.2 Using feed tables

Generally the most important requirement for animals in a drought is energy. The common energy supplements for goats usually provide enough protein, vitamins and minerals. The energy values of feeds differ (Table 5.1), and so does the relative cost of the energy they contain. Table 5.1 shows the energy and protein ranges commonly found in feeds in Victoria (Court 2002). Similar lists are available from each Department involved in drought assistance.

Table 5.1 Average and range in the nutritive values of common grains and forages used for drought feeds (FeedTest)

Feed type	Energy MJ ME/kg as fed[A]		Protein % Crude protein	
	Average	Common range	Average	Common range
Wheat, Triticale, Maize	12	11.5-13.5	11	9-15
Barley	12	11.5-12.5	10	8-14
Lupins	12	11.5-12.5	32	28-36
Peas	12	11.5-12.5	24	20-27
Oats	10	5-11	9	6-12
Sheep pellets (brands vary)	10	9-11	12	8-20
Lucerne hay	8.5	7-9	20	16-25
Clover hay (early)	8.5	7-9.5	18	15-20
Pasture hay (mid-season)	7	6-7	11	8-16
Oaten hay	7	6-8	8	5-10
Grass hay (late)	6	5-7	8	5-10
Cereal straw	5	4-6	3	2-5

[A] Approximately 90% dry matter, except hay/straw 85% dry matter

There are variety effects that are important both for variation in nutrient value and when sowing cereal varieties. It is essential to check both nutrient value and recommended varieties.

5.2 Calculating feed costs

5.2.1 The cheapest source of energy

5.2.1.1 The cost per MJ of ME

In most circumstances choose the drought feed that provides energy at the lowest cost. Some goats have a special need for protein, vitamins or minerals and their ration needs to be determined separately. Table 5.2 shows the cost per MJ of ME for a range of common feedstuffs over a range of feed prices. The price of feed needs to be determined after delivery to your property.

Table 5.2 The cost of energy in different feeds over a range of purchase prices (as fed basis)

Feed	Energy[A] MJ ME /kg fed	Cost per unit of energy at different feed costs cents/MJ ME — Feed purchase cost $/tonne									
		60	*90*	*120*	*150*	*180*	*210*	*240*	*270*	*300*	*330*
Wheat, Barley, Lupins, Peas	12	0.5	0.8	1.0	1.3	1.5	1.8	2.0	2.3	2.5	2.8
Oats[C], Sheep pellets	10	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0	3.3
Lucerne hay, Early clover hay	8.5	0.7	1.1	1.4	1.8	2.1	2.5	2.8	3.2	3.5	3.9
Oaten hay, Mid-season hay	7[B]	0.9	1.3	1.7	2.1	2.6	3.0	3.4	3.9	4.3	4.8
Late grass hay, Cereal straw	6[B]	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5

[A] Approximately 90% dry matter, except hay/straw 85% dry matter
[B] When the ME content is 7 or lower, kid and adult goats will not be able to maintain their weight
[C] The ME content of oats can vary from 5 to 14.3 MJ/kg DM (Court 2002, Oddy et al. 1990)

5.2.1.2 Comparing the energy cost of different feeds

Table 5.2 should be used to compare the energy cost of different feeds. If barley can be delivered to your property for $270/t, you are paying an energy cost of 2.3 cents/MJ. ME. This would be the same value as buying sheep nuts at $230/t, or oaten hay at $160/t. If sheep nuts or oaten hay were selling for less than these prices, they would be better value on an energy basis.

Anon (2004c) provides a detailed guide to help sheep producers manage fodder prices during drought. Details about storage costs, forward buying and other strategies are discussed.

5.2.2 Total feed costs

5.2.2.1 Proportion of a full ration to feed

The requirements for full feeding can be estimated using the information in Chapter 4. It is more difficult to estimate what proportion of this ration to feed if stock have access to pasture or stubble. It is best to start feeding with the aim of building up to one third to a half of a full ration and monitor the goats. The ration can then be altered appropriately. As a drought progresses the quantity and quality of feed in the pasture will decline and the proportion of a full energy ration that needs to be fed out will increase, up to 100% in full droughtlot conditions.

5.2.2.2 The cost of a ration to be fed

To determine the cost of a ration requires four steps:

1. Determine the energy requirement in MJ per goat per day. Use Table 4.2;
2. Determine the energy cost of the ration in c/MJ/day. Use Tables 5.1 and 5.2;
3. Multiply these two values together;
4. Multiply this value by the proportion of the ration being fed. Eg. one third during the early part of the drought up to one half for most of the remainder.

Example: Determining the cost of feeding a 35 kg dry goat in a containment area/feedlot.

A 35-kg wether or dry doe requires 5.8 MJ ME per day for maintenance (Table 4.2). The cost is calculated by using Table 5.2.

For barley at $270/t: Daily cost = 5.8 MJ ME/day x 2.3 c/MJ ME = 13.4 cents/day.
Cost per week = 13.4 cents/day x 7 = 93.5 c/week per goats.
Cost per 100 goats for each 30 day month = 100 goats x 30 days x 13.4 c/day = $402.
If one half the ration is fed out during the first month the cost would be $402 x 0.5 = $201.

For mid season hay at $240/t: Daily cost = 5.8 MJ ME/day x 3.4 c/MJ ME = 19.7 cents/day.
Cost per week = 19.7 cents/day x 7 = 138 c/week per goat.
Cost per 100 goats for each 30 day month = 100 goats x 30 days x 19.7 c/day = $591.
If one third the ration is fed out during the first month the cost would be $402 x 0.33 = $195.

5.2.2.3 Other costs in feeding out

The cost of feeding goats is not just the delivered feed price. Storage and handling costs and the likely amount of wastage have to be taken into account when calculating the relative costs of feed on your farm. The weight of different feeds required to be fed out depends on the ME value of a feed (Table 5.3). If goats are provided ad libitum amounts of lower quality roughage such as barley straw, they will selectively eat the preferred parts and can waste up to 50% of the material (McGregor 1996, see Photo 5.1). Holst (1997) provides further details of the relative wastage of different feeding strategies. There are reports of 30% wastage in the feeding of rolls on the ground (Holst personal communication).

Wastage of roughage depends on the quality of the roughage. If it is known that animals will waste 20% of a roughage, then the calculations of feeding requirements can be changed to account for expected wastage. For example, the formulas in Section 5.2.2.2 should include an additional factor to multiply inputs by 1.20.

Photo 5.1. Goats will select the most digestible parts of hay and straw. Up to 50% of straw can be wasted

5.2.2.4 Keeping hay for later

Hay may be the cheapest form of energy during late spring or early summer but it may become scarce and more expensive later during autumn or even during the following season. Hay needs to be kept for drought feeding, particularly for lactating does during drought and also in case the need arises for a rapid change of feeds or if cases of acidosis occur which will be likely if cereal grains are the main source of energy during drought feeding.

5.2.2.5 Chemical residues in meat

Williamson (2002) provides some strategies for minimising the risks associated between drought feeding and potential increases in residues in meat.

5.2.3 Quantities of feed needed for maintenance of non breeding goats

Table 5.3 provides a ready-reckoner of the amount of feeds required to feed different goats at selected critical live weights. For accurate use of the table, producers need to determine the energy content of their feed.

Table 5.3 Estimated quantities, in kg of feed, needed for the maintenance of 100 non-breeding goats per week at selected critical live weights. Quantities are based on energy requirements in Table 4.2 for goats in stable dry conditions with minimal activity. NR: not recommended that these feeds be provided to weaned kids

Feed type	Energy MJ ME/kg as fed[A]	Weaned kids 15 kg	Angora does 27 kg	Cashmere does 32 kg	Boer bucks 50 kg
Wheat, Triticale, Maize, Barley, Lupins, Beans	12	180	285	320	445
Oats, Sheep pellets	10	215	340	380	535
Lucerne hay, Early clover hay	8.5	250	400	450	625
Mid season pasture hay, Oaten hay	7	**NR**	485	545	760
Late grass hay	6	**NR**	565	635	890
Cereal straw	5	**NR**	680	760	1065

[A] Approximately 90% dry matter, except hay/straw 85% dry matter

"I'm getting bloody sick of pouring grain into the silos"

"Feed suppliers have made more money than I have out of my goats"

(Mohair and meat producer of 20 years experience on feeding during the 2001-2005

"I'm wondering what the cost effectiveness of it all is"

"Drought feeding takes a lot of weighing up, what can you do?"

(Large scale cashmere producer after the 2001-2005 drought)

5.3 Native plant forage, weeds and drought feeding

5.3.1 Introduction of weed seeds

The introduction of weeds can be a problem with buying in feed, and samples should be inspected carefully for weed seeds. It is not always possible to detect a potential problem, or even to refuse a feed on these grounds. One way to minimise a potential weed problem is to restrict feeding out of any suspect fodder to the containment area or in a limited number of paddocks.

5.3.2 Using native vegetation and weeds as drought feed

In pastoral regions, many plants provide sufficient nutrients for growth and production (McLeod 1973, Wilson 1977, Table 5.4). However the long-term grazing of many indigenous plants is likely to result in poor nutritional status endangering the welfare of the animals. For many plants, after the leaves have been eaten, the remaining plant stems have very low nutritive value. Some plants are not eaten when provided as the sole diet (Wilson 1977). Many pasture weed species in southern Australia have high nutritional values making the plants suitable as feed for goats (Table 5.5).

Browse plants need to be protected during drought periods otherwise damage can occur with long-term adverse consequences for stock carrying capacity and biodiversity. Stannard and Condon (1968) conclude that repeated lopping of native fodder trees in western New South Wales may kill trees, will destroy shade and shelter, exposes the soil to wind erosion and destroys the valuable safeguard of temporary fodder that the trees may provide (see Photo 5.2). “If stock are sustained on fodder trees for long periods in drought, serious permanent damage will almost certainly be done to perennial grasses and small shrubs through over grazing” (Stannard and Condon 1968). In many areas of Australia, the native vegetation is protected by legislation. Goat producers are advised to check first before lopping native vegetation or releasing their goats into areas of native vegetation. In some States permits can be obtained to graze or lop vegetation for drought feeding.

Photo 5.2. Kurrajong trees are long-lived trees that can provide excellent shade and fodder. When the drought breaks, trees that were lopped too much during drought will die. Photo taken near Coonabarrabran, New South Wales after drought broke in 2005.

Producers also need to improve their skills in rangeland assessment, particularly in determining the amount of feed on offer.

Wilson (1977) demonstrated that rangeland goats were able to digest more of the organic matter from the leaves of three tree species compared with Merino sheep. The difference in digestibility averaged 3.6% implying that the ME value of these feeds for goats was about 0.5 MJ ME/kg dry matter greater than that for sheep. Harrington (1980) reported that in woodland plant communities near Cobar, NSW, that Angora goats used the browse and litter feed resources less than rangeland goats. As a consequence the Angora goats ate more of the low quality grasses. Both these groups of goats were bred in the district and should be regarded as being familiar with the feed resources.

Plumb et al. (1999) reported that during drought conditions Australian feral goats consume mulga, which has a very high content of condensed tannins (5-24% dry weight). While feral goats can survive on this diet, sheep do very poorly and lose live weight rapidly. Plumb et al. (1999) have shown that the transfer of rumen contents from feral goats to sheep can significantly improve mulga digestion, suggesting that the ruminal microflora of feral goats may contain tannin tolerant or degrading bacteria. Few of the bacterial species were closely related to previously cultured bacteria, making it difficult to assign phenotypic traits. This first molecular ecological study of tannin associated microbial communities suggested that bacteria from these two groups may be either more tolerant to tannins or able to degrade tannins. One implication of this is that the ME estimates for mulga may underestimate the ME value for goats.

As plant parts die, their nutritive value will decline. For example, leaves from gum trees may have reasonable ME values when green but when dead the leaves, stems and bark ME values are low (see Table 5.4).

Goat producers report that the availability of browse provides a greater number of options in managing feed requirements. Firth (2005) in Queensland, found that goats handled a greater range of browse species than sheep and cattle and the goats “walked into the browse” more than sheep and cattle. As a consequence the goats also got through the drought better. Producers need to be aware that as goat progressively use the browse it becomes harder for smaller goats to reach the feed as the browse line goes higher and higher. Provision needs to be made to manage the smaller goats in these circumstances. The provision of a high protein meal or a drinkable urea mix combined with scrub pulling helped establish the goats onto browse.

5.3.3 Toxic hay and plants

Some hay in some districts can be toxic. Leng (2002) summarises the potential hazards including:

- Perennial ryegrass infected with endophytic fungi;
- Annual and perennial ryegrass infected with ergot;
- Perennial ryegrass infected with a fungi that causes facial eczema;
- Annual ryegrass with a toxin causing staggers;
- Phalaris staggers either at the end of a drought or as a result of cobalt deficiency;
- Kikuyu grass poisoning.

In areas where these problems are known to occur avoid making or buying hay. If these hazards need to be managed prepare a management plan prior to drought.

There are many plants that can be toxic to goats and while this subject is not the focus of this manual some further information is provided in Chapter 7. In drought condition some goats will eat plants that they may normally have avoided. This problem can be prevented by using containment areas. Few evaluations have been made for the presence of toxic substances or for the effects of essential oils on the digestibility of the Australian plants or upon the animals. For example, Sugar Gum can be poisonous in circumstances where the leaves have become moisture stressed and pine needles can cause problems in some circumstances. Further information can be obtained from Simmonds et al. (2000).

5.3.4 Management issues when grazing native plant forage

Goats reared on pasture will rapidly adapt to “bush” grazing. They will soon learn that the sound of a chainsaw used for lopping equates to food (Cunningham 2005). To assist with management and monitoring, grain can be trailed along a track to attract the goats, where they are easily observed and caught. This process must be done regularly for monitoring and in the process the goats will learn that the sound of the vehicle equates to food and will soon be easily managed.

During drought, small goats will have difficulty in accessing feed in the bush as most of the ground cover will be eaten and the forage on lower branches of scrub will also be removed first. Small goats should be sold or if retained kept in a suitable containment area for special attention rather than released into drought affected scrub.

When providing urea based licks to help use browse the key times for provision are at joining, in mid autumn and at kidding. Urea based blocks with multiple minerals are likely to help avoid trace mineral deficiencies.

5.3.4.1 Practical feedback in feeding “bush” to goats

In the drier regions of Australia producers report that goats prefer Kurrajong, Ironwood, Rosewood and Mulga. The addition of urea blocks assists goats use mulga. While Mulga is an adequate feed compaction can be a problem. Gidyea regrowth is also eaten. Ironwood needs to be knocked over for goats. Goats will eat Cyprus pine and Popular box in small quantities. False sandlewood is not worth knocking over. Native citrus (Limebush) is preferred. Goats are hard on Leopardwood and will ringbark these trees.

Recommendations for feeding mulga to sheep in south-west Queensland (McLennan 2005) include the fact that Mulga has fairly high levels of crude protein (10-12 per cent), but livestock can only digest about 40% of this protein as it is protected by tannins. However the fragile nature of the pastures has been exacerbated by the feeding of mulga. It has allowed pastoralists to keep too many animals during dry seasons, resulting in excessive grazing pressure on the pasture, which leads to regrowth of mulga and woody weeds. The total cost of feeding mulga will vary widely depending on the machinery and labour used.

Maxwell (2005) summarises the use of dry lick supplementation for sheep on mulga. When mulga is the only source of nutrition, the sheep’s diet will be deficient in the major nutrients nitrogen, phosphorus, sulphur and sodium. Dry licks increases mulga consumption up to 20 to 30% thereby reducing the rate of live weight loss and lowering mortality rates.

Table 5.4 Nutritive values for some Australian plants grazed by goats in Australia (Everist and Young 1967, McLeod 1973, Wilson 1977, Anon. 1987, McGregor 1992b). Values presented are averages. Nutritive value of some plants can vary significantly. ME values have been determined according to SCA (1990)

Feed Type	**Plant part**	**Energy MJ ME/kg DM[A]**	**Crude protein %**
Bastard sandalwood or Budda *Eremophila mitchelli*	Leaves	10.7	10.7
Bauhinia *Bauhinia carronii*	Leaves	11.2	13.7
Beefwood *Grevillea striata*	Leaves	10.0	2.6
Belah *Casuarina cristata*	Leaves	8.0	9.4
Bendee *Acacia catenulata*	Leaves	10.3	13.9
Berrigan *Eremophilia longifolia*	Leaves	11.2	14.7
Blackwood *Acacia melanoxylon*	Leaves	8.7	19.1
Boree *Acacia cana*	Leaves	8.4	11.3
Bottlebrush *Callistemon micropunctatus*	Leaves	6.2	7.0
Brigalow *Acacia harpophylla*	Suckers > 30 cm	9.5	16.2
	Suckers 15-30 cm	9.8	18.6
	Suckers < 15 cm	11.9	26.7
Buloke *Casuarina luehmannii*	Leaves	9.0	8.4
Coolibah *Eucalyptus microtheca*	Leaves	10.3	6.4
Currant bush *Apophyllum anomalum*	Leaves	8.4	12
Currawong *Acacia sparsiflora*	Leaves	9.5	17.8
Dead finish *Acacia tetragonophylla*	Leaves	9.3	16.6
Gidyea *Acacia cambagei*	Leaves	10.0	13.3
Golden wattle *Acacia pycnantha*	Leaves	7.8	15.8
Golddust wattle *Acacia acinacea*	Leaves	7.2	14.7
Holly grevillea *Grevillea ilicifolia*	Leaves	6.0	6.1
Ironwood wattle *Acacia excelsa*	Leaves	9.5	11.8
Kurrajong *Brachychiton rupestre*	Leaves	7.0	15
Leopardwood *Flindersia maculosa*	Leaves	9.5	14.4
Limewood *Eremocitrus glauca*	Leaves	8.9	13.4
Manuka *Leptospermum juniperinum*	Leaves	8.6	6.4
Mimosa bush *Acacia farnesiana*	Leaves	7.9	23
Mulga *Acacia aneura*	Leaves	6.5	12
Myall *Acacia pendula*	Leaves	8.3	13.2
Native olive *Notelaea microcarpa*	Leaves	9.7	8.6
Needlewood *Hakea leucoptera*	Leaves	6.7	6.7
Old man saltbush *Atriplex nummularia*	Leaves	9.5	21.6
Plumwood *Santalum lanceolatum*	Leaves	10.5	14
Poplar box *Eucalyptus populnea*	Leaves	10.7	10
Rosewood or Boonery *Heterodendrum oleifolium*	Leaves	6.7	9.6
Sheoak *Casuarina glauca*	Leaves	8.5	15.4
Silver wattle *Acacia dealbata*	Leaves	8.3	14.8
Sugar Gum *Eucalyptus cladocalyx*	Leaves	8.9	9.3
	Dead leaves	7.4	4.9
	Bark	6.8	1.8
Supplejack *Bentilago viminalis*	Leaves	10.7	12.6
Sweet bursaria *Busaria spinosa*	Leaves	9.9	5.7
Teatree *Leptospermum sericatum*	Leaves	6.5	8.5
Whitewood *Atalaya hemiglauca*	Leaves	9.4	13.5
Wilga *Geijera parviflora*	Leaves	9.0	15

[A] DM; dry matter, that is no moisture present

Table 5.5 Nutritive values for some introduced weeds grazed by goats in Australia (Everist and Young 1967, Anon. 1987, McGregor 1992b). Values presented are averages. Nutritive value of some plants can vary significantly. ME values have been determined according to SCA (1990)

Feed Type	Plant part	Energy MJ ME/kg DM[A]	Crude protein %
Artichoke thistle *Cynara cardunculus*	Leaves	11.5	14.8
Blackberry *Rubus fruticosus*	Leaves and young stems	10.6	21.0
	Old stems	7.4	6.1
	Dead stems	6.4	7.9
Boxthorn *Lycium ferocissimum*	Leaves	12.4	28.3
	Stem	9.2	11.6
Carob bean *Ceratonia siliqua*	Pods	11.8	9.3
Goat willow *Silix caprea*	Leaves	9.1	11.1
Honey locust *Gleditsia triacanthos*	Pods	11.0	14.3
Horehound *Marrubium vulgare*	Leaves	10.9	23.3
Mulberry *Morus alba*	Leaves	9.9	15.1
Peppercorn tree *Schinus molle*	Leaves	10.2	20.3
Pinetree *Pinus radiata*	Leaves	7.2	9.0
Saffron thistle *Carthamus lanatus*	Leaves	12.1	14.4
Spear thistle *Cirsium vulgare*	Leaves	11.3	20.2
	Young stem	9.4	3.9
	Old stems	8.1	4.6
Sweat briar *Rosa rubiginosa*	Leaves	10.5	20.7
Tamarisk *Tamarisk parviflora*	Leaves	9.0	20.2
Tree lucerne (Tagasaste) *Cytisus proliferus*	Leaves	8.0	13
Weeping willow *Silix babylonica*	Leaves	10.0	15.9

[A] DM; dry matter, that is no moisture present

6 Goat welfare in drought

6.1 Introduction

All farmers should realise that animal welfare is an important issue at all times, but especially during a drought. Activities, such as shearing or transport, may exacerbate problems associated with goats in poor condition. During drought, an outbreak of any disease or condition that reduces intake, such as high worm burdens, footrot or pregnancy toxaemia will have a greater impact than in good seasons.

The main welfare issue in the assessment of drought affected animals is the judgement involved in deciding at what point, and at what condition score, does a hungry animal, losing weight, and maintained on a sub-maintenance ration, become an animal whose welfare is at risk (Tribe 1985). Clearly, objective criteria are required. The Farm Animal Welfare Council (1994) in the UK has recommended that any sheep flock with a significant number of animals at a condition score of less than 1.5 must be regarded as demonstrating inadequate care and welfare. While the application of sheep condition scores directly to goats is an area requiring further investigation the evidence provided in this manual supports the application of this guideline to goats.

It is unacceptable to let goats die or suffer during drought. Those goats that cannot be cared for should be humanely destroyed. As this is often a distressing task, seek advice from the Government Department managing agriculture and drought assistance and other farmers who may be undertaking the same task.

6.2. Codes of Practice

6.2.1 National and State Code of Practices for goats

The Primary Industries Standing Committee (PISC) supports the Primary Industries Ministerial Council of Australia and New Zealand. PISC manages several Model Codes of Practice for the Welfare of Animals. A guide for acceptable goat farming practice has been adopted at the National level (Anon 1991). This means that all parts of Australia are covered by this National Code of Practice.

Some States have also developed their own code of practice for goats. Victorians, for example should first refer to their own Code of Accepted Farming Practice for the Welfare of Goats (Anon 2001, see Table 6.1). The Code of Practice in Tasmania (Anon 1998) is based on the National Code (Table 6.2). Welfare information specifically for Queensland is found at http://www.dpi.qld.gov.au/animalwelfare/ where details of the *Animal Care and Welfare Act 2001* are provided.

6.2.2 New South Wales Prevention of Cruelty to Animal Act

NSW legislation provides The Prevention of Cruelty to Animals Act 1970: http://www.austlii.edu.au/au/legis/nsw/consol_act/poctaa1979360/).

This Act states that:

> 'A person in charge of an animal shall not fail to provide the animal with food, drink or shelter, or any of them, which, in each case, is proper and sufficient and which it is reasonably practicable in the circumstances for the person to provide.'

This means that the carer of an animal must provide at least maintenance feed to prevent the animal from distress and starvation, even in drought. For further information on NSW see Clayton (2002).

6.2.3 Extracts of Code of Practice (Victoria)

Table 6.1. Code of Accepted Farming Practice for the Welfare of Goats (Victoria), (Anon 2001)

2. Drought

Drought may be defined as a severe rainfall shortage which leads to deficiency in water and/or feed supply for grazing goats. Drought is not the normal seasonal shortage of feed.

Goats being fed for survival should be inspected daily for health and vitality. Less thrifty goats may require segregation for special treatment and more frequent inspection.

Where provisions for health and vitality cannot be met, goats should be moved, agisted, sold or slaughtered humanely on site.

Drought-affected goats are highly susceptible to stress and require careful handling:

- if they are unable to rise and walk, they must be destroyed humanely on site;
- if they go down after limited exercise, they are not fit to travel, and should be fed to improve condition or, alternatively, be slaughtered humanely on site;
- if they are still able to walk but in an emaciated condition, and for which supplementary feed or agistment is not available, they should be sent directly to a knackery, rendering works or abattoir, as close as possible to their on-farm location, or slaughtered humanely on site; they should not be consigned to saleyards.

Drought-affected goats should be protected against exposure to extremes of temperature and weather. Vehicles transporting drought-affected goats must provide adequate cooling in hot weather and protection against cold, wet conditions.

6.2.4 Extracts of Code of Practice (Tasmania)

Table 6.2. The Animal Welfare Standard for Goats published by the Tasmanian Department of Primary Industries, Water and Environment (Anon 1998)

Section 5. DROUGHT

Drought may be defined as a severe rainfall shortage which leads to deficiency in feed supply for grazing goats. Drought is not the normal seasonal shortage of feed.

Goats being fed for survival should be examined at feeding times. Less thrifty goats may require segregation for special treatment.

Where provisions for health and vitality cannot be met, goats should be moved, agisted, sold or slaughtered on site.

Drought-affected goats which are unable to rise and walk should be destroyed humanely on site. Carcasses should be burnt, buried or sent to an appropriate rendering works or knackery.

Drought-affected goats which go down after limited exercise are at their minimum survival weight. They must be fed and watered to maintain or improve condition. They are NOT fit to travel.

Drought-affected goats still able to walk but in an emaciated condition, and for which supplementary feed or agistment is not available, should be sent directly to a knackery, rendering works or abattoir, as close as possible to their on-farm location. They should not be consigned to saleyards.

Drought-affected goats should be protected against exposure to extremes of temperature and weather. Road vehicles transporting drought-affected goats and operating during cold, wet weather should have at least the front of the stock crate enclosed.

6.2.5 Codes of practice for transport and for feral animals

Only healthy goats should be sent to market. It is a breach of the Code of Practice for Welfare of Farm Animals during Transport (Anon 2002b) to send sick or injured animals to market. Animals with broken limbs, broken horns or other physical injuries should be removed from any mob of goats being sold and carefully treated.

For transport, draft goats into groups of similar sex and size and the pens small and not overcrowded. Goats tend to pack down and small pens avoid large pile-ups and suffocation of goats trapped at the bottom. The transport vehicle should drive and stop carefully. The vehicle should stop occasionally to ensure that the goats are comfortable. Transport drivers should be familiar with the Code of Practice for Welfare of Farm Animals during Transport. Transporters are expected to have a Quality Assurance system in place such as Truckcare. Truckcare has been developed for livestock transporters by the Australian Livestock Transporters Association.

The Code of Practice for the Welfare of Feral Livestock (Anon 1992) is a guide to promote agreed standards of animal welfare of feral livestock animals captured for domestication, abattoir slaughter or which may be destroyed in control programs. The Code has been developed in full consultation with animal industries, animal welfare groups and relevant state and federal Government bodies.

6.3 Implications

6.3.1 Disputes

If a dispute arises regarding the welfare of goats during a drought, then reference will be made to the State Code of Practice, or if none exists, to the National Code of Practice.

6.3.2 Humane destruction of goats

Guidelines for humane destruction are provided in the Codes of Practice (Anon 1998, 2001). Information on appropriate methods of destruction can also be obtained from animal health staff from your local office of the Government Department managing agriculture.

In past droughts, Shires have made facilities available to dispose of carcases after destruction.

6.4 Vermin control

Producers report kid predation problems from foxes, dingos, wild dogs, crows and eagles are worse during drought. This heightens the need to cull unwanted goats as early as possible.

Vermin control, particularly prior to kidding time is a recommended routine practice for goat breeders. Fox and wild dog control involves baiting 2 to 3 weeks before kidding with baits being replaced regularly during the first two to three weeks.

One goat producer from the semi-arid zone reported that over a two month period 1200 baits were taken and in the following year 900 baits were taken over three months. This baiting was associated with an increase in kid weaning from 75% to 175%.

The best management practices for guard animals such as alpacas and guard dogs during drought have not been described.

7 Disease and health in droughts

7.1 Most common diseases

While the focus of this review is not disease control during drought, there are a number of diseases related to nutritional management that may occur during drought management. If goats remain in good condition during a drought they will generally experience little disease. However, there are a number of diseases that are relatively common during droughts. Advice for the control of these diseases is available from your animal health adviser.

7.1.1 Grain poisoning

Grains are carbohydrate rich foods and if excessive quantities are eaten, there will be a sudden change in the microbial population in the rumen. This leads to the formation of large amounts of lactic acid that causes grain poisoning. The same effect may occur with a change in grain types.

In practice, the condition commonly occurs:

- When goats are rapidly introduced to grain;
- When there is a sudden increase in the amount of grain being fed;
- When there is a change in the type of grain or concentrate being fed or even the same grain type but from a different source.

Clinical signs vary from mild to acute depending on amount of grain and previous experience with grain. In milder cases goats have a depressed appetite and are unstable on their feet. In severe cases symptoms include swelling of the abdomen, frothing at the mouth, abdominal pain, moaning, scouring, writhing on the ground and death.

Initial management involves removing the immediate source of grain, assessing the flock and sitting up any goats that are down. Treatment is based on neutralising the excessive rumen lactic acid. Treat any affected goats with 15g sodium bicarbonate in 1 litre of water as an oral drench. Many goats once down, however, will not recover despite treatment. Valuable stock should receive veterinary attention. The flock should be given roughage such as hay until recovered. The affected animals should be removed to a recovery area.

To reduce the risk of this condition, follow guides for introducing goats to grain (Chapter 3) or feed calcium hydroxide treated grain (see Section 3.5). When changing feeds, there should be a gradual changeover and ideally mix the new feed into the old feed over at least four feeds before the old feed cuts out. Adding 2% sodium bentonite to grain rations will help reduce the risk of poisoning during grain introduction.

Area of spilled grain can lead to over consumption of grain. It is best to clean up unintended piles of spilled grain, especially around silos. Goats will be attracted to these areas and grain poisoning will happen.

7.1.2 Pulpy kidney (enterotoxaemia)

Pulpy Kidney is an acute toxaemia caused by Clostridial bacterial in the intestine. This disease is more common in goats when there are rapid changes in diets and when high-energy and high starch diets are fed. Clinical signs are sudden death with rapid rotting of the carcass.

In research with goats fed diets of 75 to 100% whole wheat grain, 6% of goats died from enterotoxaemia (McGregor 2005b) despite having earlier received a vaccination. An experienced producer reported the loss of 10% of maiden does (18 months of age) who died from enterotoxaemia. The does were being regularly fed 300 g/d oats and 100 g/d lupins. This event was associated with the onset of cold weather in April. In both cases it is suspected that either the vaccination procedures as kids were not correct or that booster doses every six months had not been given.

All goats should be given two vaccinations for enterotoxaemia as kids, separated by four to six weeks. A booster vaccination is then required every six months. If in doubt about the vaccination status of the goats, give two vaccinations 4 to 6 weeks apart and then the booster six months later. On occasions, another booster may be required as the drought progresses if goats are dying with the clear symptoms. Vaccine should always be stored in a cold fridge (see label for correct conditions). Storage of vaccine in warm conditions will result in failure to provide adequate protection.

7.1.3 Worm and liver fluke infestations

Goats that are stressed for any reason may have reduced immunity and may show the effects of worm (internal parasite) infestation. Clinical signs are ill thrift, anaemia and scouring. However, if goats are scouring it may not be worms. It is important to determine the cause of the scouring before reaching for a drench gun. An effective drench early in a drought will reduce the impact of parasites on all goats.

When worms are confirmed by either WormTest or post mortem, drench the goats with an effective drench. Worm burdens should be regularly monitored through the use of faecal egg counts.

Liver fluke is more common in dry times when goats are forced to graze wet fluke-prone areas such as wet gullies and creek beds. Chronic fluke results in anaemia and ill thrift. Severely affected goats can develop bottle jaw and die suddenly. It can be confused with barbers pole worm. If in doubt consult a vet or submit faeces for a worm and fluke egg count.

7.1.4 Coccidiosis

Stress and overstocking of kids and weaners under warm, moist conditions can precipitate this disease. This disease is more common if kids are confined to feedlot or shed conditions where faecal contamination of food is more likely. The clinical effects are aggravated by concurrent worm infestations. Signs are scouring with watery faeces that may contain blood, lack of appetite, and dehydration, with anaemia and ill thrift in some cases. Consider a faecal worm test to differentiate from worms and fluke and consult a veterinarian for treatment and management advice. When lot feeding, attempt to keep the kids from walking over the feed. Ensure that the feed troughs are cleaned regularly and before feeding each day.

Stapleton (2002) reported that once it rains there is a real danger of coccidiosis in kids of up to 18 months of age, who have been fed grain on the ground. They will fade away almost overnight. He reported drenching 3 times in 3 days and moving the kids to a new paddock. It is important to keep aware of coccidiosis as it can develop very rapidly.

7.2 Less common diseases

The following are a range of less common diseases that can be encountered during a drought. The list is not exhaustive and you should contact your animal health adviser for an accurate diagnosis and remedial action.

7.2.1 Pregnancy toxaemia (Twin lamb disease)

Pregnancy toxaemia is a metabolic disorder of does that may occur in the last six weeks of pregnancy. It is caused by a lack of energy at a time when there is a high demand. The resulting rapid breakdown of body tissue to provide energy for the growing foetus also produces metabolic disorder. The does most at risk are those with inadequate nutrition, shy feeders, those in poor condition and those with multiple kids. Pregnancy toxaemia can be induced by stress or other conditions causing low intake eg. worms, foot abscess and yarding.

The disease usually appears over several weeks with a few does showing signs of standing alone or lagging behind, unsteady walk and apparent blindness. Clinical signs may progress over a number of days.

Prevention involves providing an increasing supply of energy during the last 8 weeks of pregnancy. Energy requirements are discussed in Section 4.2.3. If pregnancy toxaemia occurs, close observation, increased energy in a good quality feed and careful management during the last weeks of pregnancy are needed. Treatment with registered products may be successful in the early stages, especially if does are still able to stand. A supply of appropriate products for emergency treatment should be kept on hand during kidding.

This disease should be differentiated from Hypocalcaemia, which is also seen in late pregnancy and early lactation but caused by metabolic calcium deficiency. The disease occurs over a short time frame and usually affects more does in the flock. These animals usually respond rapidly to treatment with calcium solution and a vet should be consulted. Prevention involves providing calcium in the diet as discussed in Section 4.4.4.

7.2.2 Plant poisoning

During drought, plants not normally considered toxic may be eaten in excessive amounts and can cause mortalities. Simmonds et al. (2000) have provided an extensive list of Australian plants and weeds that are potentially toxic to goats. Goat producers are advised to check Simmonds et al. (2000) prior to grazing weeds or areas of native vegetation. See also Section 5.3. Seek veterinary advice if plant poisoning is suspected, as there is a wide range of plants that can cause problems.

7.2.3 Urea poisoning

This problem can be caused by intake of excess amounts of urea from blocks or in mixed feed. Another possibility of urea poisoning is when goats drink pools of water on the top of urea blocks after rain. Try to ensure that urea is mixed thoroughly with feed when used as a supplement (see Section 4.4). Keep urea blocks out of the rain in sheltered areas.

7.2.4 Salmonellosis

Faecal contamination of feed and water supplied with Salmonella organisms can cause a salmonella outbreak in stressed goats. It is more likely to be a problem when the area becomes wet or muddy following heavy rain or from overflowing water troughs and large mobs are feeding from the same area. Symptoms are fever, scouring and sudden death. Treatment requires antibiotics and advice should be sought from your vet. Try to reduce the risk by feeding on new trails or by using troughs.

7.2.5 Urinary calculi (Bladder stones)

The common predisposing cause is a limited water intake. This can occur as a result of faecal contamination of water, stagnant water or a high salt content in the water. Losses can also occur when goats are fed on grain rations without a calcium supplement. It is usually only a problem in rams and wethers. Affected goats may be dull or found after sudden death. There may be a grossly enlarged or even ruptured bladder caused by obstruction to urine outflow, or with a heavily stained belly due to urine spray. Treatment is rarely successful. The disease is best avoided by providing the goats with the highest quality water possible at all times and adding ground limestone when feeding grain. See Section 3.5.1.4 for further information on feeding bucks and wethers.

7.2.6 Pneumonia

Pneumonia is caused by bacterial infections aggravated by dry dusty conditions. It is more common with lambs being fed on dry, dusty feeds in troughs, especially finely hammer milled hay and so may occur in kids fed under similar conditions. Symptoms are nasal discharge, coughing, ill-thrift and sudden death. To lower the risk of this disease, avoid feeding dry and dusty feeds. This may require some damping down of the feed in troughs.

7.2.7 Vitamin A and Vitamin E deficiency

Vitamin A deficiency can occur in kids born to grain fed does in drought. Grain and most hays are low in Vitamin A. Kids must be completely off green feed for some months before clinical signs will occur. For further details, see the Section on Minerals and Vitamins (Section 4.4). Vitamin E deficiency has been associated with feeding young sheep on hay or grain over extended periods, especially if the ewes have been fed on these rations during pregnancy. It may occur in goats in similar situations. Affected animals may appear bright and alert but they are reluctant to stand. In other cases there is sudden death. Examination of dead animals reveals pale muscles. Vitamin E and selenium deficiency may have an interrelationship and present with identical signs. Refer also to the Section on Vitamins (Section 4.4.4.2) for further details.

7.2.8 Chronic Copper Poisoning

Long-term excessive intake of copper in the diet, or as a result of a build-up of copper associated with liver damage caused by grazing on Paterson's curse or heliotrope can cause poisoning in droughts. The disease is brought on by some form of stress (for example, nutritional or lactation stress). Sometimes there may be copper build up in old pipes that are re-commissioned to transport water during drought.

7.2.9 Listeriosis (Circling disease)

This is caused by bacterial infection that may harbour in silage or possibly associated with intense grazing of very short pasture. The condition occurs sporadically and there are two main disease patterns that don't generally occur together:

- Single animals may be found circling or wandering/uncoordinated, convulsing or dead; or
- A syndrome of abortion in does and death of newborn kids.

Remove silage from goats and replace with hay whilst seeking veterinary advice for a definite diagnosis. A recent outbreak of listeriosis in goats illustrates how mortalities can devastate a herd. Purchased silage in round bales was fed to a goat stud during the 2004 drought. Over a period of several weeks 60% of the breeding does died from listeriosis before *post mortums* determined the cause of death. Removal of infected silage prevented further deaths. An earlier identification of the cause of death would have kept deaths to a minimum.

7.2.10 Toxoplasmosis

This disease is caused by a parasite commonly transferred by cats. One commercial producer (> 1000 does) experienced a large number of abortions that ultimately resulted in 50% kidding instead of their usual 140%. Veterinary analysis suggested the does had contracted toxoplasmosis after eating hay from a hay storage area that had sheltered a number of feral cats. To prevent this disease keep cats from sleeping in feedstuffs.

7.3 Potential connection between feeding and Johne’s disease

There is mounting evidence that goats may contract Johne’s disease if they eat the faeces of sheep or cattle that have Ovine Johne’s Disease (OJD) or Boving Johne’s Disease (BJD). Cunningham (2002b) provided the following information from recent research. Details have been expanded after checking with Cunningham. As part of research at CSIRO Geelong to measure the efficiency of gamma interferon test for detecting Johne's Disease, the disease-causing bacteria was administered to goats, cattle and sheep by mouth. Researcher D. J. Stewart noted that, when orally dosed with the bacteria, goats were more susceptible to BJD than cattle and as susceptible to OJD as sheep. The fact that this level of infection has not been found in the field infers that goats' grazing habits have a part to play in the transmission of these diseases. Demonstrating this, the owner of the sole source herd for OJD in goats in NSW has since confirmed (to Cunningham 2002 and this author) that the goats became infected after being grain fed from the same grain trail as sheep during the 1994 drought. In this situation the sheep had access to the grain trail before the goats. Producers are urged to avoid faecal contamination of feed, wherever possible.

8 Discussion and implications

8.1 Action Plans

The following Tables (Tables 8.1, 8.2, 8.3, 8.4) provide a summary of suggested activities to minimise and manage drought risk. These Tables can be used as checklists that can be ticked when each activity has been completed.

8.1.1 Prior to drought

Table 8.1. A suggested checklist of activities to be completed before drought

Time before drought	**Activity**	
1 year	Develop Whole Farm Business Plan which includes: Property Development Plan (future fencing, water and shelter needs).	
1 year	Develop Drought Plan including: Identifying potential areas for construction of confinement area. Research the financial costs and benefits of a long-term drought feed reserve on your property. Identify trigger points for staged decisions for the first six months on key decisions including: Selling stock; Feeding; Joining breeding goats etc.	
Annual	Develop Financial Plan. Identify financial limitations including: Alternative uses for money. How much can be afforded on drought feeding and management. Cashflow, where is income coming from? Consider long term impact of decisions on herd structure, succession planning, income and cashflow.	
Annual	Develop environmental management plan including: Pasture management plan.	
Annual	Identify feeding requirements and future suppliers: Costs and feed quality. Labour needs.	
Annual	Obtain and maintain equipment needed for drought management.	
Annual	Have contact details for FEEDTEST on hand.	
Every three months	Identify suitable livestock markets. Maintain up-to-date market specifications.	
Every month	Identify water requirements: Water limitations. Water supply sources.	
Each month	Monitor and evaluate (weigh and condition score) goats. Adjust nutrition as needed.	
Every month	Maintain good animal health management including vaccination.	
Before each activity	Maintain a supply of declaration forms for selling animals. Record chemical usage and withholding periods.	

8.1.2 At the onset of drought

Table 8.2. A suggested checklist of routine activities to be completed at the onset of drought

Activity	
Implement Drought Plan.	
Determine amount of feed available on pastures/range. Determine how much water is available and where is it.	
Visit financial institution to confirm/implement financial plan.	
Contact livestock agent to identify current markets, prices and marketing arrangements.	
Evaluate (weigh and condition score) all goats suitable for sale, future breeding requirements and those that can be finished for meat.	
Obtain latest information on feed supplies and costs. Prepare updated feed budget.	
Implement feeding program to finish suitable goats for meat market if that opportunity is economic.	
Cull unwanted animals. Day before transporting unwanted goats, draft suitable animals into the agreed size sale lines. Wean capretto kids on day of transport. Identify different sale lots with raddle only on head.	
Prepare confinement area to admit animals.	
Move livestock away from environmentally sensitive areas of farm. Plan when livestock will move into confinement area.	

8.1.3 As the drought continues

Table 8.3. A suggested checklist of routine activities to be completed as drought continues

Activity	
Regularly weigh and condition score goats.	
Implement correct nutrition and husbandry practices.	
Adjust nutrition as needed.	
Separate bullies and goats that need special attention.	
Record chemical usage.	
Plan feed purchases several weeks ahead of need. Introduce new rations slowly.	
Continually monitor animal health and welfare. Maintain vaccination program.	
Monitor water quality and availability.	
Maintain your social networks. Talk to other farmers and goat breeders about how they are managing the drought.	
Attend drought meetings and workshops arranged by local and State government.	
Read rural newspapers and listen to radio and TV on drought management.	
Revise and update Drought Plan.	
Visit financial institution to keep them updated on your program.	

8.1.4 As drought breaks

Table 8.4. A suggested checklist of activities to be completed as drought breaks

Activity	
Determine amount of feed available on pastures/range.	
Determine how much water is available and where is it.	
When the decision has been made to allow some grazing, increase grazing time each day until full grazing is provided after 6 to 7 days.	
Stop feeding when less than a quarter of the stock remain at a condition score below 2 provided there is sufficient pasture to allow growth. Provide shelter in paddocks for drought affected goats.	

8.2 Outcomes of review

This review has identified and developed information for the best practice of goats during drought. Wherever possible reference has been made to original scientific data. Where relevant data is available for goats, the recommendations provided often differ to those provided for sheep. Where relevant data for goats is not available, the work relies on research undertaken with sheep.

Guidelines for determining the critical live weights for goats are provided. The review has updated and revised the energy requirements for goats for maintenance and growth based on published and unpublished research with Australian goats. A number of useful existing and potential practices for improving the nutritional management and welfare of goats during drought have been identified. The impacts of cold and heat stress on the energy requirements of goats have been reviewed. Research on water requirements of goats has been summarised. Welfare requirements of goats during drought have been briefly reviewed.

The review has identified a number of deficiencies in knowledge regarding best practice and welfare of goats during drought. The review does not claim to be exhaustive but presents as a manual containing a substantial amount of technical information pertaining to the drought management of Australian goats. There are a number of significant gaps in our knowledge that should be rectified and in some areas the suggestions need to be validated.

9 Recommendations

1. That this manual be published and made available to producers and advisors

This manual should be produced in pdf format and made available on the RIRDC internet site. The extension bulletin should be included in the next revision of Australian Goat Notes.

2. That industry associations be encouraged to link their internet sites to the drought feeding information on the RIRDC and the DPI internet sites

RIRDC should encourage the goat industry associations, product groups and breed societies to link their internet sites to the RIRDC web page and specifically to this drought feeding manual.

3. That validation of unpublished information be undertaken

This manual is the best available information for goat producers but it requires further work to validate some of the issues raised. The review uncovered critical gaps in our knowledge of the best strategies for drought management and nutrition of goats. The following are examples of where existing information needs to be fully analysed and published:

- The applicability of body condition scores to the assessment of welfare status of goats; and
- The relationship between body condition scores, drought feeding, improvements in nutrition, voluntary food intake and changes in body reserves of goats;

4. Investigate a number of important areas impacting on management of goats

Defining what are acceptable production targets for goat production as a means of understanding when droughts are impacting on production. To adequately answer this question requires analysis of industry wide benchmarking data. The manual has highlighted a number of areas where information is lacking including: documented objective guidelines for the early weaning of kids; and confirming how these guidelines apply to the new genotypes of goats being farmed under Australian conditions.

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Appendix 1 Further information

All the State Departments involved with agriculture have drought information on their internet sites. The following links take you directly to those web pages.

Queensland Department of Primary Industries
http://www.dpi.qld.gov.au/drought/default.html

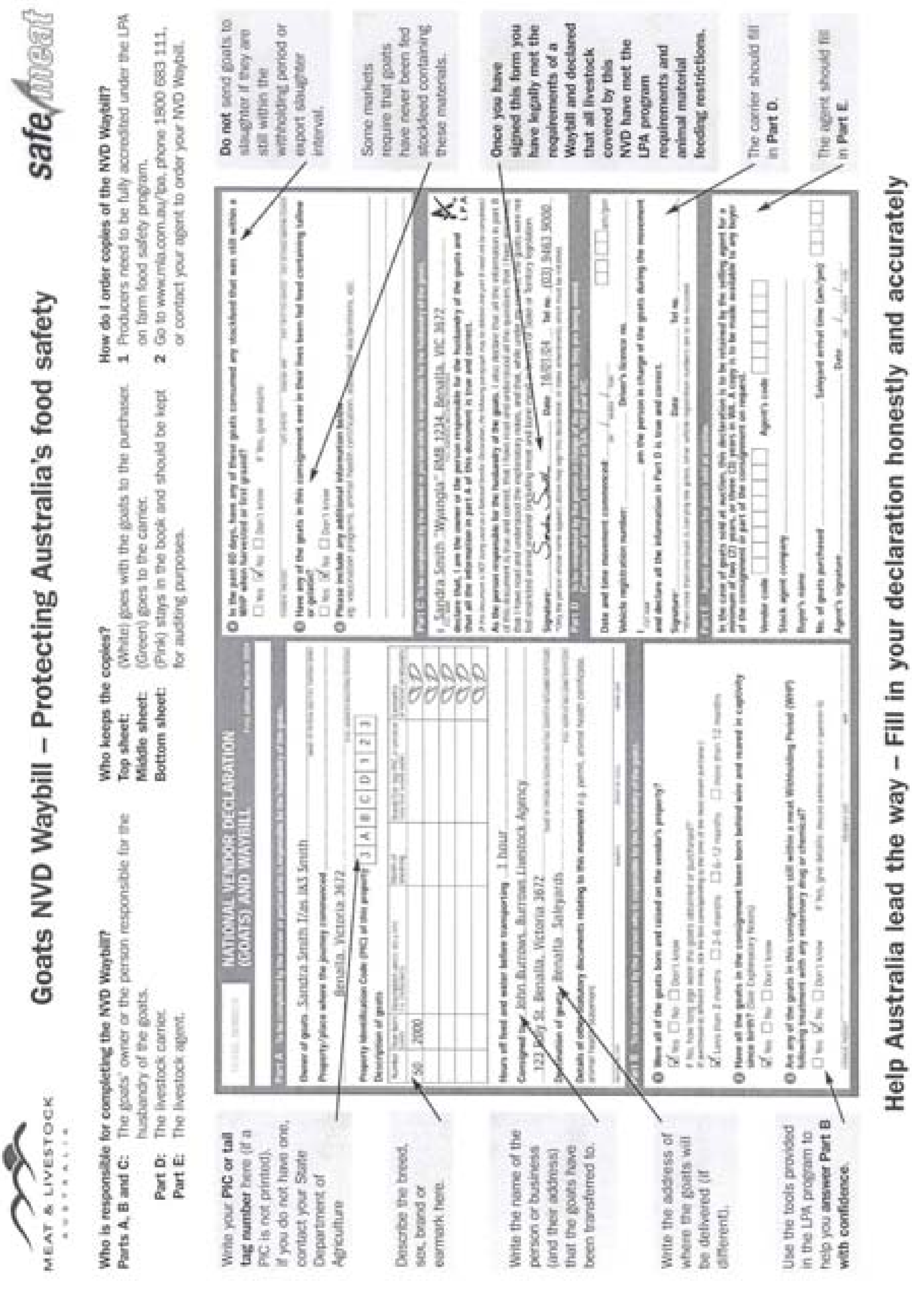
New South Wales Department of Primary Industries
http://www.dpi.nsw.gov.au/agriculture

South Australian Department of Primary Industries and Resources
http://www.pir.sa.gov.au/

Department of Agriculture Western Australia
http://www.agric.wa.gov.au/

Victorian Department of Primary Industries
http://www.dpi.vic.gov.au/

Appendix 2 National Vendor Declaration



EXPLANATORY NOTES – NATIONAL VENDOR DECLARATION (GOATS) AND WAYBILL

Background

The National Vendor Declaration (NVD) is part of the goat industry's commitment to food safety and product integrity.

Waybills are required when goats (and other stock) are moved in the Australian Capital Territory, Northern Territory, New South Wales, Queensland and Western Australia. Only this combined NVD/waybill need be completed in these States/Territories when goats are being moved. The completion of Part D of this combined NVD/waybill is optional in those States where waybills are not required.

This document can be used as a waybill without using the NVD component, in which case Part B is not completed and the second paragraph of Part C is struck out. Standalone waybills will continue to be available from relevant regulatory authorities, and their use is preferable if only a waybill is required.

Producers are strongly encouraged to provide a copy of this document for all goats they offer for sale or slaughter, and to insist on a correctly completed copy when buying goats.

General

Answer all items accurately. Any false, misleading or unverifiable statements may result in prosecution and/or civil action. If you rely on the document to verify future claims about purchased stock, then the stock should be identified and recorded against their accompanying document.

The cost of any residue testing required or undertaken in response to information given on the document is a commercial matter between the vendor and buyer (except where industry funds such testing).

The document is in triplicate.

- The original goes with the goats to the purchaser or destination. Saleyard agents completing Part E should retain the original for 2 years (for 3 years in Western Australia) and supply a copy to any buyer on request.
- The first copy goes to the person who transports the goats and completed Part B. In the Northern Territory it must be sent to the Chief Inspector of Stock, and the Australian Capital Territory it must be sent to the Controller of Stock.
- The second copy stays in the book for your records and must be retained for 2 years (for 3 years in Western Australia).

PART A

Part A is only to be completed by the owner of the goats or person responsible for the husbandry of the goats

Address and PIC (Property Identification Code) of property/place where the journey commenced

The address and PIC (if it is not pre-printed) of the property/place where the journey commenced must be recorded regardless of the length of time the goats have resided on the property/place. NVD/waybill forms, preprinted with a property PIC, can only be used when goats are to be moved from that property.

If the goats were walked to yards on another property exclusively for the purpose of loading at the commencement of this journey, do not record the PIC of the property on which the goats were loaded. In such instances, record the PIC of the property of last residence.

A new NVD/waybill must be completed if the goats have been purchased and/or moved to a new property, and then dispatched to a saleyard, abattoir or other destination.

Property Identification Code

The Property Identification Code (PIC) is the current property number allocated to your goat producing property by the relevant State/Territory Government authority. The PIC is commonly known as the property's "tail tag number" because the same number appears on the tail tags used for the identification of cattle leaving the property. In WA the owners brand may be used instead of the PIC.

Identification of goats

The identification of goats creates a clear linkage between the livestock and the information provided on this form.

Ear tagging, ear notching, tattooing or distinctive nose or head raddles may be used for identification purposes. The application of brands to the body of goats immediately prior to dispatch is not recommended as such brands may not be completely scourable.

The goat industry is currently considering the introduction of a national livestock identification system for goats. This system should be available in the near future.

Details of other statutory documents

Other documents relating to this movement eg. permit, animal health certificate, animal health statement, including additional sheets of descriptions of goats. The words "Attachment to NVD/Waybill serial number..." must be on every additional document with the serial number recorded. Additional document(s) must be attached to the original and both copies.

PART B

Domestication Requirements (Question 2)

Animal welfare issues may arise when goats which have not been sufficiently domesticated are handled. Trapped feral goats are not eligible for live export to Saudi Arabia. Goats for live export should be kept in holding paddocks and fed and watered from troughs prior to delivery to the feedlot.

Veterinary drugs and chemicals (Question 3)

Detail any veterinary drugs or chemicals administered orally, by injection or to the skin, including antibiotics, vaccines, worm and externally applied insecticides, but exclude vitamin and mineral treatments.

Export Slaughter Intervals (ESIs) and Withholding Periods (WHPs) for commonly used veterinary chemicals are listed in the table to the right. ESIs are the period following treatment when goats are unsuitable for export processing. ESIs are an industry standard to ensure export requirements are met. WHPs are the periods following treatment when goats are unsuitable for processing for domestic consumption in Australia.

Agricultural chemicals (Question 4)

This question is important to ensure that goats do not have unacceptable residues after consuming conventional stockfeeds, such as pasture, crop, stubble, grain or a prepared stockfeed, previously treated with agricultural chemicals. If the answer is "Yes" record all requested details in the space provided.

If the goats have consumed purchased feeds within 60 days prior to sale the vendor should answer "Don't know" to this question unless they hold SAFEMEAT endorsed vendor declarations for that feed and those declarations confirm that all required WHPs have been met and/or that the feed complies with all requirements relating to chemical residues through a QA testing program.

If any of the goats consumed pasture, stubbles or failed crops previously treated with a chemical that had no grazing/fodder WHP on the label the question should be answered "Yes" and details provided.

Feeding restrictions (Question 5)

The NVD includes a manager's declaration that the goats described have not been fed contrary to the law. State law prohibits feeding of most animal materials to ruminants.

Animal materials include any tissue, blood or other material taken from an animal and any meals derived from animals. Examples are meat and bone meals, blood meal, fish meal, feather meal, etc. It does not include tallow, gelatin or milk products. Contact your State Agriculture/Primary Industries Department for more details on these feeding restrictions.

Some overseas customers also require that the goat meat and offal they receive be sourced from goats that have never in their lives been fed animal material such as meat and bone meal as well as animal fat such as tallow which may be included in supplementary feed materials.

Additional information (Question 6)

List any required attached documents, and attach copies of the documents to the original and all copies of the declaration.

PART C

Signing Part C has legal significance. Regulatory authorities may take legal action, and purchasers may seek damages if any information in Parts A and B is incorrect. Before signing you must be absolutely satisfied you understand all elements of the document, and these explanatory notes.

If the person signing the document has not been responsible for the husbandry of the animals, the second paragraph of Part C must be struck out and the document will not be a NVD.

Livestock agents in particular are advised that unless they are directly responsible for the husbandry of the goats they must not sign unless the second paragraph has been struck out.

PART D

The carrier, including the drover, must complete this part and sign it. When more than one truck is carrying the goats all vehicle registration numbers are to be recorded. If there is insufficient space to record all the vehicle registration numbers an additional document must be attached to the original and all copies. Some state regulatory authorities will require a copy of the NVD to travel with each individual vehicle. If any information is incorrect regulatory authorities may take legal action. Completion of this part is optional within South Australia, Tasmania and Victoria.

Updated ESI information is available on the internet at the MLA website www.mla.com.au/esi or from MLA on 1800 635 445.