DEPARTMENT OF

AGRICULTURE

UNIVERSITY OF RHODESIA

An Introduction to Dairying in Rhodesia

by

JOHN OLIVER

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AN INTRODUCTION TO DAIRYING IN RHODESIA

Department of Agriculture

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FOREWORD

A very large increase in the supplies of dairy products is needed to provide healthy standards of nutrition for Central Africa's human population; malnutrition due to unbalanced diet rather than to lack of food is still all too common. This increase in dairy products is needed now. To bring it about requires far more than a slow evolutionary process of change from traditional African methods of cattle keeping. The need is for a complete revolution in thinking, based essentially on recognition that no great increase in out-put of high value dairy produce from the "National herds" can be brought about without a corresponding increase in the in-put of energy and protein as cattle foods. While cattle are subjected annually to a long period of semi-starvation, only hardy beasts of low milking potential can be expected to survive.

Dr. Oliver's manual sets out the basic requirements for dairy production in the tropics in clear and simple terms. It will save the extension officer many hours of hunting through text-books and papers for specialised information of known application to our tropical environment. It brings together information formerly scattered through a range of publications, many of them written without reference to the limitations of tropical conditions.

This hand-book will also be a valuable text-book for students and its reading would provide a useful refresher course for many experienced dairy farmers, reminding them of salient points which they may have overlooked. It will have application far beyond Central Africa and will be welcome in all English-speaking countries of tropical and sub-tropical Africa.

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(Formerly: Director Agricultural Research Council of Central Africa).

PREFACE

In the last twenty years agricultural scientists have provided the background of fundamental knowledge which has enabled productive and profitable dairy industries to be created in many parts of the world. The fact that much of this knowledge has arisen outside Africa does not detract from its value. The factors which govern success in dairy farming, i.e. breed of cow, diet, health and management, are the same all over the world. Only the environment differs and this may impose stresses on the parts which together make the whole which is dairy farming.

The stresses in Central Africa arise partly from climate and partly from lack of knowledge. The climate of Central Africa limits dairy farming only where insufficient rain prevents cattle food from being grown cheaply and abundantly. Knowledge can be acquired by the eager mind and if this manual stimulates a desire for new knowledge then one of its purposes will have been achieved. I have tried to do this by presenting in simple terms an up-to-date account of the elements of successful dairy farming in Central Africa. This is no more than an introductory manual because any single chapter on its own could be expanded into a book. For this reason a reading list has been included.

Many people have helped to shape the ideas and to provide the information put forward in this manual. My thanks are offered to many dairy farmers, extension officers and other Government officials who have shared with me their knowledge and experience. I am particularly grateful to my colleague, Dr. J. H. Topps for reading the manuscript carefully and for many valuable suggestions. Others have helped in this respect and I would like to make special thanks to Messrs. D. J. Barnes, G. J. Christie, M. Rodel and P. J. Conradie. Professor C. A. Rodgers and Mr. P. Jambaya read the manual for educational presentation and comprehension, respectively, and I found their comments of great value. Several people have helped with illustrative material and in this connexion the help of Mr. J. J. Duvenage, formerly Director of Conservation and Extension and Mr. J. Steytler is specially appreciated. Much of my own experience was gained at the National Institute for Research in Dairying, Shinfield and on the University College Farm at Mazoe. I am indebted to Professor A. G. Davis for the opportunity to establish and initially to direct the College dairy enterprise.

J. OLIVER.

Salisbury, 1971.

AN INTRODUCTION TO DAIRYING IN RHODESIA

1.0 Milk and Milk Products

1.1 INTRODUCTION

Milk is an exceptional food which is specially provided for the feeding of the newly born by the breasts of women and by the udders of animals. It is remarkable because it contains almost all of the food constituents that the newly born need for vigorous and healthy growth. It is a balanced food because its constituents are present in proportions which are suited to the needs of the kind of animal (species) for which it is provided. Above all, milk is easily digested—a factor of great importance to the very young. It is not surprising, therefore, that young animals often grow at a remarkable rate while suckling. For example, the lamb can double its birth weight in 15 days and the calf in 50 days. In comparison the human child grows much more slowly and requires about 180 days to reach twice its birth weight. These differences in growth occur partly because the milks from the various species are different in composition (Table 1) and partly because of differences of inherent growth rate.

Milk itself remains fresh for a relatively short time but it can be processed into several nutritious products which can be stored and then marketed. It is quite understandable, therefore, that from the earliest times man has domesticated animals in order to provide him with this useful product.

1.2 THE COMPOSITION OF MILK

Milk is composed of water, fat, sugar and protein, together with small amounts of salts and accessory food factors called vitamins. The latter are essential in the diet of all animals including man for the maintenance of good health. It is usual to classify milk on the basis of its food value as reflected indirectly by "Total Solids" content. This in turn is made up of milk 'fat' or butterfat and 'Solids-Not-Fat', part of which consists of the milk proteins. The sugars are dissolved in the water of milk while salts exist partly in solution or partly in combination with the proteins.

Fat. The fat in milk can be digested readily and used by the body as energy or fuel. Fuel is required by the muscles of the body so that they can do work such as hoeing, walking and running, it is needed to keep organs such as the heart and lungs functioning and it is used to keep the body warm. Energy can also be obtained from starch which is the main constituent of foods like maize.

However, fats give about 2¼ times as much energy as the same weight of starch. The butterfat of milk contains vitamins A and D.

Protein. Proteins are body building foods and are essential for growth, repair and normal functioning in all animals including man. Foods like fish, lean meat and eggs are particularly rich sources of dietary proteins while beans are other sources. All proteins are different and some are more useful to man than others. Milk proteins, chiefly casein, are of particularly high quality and well suited to the needs of the body of man—for growth in the young and tissue repair in the adult. One of the most serious diseases of childhood is due to a lack of sufficient protein in the diet. This disease, called kwashiorkor, is common in most countries of Africa.

Lactose. This is the sugar which milk contains and is similar to cane sugar but is not so sweet. It is readily digested and supplies energy to the body.

Ash and Mineral Matter. When the water in milk is boiled away and the remainder burnt completely, a white powder known as ash is left. This is similar to the ash left behind when wood is burnt away. It is made up of a large number of salts which were originally present in the milk, the chief of which are calcium salts and phosphate. Milk is a very important source of minerals, especially calcium, for young animals.

Vitamins. These are required in very small amounts by the body for normal health. They take part in the important processes by which food is broken down by digestion into raw materials which can be used by the body for all of the complex functions it performs. Vitamins are usually known by letters of the alphabet, e.g. vitamins, A, B, C, D, E and K, although the many vitamins of the B group have distinctive names. Normally a well-balanced diet, i.e. one made up of several different foods, ensures sufficiency of vitamins but lack causes what is called deficiency diseases. Provided a cow eats green food her milk is a good source of vitamin A. Cows' milk also contains some of the B group of vitamins and is well known for its pellagra-preventing properties. (Pellagra is a deficiency disease which results in cracking of the skin). Unfortunately some vitamins break down when milk is stored (A, B, C) and others (B, C) are destroyed when milk is heated. In consequence milk may not always be a very good source of vitamins.

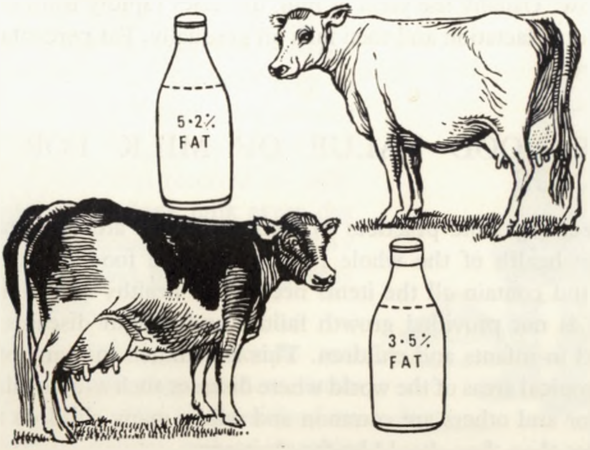
The main constituents of milks from various animals and humans are shown in Table 1. There is wide variation in the composition of the milks of the species, e.g. human milk 3.3 per cent fat compared with ewe milk 8.5 per cent fat. This can also occur between the different races and tribes of animals within a species, e.g. the cow, Friesland 3.5 per cent and Jersey 5.2 per cent fat.

TABLE I

Approximate Composition of the Milk of Various Species

Species	*Water* %	*Fat* %	*Solids Not Fat* %	*Protein* %	*Lactose* %	*Ash* %
Human	88·4	3·3	8·3	1·3	6·8	0·30
Cow: Friesian ..	87·5	3·5	9·0	3·4	4·8	0·68
Jersey ..	85·3	5·2	9·5	3·9	4·9	0·70
Zebu ..	85·9	5·3	8·8	3·3	4·7	0·76
Buffalo	83·5	6·9	9·6	3·8	5·1	0·75
Goat	88·2	4·0	7·8	3·4	3·6	0·78
Ewe	79·5	8·5	12·0	6·7	4·3	0·96
Camel	87·0	2·9	10·1	3·9	5·4	0·77

These differences in milk composition are interesting and help us to understand why the lamb, for instance, grows so much more rapidly than the calf. The dairy farmer, however, is mainly interested in the total milk yield of the cow and needs to pay attention to milk composition only when it falls below that required by the purchaser. Consequently breeds like the Frieslands are popular with dairy farmers because they are able to give relatively large quantities of milk of a satisfactory total solids content.



1.3 THE CAUSES OF VARIATION IN MILK COMPOSITION

The values given for milk composition shown in Table 1 are representative for humans and various domestic species. Because milk composition may be quite different from the figures shown, a brief account follows of the factors which cause these differences.

Breed of Cow. Some breeds give milk of a higher fat content than others and often when fat content is high, solids-not-fat are high also. On the other hand these breeds usually give a lower total quantity of milk than animals which produce milk of low fat content. At the same time individual cows of the same breed can show important differences in the quantity and quality of milk produced.

Stage of Lactation. Milk yield rises to a peak about six weeks after calving and gradually declines until the cow becomes dry. The trend of fat and solids-not-fat percentage is opposite, i.e. fat and solids-not-fat content is lowest when milk yield is highest and increases as yield falls off.

Feeding. This is important in its effect on fat, solids-not-fat, mineral and vitamin A content and will be discussed elsewhere.

Season. This is another feeding effect because grazing is nutritious and supports peak production in the rainy season. In the dry season the quality of grassland is not sufficient for milk production and the farmer must store food for winter feeding. Usually winter milk is rich in fat compared with summer milk but a greater amount of milk is produced in summer.

Age of Cow. Usually the yield of milk increases rapidly from the first to the third or fourth lactation and then falls off gradually. Fat percentage shows the opposite trend.

1.4 THE FOOD VALUE OF MILK FOR HUMAN BEINGS

Infant Feeding. The practices in feeding infants are important in determining the health of the whole population. The food of infants must be adequate and contain all the items needed for healthy and rapid growth. If such food is not provided growth failure and certain diseases can become widespread in infants and children. This is common in many of the tropical and sub-tropical areas of the world where diseases such as anaemia, marusmus, kwashiorkor and others are common and where many children are considerably smaller than they should be for their age.

In these areas prolonged breast feeding is often practised amongst poor people. This is largely because it is the only suitable food available. It is also practised because of the mistaken belief that further pregnancy can be avoided in this way. There is little doubt that human breast milk is the best food for young infants. Healthy well fed mothers are usually able to produce sufficient milk to provide all the nourishment necessary for the child for the first four to six months of life. It assists both the health of the mother and the production of adequate breast milk if the mother regularly drinks milk from domestic animals. This is especially important in many homes in Africa where the mothers' diet may be poor and consist mainly of a starchy food such as maize or cassava.

Between the age of four and six months, it is usually desirable to begin feeding the infant some solid food in addition to breast milk. In Africa this food is usually a cereal grain such as maize or a root crop such as cassava which are short of the proteins that the child needs for healthy and normal growth. From this time on, although it is highly desirable that breast feeding should continue, milk from farm animals should, if available, form part of the daily diet of the child. This milk can be mixed with the gruel, mealie pap or other starchy food of the child while it is being cooked. Alternatively milk, preferably after it has been boiled, can be given to the child to drink separately from food.

Child Feeding. There is wealth of experience which shows that milk has a highly beneficial effect on healthy growth when given to young children. In some countries it is customary to enable school children to have a third of a pint of milk a day either at a reduced price or at the expense of the State. The poorer the feeding value of the home diet the more obvious has been the beneficial effect. Observations by Lord Boyd Orr, the international authority on human feeding problems, are of interest. He found that when children from between five and 15 years of age received milk in addition to their normal food, they showed an increase of 20 per cent in height and weight over children who received no milk. Usually children who drink milk every day are more alert at school. There is every reason why milk should be drunk regularly by growing children.

Adult Feeding. Although adults do not need food for growth they need to have enough food and the right kinds of food to keep their bodies healthy and to provide energy to carry out their daily tasks and activities. If a person's food contains enough of all the necessary nutrients he is said to have a balanced diet. Foods such as maize contain mainly only one nutrient, others such as beans contain good quantities of two or more nutrients but few foods contain such a good balance of nearly all the essential nutrients as milk. Thus, although milk is more important in the diet of children and of pregnant and lactating women than of other people, it is also an excellent food to help balance the diet of all adults. When compared with other foods it is relatively cheap, e.g. one pint of milk has the same food value as approximately (i) ½ lb. lean meat, or (ii) five eggs, or (iii) ½ lb. chicken, or (iv) 1½ lb. fish when added to a starchy diet. Milk is of great value to pregnant women and especially during the last three months of pregnancy. This is because during this time the unborn child is growing rapidly and has an extensive need for food nutrients. These are obtained from the food eaten by the mother. Deficiencies in the diet of the pregnant woman can cause ill effects in her and her infant.

1.5 MILK PRODUCTS

Milk can be kept fresh for about two or three days but sooner or later (rapidly, in warm climates) it turns sour and then goes bad. For these reasons man has developed ways of processing milk into products which remain fresh for a time depending on their nature and the way they are stored. These different milk products vary greatly in food value but all are useful to man. A brief account follows of some of the more common of these products.

1.6 CREAM AND BUTTER

Cream. The fat in milk is made up of tiny drops or globules which rise to the surface to form cream when milk is allowed to stand. Cream can be separated from milk either by hand or machine. It can then be used at the table or sold for manufacture into butter. This is commonly done in areas which are so far from towns that the cost of transporting whole milk is too high. Where milk is produced so that cream can be sold for manufacture, it is usual for the large farmer to own a mechanical separator. In some rural areas, where farmers own a small number of cows, a communal separator is operated. Mechanical separation removes nearly all of the cream from milk, i.e. 99 parts in 100 (99 per cent) and can be done as soon as the milk is drawn from the cow. Hand separation is carried out after milk has been allowed to stand for 24-36 hours when about 80 per cent of the cream can be recovered. In this method there is a danger of the cream going sour and so becoming unsaleable.

Butter. This is made from cream by churning. Cream is placed in a container and then shaken for about 30 minutes until the cream "breaks", i.e. fat globules join together to form grains about the size of sorghum or kaffir corn seed. The liquid in the churn, known as "buttermilk", is drawn off and water added to the churn to wash the butter. The butter is then removed, salted and finally "worked" to remove as much water as possible. The composition of butter varies but on the average contains 80 per cent or more fat, 16 per cent water and the remainder is made up of casein (milk protein) lactose and mineral matter.

Ghee. Butterfat from which the water has been removed is called ghee in India and is manufactured in many parts of the world including East Africa. Milk is collected over a few days, churned and then heated over a slow fire. Heating is increased until active boiling ceases and so indicates that free moisture has been driven off. Heating is continued carefully until the non-fatty solids settle to the bottom and dry to a light amber colour. The fat is then allowed to solidify by cooling and the lower layer of butter-milk is run out. Ghee keeps well in a cool place if it has been made carefully and is stored in a tin vessel filled to the brim. Storage in copper or iron containers leads to deterioration of the product while overheated samples may become rancid quickly. Ghee is a valuable food containing vitamin A and is very rich in energy. It is palatable and easily digested and is also a valuable cooking fat.

1.7 SKIMMED AND SEPARATED MILK

These are milks from which most of the fat has been removed by the process of separation in butter making. Separated milk contains almost no fat. Milk which has been skimmed by hand contains about one fifth of the fat which was present in the whole milk. Such milk contains all of the valuable solids-not-fat. Because the vitamin A is removed with the fat, these milks are unsuitable as the sole source of food for babies. Nevertheless they are useful foods for children and adults.

1.8 CHEESE

Cheese is made up from curd which forms in milk that has been clotted by the action of rennet. This substance is found in the stomach of animals. Kon* writes: "Legend has it that cheese was first made by an Arabian merchant who put milk for a journey across the desert into a pouch made from a sheep's stomach; in the heat of the sun, the rennet in the stomach lining clotted the milk, which separated into curd and whey". Milk can be clotted also by souring and many cheeses are made in this way. Thus cheesemaking is a useful way of changing milk into a product which keeps well, is easily carried, has a high food value and is both readily eaten and digested.

There are a great number of different kinds of cheeses but the general methods used to make them are the same. Milk is heated and mixed with a "starter" to give a slightly acid or sour condition. Rennet is added and a curd forms. This is cut into small pieces which float in the whey. The mass is heated again and stirred until the curd settles to the bottom of the container. The whey is now drained off. The curd is then salted, put into a cloth, packed into a mould and pressure applied increasingly, until the required amount of water has been removed. The duration of this operation will depend on whether a "hard" or "soft" cheese is to be made. The cheese is then bandaged and stored to ripen. Yield varies but in general will be one part of cheese to 10 parts of milk for a hard cheese.

The food value of cheese is obviously different from that of milk. It can vary enormously according to the quality of the milk used and method of manufacture. Of the original wholemilk the curd usually contains about half of the total solids. This includes most of the fat and three-quarters of the protein. Most of the lactose and calcium stay in the whey while most of the vitamin A and some of the B vitamins stay in the curd. Consequently cheese is rich in valuable protein and thus can be an important addition to diets composed of maize or other cereals.

1.9 WHEY

We have seen that whey contains some of the valuable parts of milk. The amounts of solids it contains varies but is about 6 to 7 per cent. Although it can be drunk its main use as human food is in the making of whey cheese. This is done by boiling and stirring the whey until about a quarter of the original quantity is left. It is then set aside in containers to cool.

1.10 SOURED MILKS

Fresh milk turns sour in time and so many peoples in the world have developed palatable products which make a useful addition to their diets.

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*Kon S. K. "Milk and milk products in human nutrition". Nutrition studies No. 17. FAO 1959.

Souring is due to the action of extremely tiny living things known as bacteria. Some of these are able to change the sugar of milk (lactose) into an acid which causes a curd to form. There are many local ways of making sour milk foods. In the simplest method fresh milk is allowed to stand in an open vessel until it turns sour of its own accord. The Masai of East Africa and the Zulu and Swazi peoples put fresh milk into gourds which contain the remains of a previous batch of sour milk while other peoples add a piece of curd to the milk. Such practices ensure a rapid start to souring. Curd may be eaten as a relish with starchy food such as boiled potatoes or cooked cereal.

Yoghourt is a sour milk preparation made in Eastern Europe and is similar to the Dahl of India. Fresh milk is usually heated or sometimes brought to the boil and allowed to cool to just above blood heat. A starter is added to the liquid which is kept warm until it becomes clotted and thick. Yoghourt is often diluted with water and used for drinking. It can be either stored in sealed jars or dried in the sun.

Feeding Value. Some people believe that sour milk has special health giving properties that can lead to long life in human beings. Such beliefs have not been confirmed so far. Nevertheless souring can make milk a safer product than it sometimes may be. In certain areas of some hot countries, milk may carry bacteria which cause fevers like typhoid and paratyphoid and others which can cause severe stomach disorders. The acid formed when milk turns sour stops some of these bacteria from growing and eventually kills them. This, of course, reduces the sugar content of the product compared with fresh milk. Apart from this change, provided the process of manufacture has not entailed prolonged heating, the value of soured milk products is very similar to that of fresh milk. It stands to reason that they must be a valuable addition to simple cereal diets. Apart from this their great value is that sour milk products are the only practical way in which milk can be preserved by the vast numbers of people who inhabit the rural areas of the tropics.

1.11 INDUSTRIAL MILK PRODUCTS

No description of milk products, however brief, should omit those which are manufactured in modern factories. This is because they are valuable foods which are available occasionally in rural areas.

Condensed and Evaporated Milk. These are produced when heat is used to drive away some of the water in milk. Whole or skimmed milk may be used while cane sugar may be added. These products are sealed in cans for marketing. The term "condensed" milk is often used to refer to sweetened milk, while the unsweetened product is commonly called "evaporated" milk. Food value is reduced by the heat treatment. It is important to remember that when fat is skimmed from milk the vitamin A goes with it. Consequently skimmed milk products are unsuitable for infant feeding and this is usually stated on the label. With this reservation, these products can make useful contribution to human diets.

Dried Milk Products. As the name suggests these are milks from which all water has been removed. The ancient Chinese are known to have dried milk over fires but this method reduces food value. Today dried milk can be made by running a thin layer of milk over large heated rollers or drums and scraping off the dried milk as it forms. Alternatively, milk may be very finely sprayed into a current of heated air which drives off the water it contains immediately. When modern processing plant is used the dried milk is of very high quality. Dried whole milks are of great value in baby foods. They are very useful in areas where fresh milk is not obtainable because they are easily transported and, when dissolved in water, can be used in place of fresh milk. Apart from fatty solids, dried skimmed milk contains all of the valuable parts of whole milk. It is usually cheaper than dried whole milk powder because it is a residue from butter making.

1.12 THE PLACE OF MILK PRODUCTS IN HUMAN NUTRITION

Differences between families and peoples in the consumption of milk are partly due to custom and partly to the cost of milk and milk products.

Nutritional problems of African people have been investigated in Rhodesia.

In general traditional diets in rural areas were found to be adequate for adults. Such staple diets were composed of cereals (maize, millets or rice) with relishes (groundnuts, dried fish, meat) together with fresh vegetables or fruit and beer brewed from millets or sorghums. Unfortunately the social upheavals of this century have led to a deterioration rather than an improvement in dietary habits. This is particularly true of the populations of large towns. Many of these people have lost what traditional dietary patterns they had since leaving their rural communities. As their incomes have risen the nutritive value of their diets has fallen. Too many have developed a taste for white bread, cream buns, sugar and "mineral" waters of exotic taste. Such diets are largely deficient in protein, minerals and vitamins and may lead to the development of kwashiorkor or other deficiency diseases.

Reliance on white bread as a staple cereal has its dangers. All wheats are poorly supplied with calcium and although wheat flour is enriched with this mineral in some countries, this is not practised in Central Africa. Wheat, like other cereals such as maize, contains relatively little protein and this is of rather poor quality. Potatoes, cassava and other root crops are even more deficient in protein. If any of these foods form the main or staple food of the diet it is particularly important that they be supplemented with some foods containing good protein. One of the best of these is milk.

Milk is a rich (and relatively cheap) source of good protein as well as calcium and vitamins. Milk products, depending on their nature and method of manufacture, are also extremely palatable and are readily digested by, and available to, the human body. There can be little doubt that in Central Africa there is an urgent need to increase the production and consumption of dairy produce.

2.0 FACTORS THAT AFFECT THE AMOUNT OF MILK A COW YIELDS

Environment controls almost entirely the amount of milk a cow produces so it is important to understand what this is. Simply, it means surroundings and these are influenced by climate and by man. Climate, of course, is made up of several factors such as temperature, dampness of air and rainfall. These, in turn, largely control vegetation which also depends on soil and the slope of the ground. Most of Africa is in the tropics yet there are remarkable differences in climate. In fact many different climates are met which range from cool temperate in a few mountainous areas to hot-dry and hot-wet in others. Some environments are unsuitable for dairy cattle. How all of these factors affect the amount of milk a cow can produce is described in this chapter.

2.1 CLIMATE

Climate affects milk yield in two main ways. Firstly, by controlling vegetation, it controls the quality and quantity of food eaten by cattle which are grazing. Also, depending on the length of the rainy season, it controls the length of time that nourishing food is available. Food, its quality and the amount fed, is probably the greatest single factor which affects milk yield. Much more attention will be given to this in the chapters which follow. Secondly, cattle must keep their body temperature within a range (decided by nature) which is suitable for ideal productivity. The higher body temperature rises above normal (101.8°F., 38.5°C.) the less milk the animal will produce and it may die eventually. The skill of man can usually overcome the limitations of climate when there is enough rain. He can prolong the time of high quality feeding by planting crops which can be "conserved" or stored for dry-season feeding. He can reduce the effect of environmental temperature in various ways to prevent milk yield from becoming less in the hot months of the year.

2.2 HIGH TEMPERATURE AND MILK YIELD

Cattle have what is called a "comfort zone" for body temperature and inside this limit they are able to thrive and produce well. The upper limit of mean annual air temperature for European-type cattle is said to be 65°F.

(18°C.) and for African or indigenous cattle 70°F. (21°C.). Above these limits cattle have difficulty in keeping the temperature of their bodies at normal, i.e. 101.8°F. (38.5°C.). In their efforts to lose the extra heat they will seek shade and cool breezes, drink much water and finally eat less food. When this happens milk production declines and in time may stop altogether.

These "comfort zones" were established by studying cattle when they were kept in special "climate rooms" where air temperature could be kept at chosen levels. In the highveld of Central Africa air temperature is often very much greater than 65°F. (18°C.) but fortunately this is neither all day long nor all the year round. Although cattle may be too hot for part of the day they gain relief from the heat at night as we do ourselves. Much can be done to reduce discomfort on hot days.

High air temperature affects the productive activities of dairy cattle (growth, milk yield and reproduction) indirectly. It can, however, cause a reduction in the amount of food eaten which directly governs production. Thus the growth of young animals will be reduced and milk yield less when air temperature is high enough to affect appetite. While milk yield falls the production of milk fat is not always affected. Thus the proportion of butter-fat in the milk usually decreases. There is not much known of the effect of high temperature on reproduction. So far as we know neither pregnant cows nor the calves they carry are affected. However, bulls may have less success with cows because semen quality declines when air temperature is over 104°F. (40°C.) for more than eight hours a day.

2.3 GRAZING HABITS IN THE TROPICS

A great deal of valuable information on management has been gained through studying the grazing habits of cattle. In the heat of the day when the direct rays of the sun raise body temperature, cattle seek and need shade. This is more noticeable in European than in African (indigenous) breeds of cattle. Grazing time is reduced when cattle seek shade and less food is consumed so that milk production declines. The lesson to be learnt is that, in the hot season, cattle must be provided with shade and given either night grazing or extra food when they have to be kraaled at night. Shade can be provided by either conserving or planting suitable trees in the grazing area. Because cattle circulate water in their bodies to help cooling, plenty of water must be available throughout the day. Warm water does not cool the body as well as cold, so that water troughs should be shaded.

2.4 CLIMATE AND COMPOSITION OF FOOD

Grains are more easily digested than hay made from mature grasses. This is due entirely to the difference in the amount of fibre they contain. For example, 1 lb. of maize meal and 2 lb. of veld hay each supply a dairy cow with about the same amount of nutrients which can be digested. However, hay contains about 25 times as much fibre as maize. The digestion of fibre and the use in the body of the materials which result from this, causes more body heat to be produced than when grains are fed. Clearly much more body-heat will be produced when hay is fed than when maize is fed. Unfortunately there is not a great deal of practical knowledge on the most suitable kind of food to feed cattle in hot climates. In Africa this is due to mistaken attempts to try to suit the cow to the environment instead of trying to find out how far the environment can be altered to suit the cow.

The approach has been different in Israel where environment should have an adverse effect on milk yield. However by the importation of improved cattle to grade up the indigenous stock, a modern approach to disease control and cattle management, the national average of Israeli Friesians is 1,250 gallons a year. This productivity is achieved even in areas where air temperature is greater than body temperature for several months each year. The provision of shade and diets which have a high grain content are important parts of Israeli management.

From comparisons made between grain and hay it is obvious that foods which contain a great deal of fibre are unsuited to cattle in hot climates. On the other hand, in places where days are very hot and nights are cool it would be best for the cow to eat grain in the morning and fibrous foods in the late afternoon. Thus the heat produced in digesting hay would affect the body in the cool night and not add to the animal's distress in the heat of the day.

2.5 HEALTH AND MILK PRODUCTION

Health is that condition of well-being in which the body can carry out all of its functions satisfactorily. Production is the name given to the activities of domestic animals which are of benefit to man. Farmers tend cattle because they produce milk, meat, hides and calves. No aimal can do these things unless it is healthy and for good health an animal needs a balanced diet in the same way as man himself. The healthy animal is far better able to resist diseases which lower productivity.

When milk production falls off or stops a farmer can see at once what his loss is likely to be. He also knows the cost of drugs, veterinarian charges and the value of an animal which dies. It is less easy to know of the cost when milk yield is not quite what was expected. Nor is it easy to find out the loss of income from slow-growing young animals or of females which do not calve regularly. Yet this kind of lowered productivity is the result of disease and is common throughout the tropics. It must be clearly understood that diseases are the cause of a great loss of animal products. While many measures must be taken to keep disease at a minimum, the most important aid to animal health is a belly full of the right food.

2.6 CATTLE BREEDS AND MILK PRODUCTION

The composition of milk from various breeds or tribes of cattle is different (Table 1). In the same way there are differences in the quantity of milk given by different breeds. The average yields of various breeds are given in Table 2. Quantity of milk is usually given in terms of "lactation yield", i.e. the period when cows are giving milk or lactating. The length of lactation is usually given as a number of days and the yield in either pounds (lb.) or gallons. A gallon of milk weighs just over 10 lb.

TABLE 2

The Milk Yields of Some Breeds of Cattle

Breed	*Milk Yield lb.*	*Fat %*	*Days in Milk*	*Live Weight lb.*
Friesland†	9,000	3·6	298	1,200
Jersey†	7,000	5·1	297	800
Boran	3,500	5·0	305	850
Angoni	1,400	—	288	—
Nyasa Zebu*	1,757	—	288	—

†in milk recorded herds.
*from "The indigenous cattle of the British Territories in Africa".

Figures which show the average yield of different breeds of cattle have a very limited usefulness. For example Table 2 shows the average yields of Friesland and Jersey cows (Plate 1). These are the two most numerous dairy

PLATE 1. Dairy breeds of European origin.
Top Left: Ayrshire, *Top Right:* Guernsey.
Bottom Left: Jersey. *Bottom Right:* Friesland.
(Photographs by courtesy of The Rhodesian Farmer)

breeds in Southern Africa. The figures give no idea of the great differences in milk yields between different herds of say, Frieslands, nor does it tell us the big differences in yield which occur between cows in the same herd. For example, in Rhodesia the yearly (average) milk yield of Friesland herds varies from below 3,000 lb. to above 9,000 lb. If the records of individual cows are examined we find that cows vary in lactation milk yield from below 3,000 lb. a year to over 20,000 lb.* Thus average figures are only a guide to the milk yield of a particular breed under average conditions. The milk yield of cattle indigenous (belonging) to Africa is generally low.

*Claire, a Friesland cow in the Upper Umguse area, produced 29,152 lb. of milk at 4.6 per cent butter-fat in 300 days. (1963/64).

2.7 CATTLE BREEDS AND MANAGEMENT

Many farmers of the Western World have the skill and knowledge in dairy cattle management which their forebears gathered over hundreds of years. This experience shows that only cattle that are properly looked after will produce well. Interest is taken in each dairy cow and she may even receive special food which she likes best. In other words, these farmers go to a great deal of trouble to look after, and so help the cow to produce a good supply of milk. In contrast African communities have traditionally regarded cattle as social assets to be used in the purchase of brides and in the settlement of disputes. In these circumstances numbers are of great importance and, provided cattle can be kept alive, their well-being is of little importance.

In tribal societies, where the family provides its own food from family resources, the need to produce milk for sale has never arisen. Where milk is regarded as a gift from the cow when she has a calf at foot, then there is less desire to develop the many skills which make up good management.

The old system of management was sufficient for the kind of tribal society in which it developed. It is the new situation of rapid population increase which demands a change from the old ways so that extra hungry mouths can be fed.

Again European cattle receive much more food than indigenous cattle. The successful dairy farmer goes to a great deal of trouble to see that his cows have plenty of food. Today some African farmers have begun to realise the need to feed cattle if they are to do well. This is different from the old days when cattle starved in winter because no food crops were grown and stored for them. Cattle in winter lost weight and, if they were unfortunate enough to calve then, they gave milk at the expense of their own flesh and lost even more weight.

Finally, the European breeds have been chosen for hundreds of years for their ability to produce milk. We cannot, of course, choose a bull on milk yield but we can take a bull calf from the best cow in the herd and use him for breeding. The chances are that such a bull will pass to his daughters some of his mother's ability to produce milk. In this way daughters inherit the characters possessed by their parents and other ancestors.

2.8 AFRICAN BREEDS OF CATTLE

There is much controversy about which breeds of cattle should be used for dairying by African farmers. Some people argue that because the African breeds of cattle have survived in their own local environments for many hundreds of years they are the most suitable breeds for milk production. By careful selection over a long period of time, it is said, enough improvement could be made to keep pace with the improvement in standards of husbandry which are likely to take place slowly. These ideas ignore practical experience and are out of touch with the needs and spirit of Africa today.

Investigations over the last 30 years have shown the unsuitability of local African cattle breeds for dairying. Mahadevan, the modern authority on dairy cattle breeding in the tropics, states categorically "that selective breeding for milk production with the indigenous cattle of East Africa has failed to give any worth-while results." Similar remarks apply to attempts made to improve the indigenous (local) breeds in Swaziland, Zululand and Rhodesia. Under the best conditions of feeding and management in these areas milk yield is too low to provide a reasonable source of income to the farmer. To attempt dairy farming with local cattle, therefore, means that African farmers will have little or no hope of lifting themselves out of a subsistance farming economy. Without hope of this kind they will have no incentive to adopt the improved husbandry practices which are essential to successful dairy farming.

Dairying can only be justified if the farmer can make a reasonable living from his efforts. It has been shown again and again all over the world that the higher the yield the more profitable the cow. Consequently dairy farming should only be undertaken with breeds or crossbreeds which are likely to be productive under local conditions. These conditions include climate with the limitations it may impose on the provision of cattle food and the standard of management which can be applied. In Africa these variables are too great to allow for firm recommendations of the most suitable breed to be made. For example in those parts of the highlands of Kenya where rainfall is over 30 in. and food crops can be grown abundantly, European dairy cattle can be highly productive. In lower rainfall areas, where crops are less abundant, Indian breeds such as Sahiwal and Red Sindhi, have been shown to be more suited to the conditions than European cattle. In Central Africa the European breeds produce well so long as food is abundant and management is of a high standard.

A general recommendation can be made to the beginner in dairying with little capital. This is to start with local cattle and to get them in calf, by artificial breeding methods (Section 9.5), with semen from a bull of a European dairy breed. With good management the crossbred calves will be in milk three years later. During this time the beginner will have had time to learn how to provide the food needed for this improved type of cow and the other aspects of dairy husbandry needed for profitable dairying.

2.9 DAIRY TYPE

There is little doubt that the experienced dairy farmer can tell by looking at cows which will make a good milker (PLATES 1 & 2). This does not mean that mistakes are never made but rather that the more experience a farmer has the fewer mistakes he will make.

Each breed of cattle has an appearance which is typical for that breed so that a Jersey cow, for example, is quite different from a Mashona cow. All over the world men have gathered together and started "breed societies" with the idea of improving a particular breed of animal. Each society has written down a description for its own breed and of its appearance, colour, size, shape of head and many other body characters. Some of these are related to milk yield and others are not. This is no place to consider breed societies and their requirements. The point to be made is that a good judge of dairy cattle can usually pick a likely milker no matter which breed he sees. The characters he relies upon are of very great importance to all dairy farmers.

First of all, lactation is a process achieved only by the female no matter what species of animal is involved. Consequently the dairy cow should have a feminine appearance, that is it should look like a cow and not like a bull. There

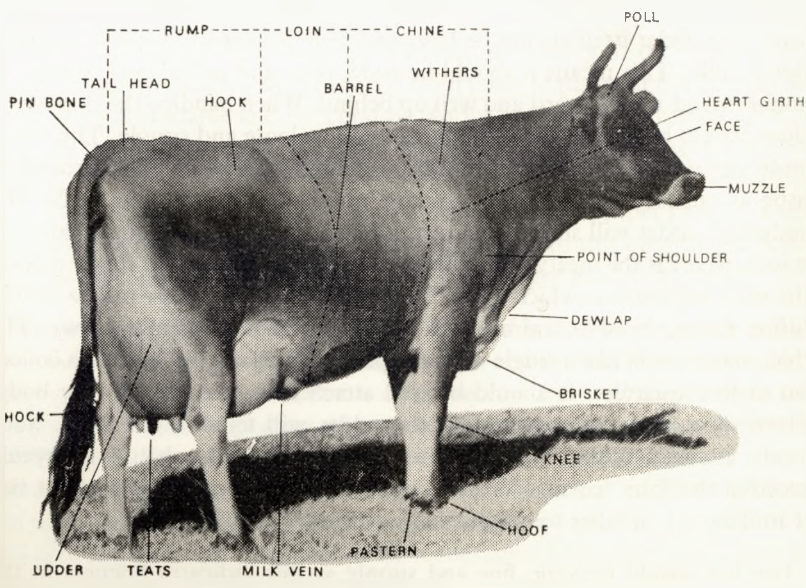


PLATE 2. The points of a dairy cow.
Schoengezicht Paulette.

(Photograph by courtesy of Schoengezicht Jersey's, Stellenbosch, R.S.A.)

is good reason for this because irregular or non-breeding cows often develop a rough or coarse appearance like that of a bull. Such animals give little milk in their lifetime. Femininity is best seen in the head and neck which should be refined without any heaviness or coarseness of skin, hair or bone. The eyes should be bold, bright and alert but docile rather than fiery. This indicates ease of handling and a courageous temperament to endure the heavy strain which lactation imposes on the body. A dull, sunken or sleepy eye shows either a "poor doer" or ill health.

The body should be long and deep while the ribs should be well-sprung. These characters show plenty of space for heart, lungs and digestive system, upon which milk production depends. The lactating cow does more "work" than any other domestic animal. It has been found that a cow's heart pumps 500 lb. of blood through the body each day in order to produce 1 lb. of milk, i.e. a cow yielding 40 lb. of milk a day must pump nine tons of blood. This is a tremendous amount of work to get through and is equal to that of a draught animal at the plough. Such work and productivity requires a great deal of food, hence the need for a long, deep body which indicates a big stomach to handle food.

The girdle of bones which make the hips or pelvis should be large enough to provide enough room for easy calving and sufficient area for udder attachment. The udder itself should be large and well developed so that it can hold a lot of milk. This means it should be wide, deep and in the best milkers, it should extend well forward and well up behind. When handled the skin of the udder should be fine to the touch and should be loose and supple. The tissue inside the udder should feel soft and yielding, suggesting milk producing tissue as opposed to meaty, fatty udder tissue which gives little milk. The productive udder will shrink when emptied and many folds of loose skin will be seen, whereas the meaty or fatty udder is about the same size, full or empty. The veins and arteries which carry blood to and from the udder can be seen in outline under the skin and are well developed in high yielding cows. The udder should look like a single organ or part of the body rather than a collection of four quarters. It should be well attached or joined on to the body, otherwise, as the cow grows older the udder will tend to fall away. Such loosely attached udders are liable to injury. The teats should be evenly spaced at the four "corners" of the udder and must be of a convenient size for milking, i.e. neither too large nor yet too small to grasp.

The tail should be long, fine and supple as this indicates fineness in the animal and it should be set neatly into the pinbones. In some animals the tailhead is high or coarsely set. This sometimes indicates shy breeding and, when exaggerated, makes service by the bull difficult.

The forelegs of the dairy cow should be straight and the feet close together when the animal is standing. If the feet are wide apart this indicates that the animal is fat or the shoulders are coarse and clumsily placed. It can also mean a well-developed brisket which is a character of beef cattle which produce little milk. The hind legs are kept wide apart by the udder when a cow is in full milk and should be straight. Hind legs should not bend inwards at the hocks as this can lead to udder damage.

The lactating cow should not be excessively fat as this usually means that the cow has put her food onto her back rather than in to the milk pail. All bones should appear to be fine. The skin should be thin and easily stretched as an indication of quality.

These, then, are the points to which the experienced dairy farmer pays attention. He looks for what is called "quality" and finds it in the neat, well proportioned animal that looks every inch a dairy cow.

2.10 STOCKMANSHIP

A dairy cow is only as good a milk producer as her master will allow her to be. She cannot look after herself apart from eating and drinking what she is offered. Therefore the skilled stockman ensures that she has all she needs to do her job properly. He must see that she gets plenty of the right kind of food. In summer cows must be moved from place to place on the farm so that good grass is available and infection by worms and flukes is avoided. Waiting until all the grass has gone will lower milk yield and once this has started it is difficult to stop. Over most of Central Africa grass can only maintain high yields for a few weeks. If a cow is to give her best yield a proper plan for winter feeding is necessary. Again the skilful stockman begins this programme before a decline in milk yield shows that grazing is no longer enough by itself.

Stockmanship is mainly a question of seeing that the dairy cow has enough nutritious food to eat when she needs it. Yet observation in many countries shows that there is more to it than correct feeding. It is well known that a new stockman can make important changes for better or worse in the milk yield of a dairy herd. Even when he feeds the same foods as were fed by the man he has replaced this can occur. This is due to several factors which will be described in detail later. Briefly they are due to feeding plans, i.e. the method by which young cattle are reared and to the recognition of the stages in a cow's life when either more or less food is required.

The way in which a cow is milked will be shown to affect milk yield, the amount of fat it contains and mastitis, i.e. inflammation of the udder. A good stockman also has a careful plan to avoid sickness in his animals. To bring all these factors together we can say that the good stockman has a wide knowledge of cattle and their needs and a good eye for changes in management that need to be made before health or milk yield decline.

3.0 The General Principles of Feeding Cattle

by

DR. J. H. TOPPS

3.1 INTRODUCTION

Food is probably the most important single factor which governs profitability in dairy farming because the amount and quality a cow eats largely determines how much milk she will yield. Again the food bill is the greatest single item in the cost of milk production so effective use must be made of it. A discussion of the principles of feeding helps us to understand how this can be done.

Animals use food and water in two important ways—for maintenance of body structure and for production. Production is an important general term which covers growth, reproduction and the production of milk, meat, wool and other animal products. Animal foods are composed of a very large number of different substances but for convenience these are usually grouped into six parts. The six parts are Water, Crude Protein, Ether Extract, Crude Fibre, Minerals (or Ash) and Nitrogen-free Extractives. Crude protein is made up of natural proteins and other substances which contain nitrogen. The Ether Extract is mainly fats and oils with small amounts of other compounds. Crude Fibre in many feeds is mainly cellulose, a valuable nutrient, but in mature forages its value may be reduced by the presence of a substance called lignin. Nitrogen-free Extractives are composed of substances called carbohydrates (i.e. sugars and starches) and substances very much like carbohydrates. All animals for their maintenance and production need water and substances which provide energy, proteins, mineral and vitamins. These nutrients are called *Essential Nutrients* since they are absolutely necessary to the animals. Let us consider each one in more detail.

3.2 WATER

No animal can exist for long without water. All animals, including humans, can go without food for longer than they are able to be without water. Cows have been known to drink 30 gallons a day, but the actual amounts needed by cattle are not important. Water should be available in unlimited amounts at all times to dairy cattle to allow them to drink the amount they need. Water has many important functions in the animal. It is needed for the transport around the body of digested food, for ridding the animal of excessive heat and so regulating body temperature, and for purposes of lubrication and protection of vital tissues.

3.3 ENERGY

All cattle must be supplied with enough energy for the normal "working" of their bodies (that includes maintaining the body temperature), for walking about, and for the muscular activity used in grazing. Energy in the food surplus to these needs will be used to produce milk or flesh or fat or all three. Of all the nutrients, the energy-yielding substances are needed in the largest amount. For this reason animals frequently receive insufficient energy in their diet for their needs. This is particularly so with dairy cows producing a large amount of milk and with rapidly growing young stock. The energy requirements of these two classes of cattle are especially large and they need food with a high energy value. Dairy cattle fed on normal diets obtain most of their energy from carbohydrates in the food. A second source is the fats and oils, but the amount in most dairy cattle foods is very small. However, a given weight of fat provides 2¼ times the energy of the same weight of carbohydrate so if fat is present in large quantities it supplies a large amount of energy. Crude fibre is also a valuable source of energy if it is mainly composed of cellulose. The amount of energy an animal obtains is mainly controlled by the digestibility of the food. The digestible part of a food is that which is broken down in the stomach and other organs of the digestive system and is then absorbed and used in the body. The remainder (the indigestible part) passes through the animal and is voided as dung. Some cattle foods are very digestible, while others have a low digestibility. In general, foods which are mainly composed of "starchy" and/or "sugary" carbohydrates, e.g. maize and other cereal grains, potatoes and molasses, are highly digestible. Thus nine-tenths of the solid or dry matter of maize is digested provided the grain is crushed or ground. Foods rich in protein, e.g. groundnut cake and fishmeal, are also very digestible. As foods become more fibrous, i.e. increase in crude fibre content, their digestibility is reduced. Maize bran, which is principally the outer skin of the grain, is more fibrous than maize and so it is less digestible. Young veld grass which has a dry matter composed of about 30 per cent crude fibre, is 60 per cent digestible. As the grass matures it becomes more fibrous and less digestible, until in the winter it is only about 40 per cent digestible. The same applies to hays and silages, good hay made from young grass is more digestible than old "stalky" veld hay. With grass, and indeed with many other plants, the content of lignin as well as the amount of fibre increases as it becomes older. Lignin is an indigestible substance found in large quantities in wood. In simple terms the herbage becomes very fibrous, woody and "stalky" and highly indigestible.

3.4 PROTEIN

Proteins are the flesh or muscle-building parts of the diet, so that young growing stock have a particular need for protein. In addition there is a certain amount of wear and tear of body tissues in all animals and protein is needed for their repair, and in lactating cows protein is needed as a source of milk proteins. Proteins are made up of substances called amino acids.

When digested, proteins are broken down into amino acids and it is these which the animal uses to build up into its own body proteins. There are 23 different amino acids. Thirteen of these the animal can make in its body, provided it is healthy and has enough raw material (certain substances which contain nitrogen) for synthesis. The other ten can only be made in very small amounts or not at all, and the animal must have them supplied in sufficient quantities from food. In other words, they are essential nutrients or, more specifically, essential amino acids (E.A.A.). From this we talk about proteins in foods having a certain "quality". This "quality" is their ability to supply animals with all the essential amino acids in sufficient quantities for the animal's needs. A protein which does this is said to be *High Quality* and in the best of these are milk and egg proteins (see Chapter 1).

Very fortunately the presence and activity of bacteria and other small organisms in the rumen of cattle make the consideration of protein quality of cattle foods an unimportant one. These bacteria break down food protein and from the products, and from other food substances which contain nitrogen (including urea), build proteins. These bacterial proteins are of high quality and after digestion provide the animal with adequate supplies of essential amino acids. This is not so with very young calves. Their rumens are undeveloped and contain very few bacteria and so calves need to be fed high quality proteins, e.g. milk or milk products. Like energy-yielding constituents the value of food protein to cattle is mainly controlled by its digestibility. Further the more protein there is in a cattle food the greater the proportion of it that is digestible. In fact there is a simple formula which is generally applicable and provides a useful assessment of the amount or content of digestible protein in a cattle food.

It is :—

% Digestible protein = (Crude protein in dry matter x 0.9) —3 in dry matter

e.g. Hay with dry matter containing 10% crude protein.

Thus digestible protein in dry matter = (10 x 0.9) —3 = 9 —3 = 6%

3.5 MINERALS

The minerals which are needed by animals are calcium (which forms the greatest part of lime) phosphorus (frequently called phosphate) certain metallic minerals such as iron, copper, zinc and manganese and several other substances. They are all known, in chemical terms, as elements. The complete list of elements essential to animals is as follows:—

Calcium	Iron
Phosphorus	Manganese
Magnesium	Copper
Sodium	Zinc
Potassium	Cobalt
Chlorine	Iodine
Sulphur	Selenium

The seven listed on the left are needed in fairly large quantities and for this reason are named major elements, while the other seven are only necessary in very small amounts or traces and they are called *trace* elements. The amounts found in the common foods are usually adequate for the animal's requirements. If the foods are short of one or more elements a special mixture of minerals must be provided. Minerals are needed by animals for the building of bones and teeth (calcium and phosphorus are especially important for this purpose) and as important constituents of other parts of the body, including the blood. Further they are necessary for the correct working of some vital changes in the body, e.g. making the best use of digested food, keeping muscles and nerves in good condition and controlling the movement and use of water in the body. Finally milk contains all the essential minerals and the lactating cow needs them to put into her milk. Since bones and teeth contain a lot of calcium and phosphorus and milk is rich in these elements (see Chapter 1) calcium and phosphorus are needed by the animal in far larger amounts than any of the other elements. For this reason they are the most likely elements to be in short supply. This is particularly so with young calves whose bones are growing fast and with high-yielding dairy cows. For these classes of stock and to a lesser extent other cattle, generous amounts of calcium and phosphorus should always be supplied. This is easily done by providing mineral licks, which are the mineral mixtures mentioned earlier, in rock-like form which the animals lick. In addition the concentrates given to dairy cows should contain three parts in a 100 of mineral supplement. In some grasses and other foods the amounts of the elements sodium and chlorine are small. These elements are found in salt and hence this is another reason for always supplying mineral mixtures. Under most normal conditions, the food cattle eat supplies enough of the other essential minerals. If one or more is insufficient in the diet the animal becomes ill or is said to have a "deficiency disease".

Deficiency diseases cause characteristic symptoms, e.g. a shortage of cobalt make the animal stop eating or eat very little and it soon becomes very thin and in poor condition. If trouble of this sort arises it is very advisable to consult a veterinarian or animal nutrition specialist for a correct diagnosis since many other illnesses and a few other "deficiency diseases" cause similar symptoms. It may be a waste of money to buy a feed and special cobalt compound if the cause of the illness is not a shortage of cobalt. To ensure that animals are never short of all the essential minerals, special mixtures or supplements containing all of the minerals are made for this purpose. These mixtures are usually fairly expensive and since animals do not normally need "extra" amounts of many minerals their purchase is not recommended.

3.6 VITAMINS

Vitamins are very complex substances needed by animals in very small amounts. They are usually known by a certain letter, e.g. Vitamin A, and sometimes there is a number with the letter, e.g. Vitamin B^1. A few vitamins are now more commonly called by another name, instead of a letter and number, e.g. Riboflavin which is vitamin B^2. However, all the vitamins may be conveniently listed in the following way:—

Vitamin A
A group of B vitamins
Vitamin C
Vitamin D
Vitamin E
Vitamin K

Frequently they are divided into two groups: the fat-soluble vitamins (A, D, E and K) and the water-soluble vitamins (group B and C). This is a useful classification for it gives some indication of where to find the vitamins, e.g. vitamin A in milk is in the fat or cream. Dairy cattle receive adequate supplies of many vitamins either through plentiful amounts in their foods or they make the vitamins in their body. Vitamin C is made by all farm animals and vitamin D is made in the skin of animals when they are exposed to sunlight. Obviously a shortage of D is very unlikely in Central Africa. All the B vitamins and vitamin K are made by rumen bacteria which provides the animal with adequate amounts. These vitamins must be supplied in the diets of very young calves because their rumens do not begin to function until they are several weeks old. With normal feeding, i.e. of milk or milk products the calf will receive sufficient for their needs. Vitamin E is plentiful in many foods, particularly green foods and several grains, but calves fed for a long time on milk and having access only to poor quality hay may not obtain enough vitamin E. If so they develop a "deficiency disease" called "white muscle disease", i.e. the muscle starts to "rot". It is cured by giving vitamin E. Incidentally, feeding cod-liver oil makes the disease worse. Vitamin A is not found as such in most dairy cattle foods. A substance, called carotene, which the animal readily converts to Vitamin A, is widely found in all growing plants and many plant products. Young, rapidly growing grasses and legumes are especially rich and although carotene is not green itself, the greenness of the food gives a good indication of its richness in carotene. Dry veld grass in the winter contains very little or no carotene. The requirement of cattle for vitamin A is high for a vitamin. All cattle need it for various functions in the body while lactating cows need extra amounts to put into their milk. The abscence of natural green grass during our long dry winter and the fact that most of the hay made is bleached means that supplies of carotene in dairy cattle foods in Central Africa are frequently very low. To overcome this shortage, green crops such as lucerne or oats may be grown under irrigation during winter and a little given to the cows daily. Alternatively either concentrates can be bought which contain vitamin A specially put there by the manufacturer or preparations of pure vitamin A are obtainable which can be injected into the animal. The source of Vitamin A used depends on the resources of the dairy farmer. If an animal is deficient in vitamin A its eyes are affected and it is unable to see in the dark. Its bones may also be affected and it becomes stiff with sore shins. Cows sometimes have trouble with their calving and if the deficiency persists for a long time the animal becomes very ill and permanently blind. Once again it must be emphasised that if vitamin A trouble is suspected the advice of an expert should be sought, since eye trouble can be caused by many other factors as well as vitamin A deficiency.

3.7 FOOD VALUES AND NUTRIENT REQUIREMENTS

Dairy animals need known amounts of the essential nutrients, energy protein, minerals and vitamins. These requirements depend on the size or weight of the animal and the amount of milk or flesh it is producing. For convenience, requirements are usually divided into maintenance requirements, i.e. nutrients needed to keep the body working properly without losing weight, and production requirements, i.e. nutrients needed in milk and new growth. Before considering the actual needs of animals it is necessary to see how the nutritive value of animal foods is measured. There are several different measures of a food's energy value. In Central Africa total digestible nutrients (T.D.N.) is the measure used. This is obtained in the following way. From digestibility trials with cattle and sheep the amounts of digestible crude protein, digestible ether extract, digestible crude fibre and digestible nitrogen-free extractives are determined in a food. The digestible ether extract is multiplied by 2.25, for it probably contains that much more energy than any of the other nutrients, and is added to the other three digestible parts to give total digestible nutrients. The calculation is made on a 100 lb. of the food and so the value found is the percentage of T.D.N. in the food.

Example: *Dried veld grass cut in February*

	Nutrient in 100 *lb. dried grass* lb.	*Digestible nutrient in* 100 *lb. dried grass* lb.
Crude protein	5·6	1·62
Crude fibre	34·8	23·87
N-free extractives	48·1	28·57
Ether extract	1·5	0·48 (x 2·25)
Total digestible nutrients		55·14

Unfortunately T.D.N. is not an exact measure of the useful energy an animal derives from its food. It takes no account of energy losses in the urine, gases "belched out" and, more important, heat losses. A considerable part, $\frac{1}{4}$ to $\frac{2}{5}$ of a food's total energy, is converted to heat by the animal. Some of this heat helps to maintain body temperature but in a warm climate much of it is not useful and just escapes from the body. These heat losses are much larger for roughages than for concentrates and so a pound of T.D.N. from roughage has much less productive value than a pound from concentrates. It is particularly important to remember this when animals are fed rations containing a lot of roughage. The protein value used in Central Africa is the digestible crude protein content expressed as a percentage. It is frequently abbreviated to digestible protein (D.P.) and is a fairly accurate measure of useful protein. The mineral and vitamin value of foods is given as the number of grams, milligrams or micrograms of the mineral or vitamin per pound of food or as so many parts per million of the food.

In deciding upon or checking the rations given to cattle the actual amounts of minerals and vitamins needed are rarely considered. Instead, the minerals and vitamins which may be in poor supply are provided by mineral supplements and a source of vitamin A. Thus in rationing cattle we consider their need for T.D.N. and D.P. Firstly maintenance needs. The larger the animal the larger its requirements but this is not a direct connection, i.e. an animal double the weight of another does *not* require twice the amount of nutrient. Instead requirements vary with the weight to the power of three quarters. This means that small animals need relatively more than large animals. In Central Africa the two breeds of cattle used almost exclusively are the Friesland (average weight—1,200 lb.) and Jersey (average weight—800 lb.). The daily maintenance requirements of these cows and those of three other breeds are:—

Nutrient Requirements for Maintenance for Various Breeds

	T.D.N.	*D.P.*
	lb.	lb.
Friesland (1,200 lb.) ..	8·0	0·7
Ayrshire (1,000 lb.) ..	7·0	0·6
Guernsey (1,000 lb.) ..	7·0	0·6
Jersey (800 lb.) ..	6·0	0·5
Mashona (800 lb.) ..	6·0	0·5

The amount of T.D.N. and D.P. needed for milk production depends on the quantity and quality of the milk given by the cow. The richer the milk, i.e. the higher the fat and protein content, the greater the amount of nutrients required per gallon. The following requirements are for Friesland and Jersey milk:

Nutrient Requirements for Milk Production

(*When yield is 3 gallons or less daily*)

	Per gallon of milk	
	T.D.N.	*D.P.*
	lb.	lb.
Friesland (3.5% fat) ..	3·0	0·51
Jersey (5.0% fat) ..	3·7	0·61

Guernsey milk is like that of Jerseys', while the milk of Ayrshire cows is similar to Friesland. Indigenous cattle produce rich milk like that of Jerseys. The total requirements of a cow are obtained by adding the amounts of nutrients needed for maintenance and milk production.

Examples:

Friesland cow (1,200 *lb.*) *producing* 3 *gallons/day*

	T.D.N.	*D.P.*
	lb.	lb.
For maintenance ..	8·0	0·7
For milk production ..	3 x 3·0	3 x 0·51
Total	17·0	2·23

Jersey cow (800 *lb.*) *producing* 2 *gallons/day*

	T.D.N.	*D.P.*
	lb.	lb.
For maintenance ..	6·0	0·5
For milk production ..	2 x 3·7	2 x 0·61
Total	13·4	1·72

There is now considerable evidence to show that the energy (T.D.N.) required per gallon increases as the milk yield of the cow increases. Because of this the quantity of T.D.N. allowed for each gallon of milk should be allocated according to a sliding scale which increases with yield. Although this may be desirable it is difficult to apply it in practice. However, it is practical to recommend and use higher requirements of T.D.N. per gallon of milk for high and very high yielders. The T.D.N. requirements already stated for Friesland milk (3.5% fat) and Jersey milk (5.0% fat) of 3.0 and 3.7 lb. per gallon respectively apply only to cows giving three gallons or less per day. For cows producing greater yields than the above, the following allowances are recommended.

	lb. of T.D.N./gallon of milk
Friesland (3.5% fat) 4-6½ gal./day	3·4
Friesland (3.5% fat) 7 and above gal./day	3·9
Jersey (5.0% fat) 4 and above gal./day ..	4·2

As far as is known at present the previously stated requirements of digestible protein per gallon of milk apply to both low and high yielders, but there is a small amount of evidence to suggest that they may be 10% too high for cows giving two gallons or less per day.

Examples of total requirements of high yielding cows.—

Friesland cow (1,200 *lb.*) *producing* 7 *gals./day*

	T.D.N.	*D.P.*
	lb.	lb.
For maintenance ..	8·0	0·7
For milk production ..	7 x 3·9	7 x 0·51
Total	35·3	4·27

Jersey cow (800 *lb.*) *producing* 4 *gals./day*

	T.D.N.	*D.P.*
	lb.	lb.
For maintenance ..	6·0	0·5
For milk production ..	4 x 4·2	4 x 0·61
Total	22·8	2·94

The feeding of other cattle, e.g. bulls, dairy heifers, is not usually carried out on the basis of their requirements. They are fed sufficient to keep them in good condition with some care to avoid either under-feeding or over-feeding.

3.8 OTHER FACTORS TO BE CONSIDERED IN THE RATIONING OF DAIRY CATTLE

Appetite. The amount of food a cow can eat should be carefully considered when rations are devised (see Chapter 6). Otherwise, a ration may be given which contains sufficient quantities of T.D.N. and D.P. but the cow cannot eat enough of it for her needs. Alternatively the ration provided although adequate in energy and protein may not satisfy the cow's appetite. Either practice is poor management. Two factors which appreciably affect a cow's appetite need to be stressed. Firstly, the poorer the quality of the food the less the cow will eat and secondly, the more milk she gives the greater will be her appetite. Detailed values based on these facts are given in Chapter 6.

Preparation of Food. Cereal grains should be coarsely ground or crushed for cows, otherwise a considerable fraction escapes chewing and digestion. Fine grinding should be avoided for it produces a meal which becomes a doughy mass in the stomach and is difficult to digest. To avoid waste it may be necessary to grind "stemmy" hays, e.g. sunnhemp hay. If so, coarse grinding should be used since the feeding of finely-ground hays causes the cow to produce milk with a lowered fat content. Coarse grinding or chopping of roughages has no effect on their digestibility.

Palatability of the Food. This is an important property which is difficult to measure or explain. Briefly it means that the food is savoury and acceptable to the taste and animals will readily eat it. Succulent foods and those rich in sugars, oil or protein are palatable, e.g. young grass, well-made silage, green crops, molasses and most oil cakes. Conversely, very dry and fibrous foods and those in a very powdery condition are less palatable. Some plants contain a certain constituent, e.g. a mustard-oil substance, which renders them bitter and very unpalatable. It is important that rations given to cattle should be palatable. New foods, which may be rejected at first, should be introduced gradually into the ration. Mixing with salt or molasses improves the palatability of concentrates and poor quality roughages, while a mixture of roughages is usually more readily eaten than single roughage.

Laxative and Costive Effects. In a pronounced form, costive (i.e. binding) and laxative effects of a ration are undesirable. With the former the elimination of waste products is incomplete and in the latter digestion is likely to be inefficient. For dairy cattle a ration should be mildly laxative. A high fibre content tends to make foods binding, whereas richness in oil, "amides" or water has the reverse effect. Thus hay, maize stover and fibrous oil cakes are usually binding and succulent foods, especially young grass, are laxative. To relieve costiveness a mash of wheat bran or succulent foods may be used, while maize meal or hay are given to reduce scouring.

Dangerous Foods. Some foods and plants contain poisonous substances which if eaten kill an animal very quickly. Every precaution should be taken to see that animals do not eat these foods. If an accident does occur a veterinarian should be called immediately in an effort to save the life of the animal(s). Do not feed any food which is mouldy, e.g. mouldy maize silage which has been badly made, or grains stored in a very damp place. Some moulds are very poisonous to cattle. Feed with care and in small amounts Jack beans and Jack bean hay and silages. In large amounts they can be poisonous. Unfortunately certain weeds in the veld are poisonous and are thus an unknown danger to the herd. They are eaten by cattle which are short of grazing or food and so the prevention of deaths in this way is in the hands of the farmer. In this connection ensure that there is no *Lantana camara* on the farm for this is a very poisonous plant. Finally, it is well to remember that urea if eaten by any animal at the rate of more than a few ounces per day is fatal, and to take special care of arsenicals used in dipping.

4.0 Grassland and Grazing Cattle

The variety and amount of grass which grows in any particular area depends on rainfall, soil fertility, altitude and the number of trees. There are too many different soils and climates to allow a full description in a manual of this size of all the different kinds of grassland which are found in Central Africa. Instead a general description of grassland follows, together with a discussion of the principles of grassland management and of the feeding value of grass for dairy cows.

4.1 NATURAL GRASSLANDS

The natural vegetation of most of Central Africa is woodland with grass, bushes and trees—a combination of vegetation known as savanna or "veld". It is an important source of food for grazing animals. It also helps to reduce the amount of soil washed away by heavy rains. Unfortunately only in certain areas does it provide enough nutritious food for the dairy cow for more than a few weeks of each year. Nevertheless our vast areas of veld represent great wealth in the form of cheap cattle food and farmers should know how to use it to best advantage.

The proportion of grasses, bushes and trees in an area depends on the quality of the soil, the rainfall and the height above sea-level. For example, in areas above 5,500 feet where rainfall is over 45 inches a year, the vegetation is mainly short grasses. At the opposite extreme are areas below 3,000 feet where rainfall is low (below 20 inches) and the temperature is high (above 100°F. 37°C.) and the soil is poor sand. Here trees and bushes are dense and grasses are scarce. Between these two extremes is much useful grazing which can carry a beast on three to 20 acres and where soil and rainfall permit arable cropping. In general these areas are the most suitable for dairy farming because carefully managed grassland can provide grazing in summer and crops can be grown for winter feeding.

4.2 GRASSLAND MANAGEMENT

In all types of savanna the various kinds of trees, bushes and grasses are in competition for living space. As woodland is the natural vegetation of sub-tropical Africa, trees tend to win this struggle unless man interferes. The more space taken over by trees the more shade they provide and the more soil foods and water they use. As a result grasses lose their vigour and the amount of grass for grazing becomes less. Grassland or veld management is that aspect of farming which deals with maintaining or improving the proportion of grass to trees in an area. Only the main principles of management can be given because different kinds of grassland respond to management in different ways.

The Control of Tree Growth. When trees and bushes are cut down there is an increase in grass growth. In some places this may enable three animals to graze where only one grazed before. Trees and bush can be cleared either by hand labour or killed by ring-barking, i.e. the removal of about one foot of bark from the bottom of the trunk so that the tree dies. Unfortunately new shoots are sent up by roots left in the ground and it is rarely practicable to remove all of them. Thus unless these new shoots are discouraged in some way, the cleared area will become woodland again. Control is either by the use of hand tools or by fire or a combination of the two.

Fire is a simple and practical way to reduce this regrowth if it is used before the young trees are much more than a year old. Grass is the only source of fuel so that it must be allowed to accumulte in order to provide the really hot fire needed to kill saplings. This can be achieved either by reducing the number of cattle in the area or by closing the area to cattle for a whole grazing season. Many burning programmes fail because there is not enough heat to kill off bush regrowth.

It is not usually possible to burn grassland more often than once every three or four years. More frequent burning will reduce the number of animals which can be carried in an area because of the need to rest the grazing to provide fuel for the fire. Again too frequent burning may be harmful to the grasses in dry areas. The best time to burn is about one month before the rains are due. The burnt area should be rested for at least two months after the rains begin and, if possible, be the last area to be grazed in summer.

4.3 GRAZING MANAGEMENT

The need to rest grassland. In order to practise veld management effectively something of the nature of grass growth must be understood. Grasses can be divided into two kinds, i.e. annuals, which grow from seed each year and perennials, which grow from a root. Heavy and continuous grazing prevents the annual grasses from seeding so they soon die out. Perennials survive from season to season by virtue of plant food which they store in their roots. When the rains begin perennials depend on these food stores for growth. Some grasses need to draw only small reserves of food from their roots before they can begin to replace the food they have used for early growth. Such grasses are able to survive fairly heavy grazing. With other grasses, however, replenishment occurs only in the late growing season. Continual close grazing of these prevents root storage from taking place so that they become weak, produce less grazing in the next season and, if heavy grazing is continued, will die eventually. Both annuals and perennials which have been over-grazed may be replaced by unpalatable grasses which remain uneaten and seed readily.

Two simple principles must be applied to keep grassland in a productive state. First of all it must not be over-grazed in summer. This means that the number of cattle grazing an area must be adjusted so that no damage to the productivity of the grasses takes place. This number of cattle is called the "stocking rate" and varies with soil and climate. A farmer judges stocking rate from his practical experience and that of other farmers in the area. Usually grassland is correctly stocked if some grazing is left at the end of the summer. It is always better to understock than to overstock. Secondly, grasses need periods of rest from grazing in the growing season so the perennials can refill their roots with food and so that annuals may set seed. While these two principles provide the basis of grassland management the degree to which they must be applied varies with particular localities. For example it is generally agreed that grassland can stand up to much heavier grazing on sandy soil than on heavy soils. The grasses found on the granite sands are almost uniformly acceptable to cattle and can be reasonably heavily grazed. On the other hand the grasses which grow on the Kalahari sands are somewhat unpalatable and heavy grazing seems to reduce their productivity. The grasses on the red soils usually must not be grazed too heavily otherwise they are readily replaced by worthless grasses. It is important, therefore, for farmers to understand the principles of grassland management so that they can be applied to suit local conditions.

The accumulation of dead grass. When an area is not grazed properly old, dead grass accumulates which tends to smother new growth and hinders the grazing animal. Also, when too few cattle graze an area, "patch" grazing is a very common occurrence. Here, certain patches of grazing are favoured by cattle while others are neglected. The grasses in ungrazed areas soon become stemmy and fibrous and consequently unpalatable. This situation will be further aggravated as dead grass accumulates.

Fire used for bush control also serves the purpose of removing old, dead grasses and of cleaning up patches of grass which have been left by cattle. On level land, which is free from obstructions, a mower can be used to even out the grasses during the growing season. Mowing has a beneficial effect by encouraging a denser ground cover of grasses and so reducing the risk of erosion. Generally speaking the cost of mowing is too high to be justified. Naturally a heavy swath must not be left on the ground because of its smothering effect.

Stocking rate. The chief factors which decide the stocking rate or carrying capacity of an area are rainfall, amount of bush and soil type. Because of the great differences in these factors in various areas and even from farm to farm, it is impossible to make firm recommendations on the stocking rate. Quite obviously carrying capacity will be highest where there is little bush, high rainfall and fertile soil. Each farmer must try to judge the state of his own grassland and to rest it or graze it according to its need. Grassland management is really the result of the farmer balancing the needs of his cattle against the needs of the pasture. Where the needs of the cattle cannot be met, without spoiling the grassland due to heavy grazing, then the land is overstocked and some cattle must be sold. If this is not done on the heavy soils of the high rainfall areas, then the palatable and nutritious grasses are killed out and worthless grasses (e.g. Sporobolus) take their place. Eventually this reduces the stock carrying capacity of the grazing.

In contrast, on the granite sand soils where rainfall is high grazing is much more productive. Provided it has been properly cleared of tree roots so that growth of saplings is no problem, it can be heavily grazed without suffering from serious invasion by worthless annual and perennial grasses.

In high rainfall areas (35 inches) where the bush has been cleared and the soil is fertile, grassland can carry a cow to 3-5 acres. In similar areas where rainfall is about 25 inches from six to eight acres is required. In less favourable conditions ten to 20 acres or more of natural pasture may be required for each animal.

Grazing management. An outline has been given of the factors which affect grassland productivity and the need for each farmer to exercise his own judgement on stocking rate. It follows, therefore, that slavish adherence to rigid systems of management have little value while the application of the principles of grassland management are all important.

A simple system which can be used over much of Southern Africa is to divide an area into four paddocks and the cattle into three herds. Three paddocks are grazed each season while the fourth is rested. At the end of the resting year the paddock is burned about a month before the rains are due and restocked no earlier than December.

Where trees and bushes are sparse, and the grassland will stand up to heavy burning, greater use can be made of it. The interval between burns may be lengthened to a five paddock system with four herds. On less productive grazing, where trees and bushes are relatively dense and the grasses need to be lightly grazed, a three paddock and two herd system may be used.

4.4 MARSHY AREAS

These are sometimes called vleis or dambos and are formed when water seeps into low-lying parts of the land. In summer such areas are too wet to carry cattle but can provide valuable grazing in winter except where the area is liable to frost. Perhaps the greatest value of a vlei or dambo is the early grazing provided from August onwards—the time when cattle are beginning to show the effects of poor winter grazing.

Marshy areas can be improved by drains which reduce continual water logging in summer and encourage palatable grasses at the expense of weeds. The drains are best made of tiles sunk below the ground although surface trenches reduce surface water. Marshy areas are of such great value that no improvement plans should be considered before technical advice has been taken. Usually the drains are closed up just before the main rains are over to ensure the area stays moist in winter.

Usually wet areas need more frequent burning than other grazing in order to keep them productive. They must be treated separately from the rest of the paddock. Burning should not take place before the end of August until the danger of frost is past. If burnt at this time the marsh grasses are encouraged to grow and provide useful grazing from September to November.

In some of the heavy soil areas palatable and nutritious grasses are found in marshy areas but this is not normally the same on sandy soils. Here the grasses may be harsh and unpalatable and it can be worthwhile to plant improved grasses. For this purpose Panicum repens, Common Paspalum, Nile Grass and Tanner Grass seem to have special merit. All but Common Paspalum are planted from runners which is established from seed. Ideally the land to be planted must be dressed with 300 to 400 lb. of superphosphate an acre before planting. Nitrogen fertiliser is not normally required until the grass is well established. Nile and Tanner Grass have to be either ploughed or disced every few years to keep them vigorous.

4.5 PLANTED PASTURES

Arable land loses its fertility as a result of continuous cropping and this loss is particularly rapid in sandy soils. The traditional method for restoring fertility was to allow the land to return to grass simply by leaving it uncultivated. Ten years or more is required to restore fertility in this way. The system is satisfactory so long as there is a great deal of land and a small number of people who can move to new areas as need be. Today there are too

TABLE 3

Common Grasses for Planting in Central Africa

Name	*Planting*	*General Information*
GIANT RHODES (Chloris gayana var.)	6-10 lb. seed/acre 18-30 in. rows.	Red soils are best in warm areas with 28″ or more rainfall. Very susceptible to frost. Spreads rapidly by surface runners. Probably the best hay grass. In normal season with suitable management gives cut for ensilage in mid-January and for hay in April or May. Continuous heavy grazing reduces vigour and weeds take over.
SABI PANICUM (P. maximum var. Sabi)	8-12 lb. seed/acre 6-12 in. rows.	A promising grass on granite sands in warm areas where rainfall is over 35″. Must be cut or grazed before mid-January and allowed to grow out for winter grazing. Will not stand up to continuous heavy grazing. Very palatable and gives high yields. High mineral content.
KATAMBORA RHODES (Chloris gayana)	5-8 lb. seed/acre 18-30 in. rows.	Needs fertile soil with over 25″ rainfall in warm areas. Spreads rapidly by surface runners. Produces less bulk than Giant Rhodes and is less readily eaten by cattle.
STAR GRASS (Cynodon plectostachyus)	Runners 36 x 36 in. apart.	Generally useful in Central Africa in 20-30″ rainfall areas, but of particular value on granite sands for grazing and for forage. Runners cover ground very rapidly. Late to start growing after rains but remains green well into growing season. Useful on edge of vleis. Fairly rich in minerals.
COMMON PASPALUM (Paspalum dilatatum)	40 lb. seed/acre broadcast.	Suitable for moist belts in high, wet regions and vlei margins in high rainfall areas. Nutritious and palatable and very high yielding. Withstands heavy grazing. Combines with clovers and lucerne. Must be kept short or it becomes coarse and unpalatable.
KIKUYU (Pennisetum clandestinum Hochst)	Runners 18 x 36 in. rows.	Only suited to fertile soils in 35″ or more rainfall area, i.e. moderately humid subtropics. A nutritious and palatable grass mainly used for permanent pastures which must withstand close grazing and trampling. Suitable to grow with clover if soil lime and phosphorus adequate. Useful in moist vleis. Very vigorous and needs annual discing or becomes rank and unpalatable. Needs a great deal of organic matter, i.e. kraal manure, mealie cobs, etc. It is worthwhile to use Kikuyu pasture as the place where cattle are fed hay and silage in winter—it benefits from what is left by way of food and droppings.
LOVE GRASS (Eragrostis curvula)	2 lb. seed/acre broadcast.	Probably most commonly used grass for leys on sandveld. Responds well to fertilizer and when kept short by intensive use, provides valuable summer grazing.

many people in Central Africa to allow shifting cultivation to be practised. Other agricultural systems are needed to maintain the fertility of arable soils. A successful system followed in temperate zones is to grow different crops on the same area of land in a planned sequence or rotation. A mixture of grasses and legumes grown together (called a "ley") forms one of these crops. Given suitable plants, together with appropriate management and fertiliser treatment, a ley rapidly restores fertility to arable land. At the same time it provides high yields of nutritious cattle food either as grazing or as silage and hay for winter feeding.

A great deal of effort has been made in Central Africa to try to develop leys suited to our soils and climate. Not only are they necessary to maintain and to improve the fertility of the soil but also because the productivity of natural grassland is too low for dairy cows in many areas. While some promising species of grasses and legumes are being developed for granite sand soils, completely satisfactory species are not yet generally available to farmers in other areas. For this reason only a few grasses can be used for leys at the present time.

Planted pastures, if fed with fertiliser, have the advantage of making a great deal of growth compared with natural pastures. In contrast practical experience shows that it is rarely worthwhile to fertilise natural grassland. In many parts of Central Africa, unfortunately, climate makes the growth of both planted pasture and natural grassland similar, i.e. a few weeks of high nutritive value after which the grasses rush to maturity, become fibrous or woody and consequently low in feeding value. Frequent and close grazing of grasses helps to keep them young and leafy, and thus nutritious. But it also reduces the vigour of the grasses because they have no chance to store in their roots the food they need for growth. This results in poor production from the ley in the following season. Experience has shown that although fertilised pasture can produce a large amount of cattle food to the acre it has the same feeding value as well managed natural grazing. Nevertheless the fertilised ley is a practical way in which a farmer can increase the stock carrying capacity of his farm.

Space does not permit a full description of the grasses commonly used for pastures in Central Africa. Information on some of the commonly used species is presented in Table 3. The remarks apply when pasture has been established successfully, receives fertiliser and is well managed. Without such practices there is no point in trying to establish a pasture because productivity will be less than that of natural grassland.

Establishment. Grass seed is usually broadcast on a fairly fine, firm seed bed into which nitrogen and phosphate fertilisers have been mixed. The soil should be moist and sowing should take place when these conditions can be expected to last for a few days. After planting the land should be lightly harrowed to cover the seed. Branches of thornbush do this well if dragged over the soil several times in different directions. Pastures established at the end of the rains should not be grazed or cut for hay or ensiling until the next rainy season. Once established, however, the pasture can be fully used but it must be rested from February to June to allow the grasses to recover or they will lose vigour. Planted pastures need to be fed regularly with fertilisers to grow successfully. On red soils in the high rainfall highlands, it may pay farmers to use their fertiliser and kraal manure on the maize crop. In this way a greater yield of nutritious cattle food can be grown to the acre.

4.6 THE FEEDING VALUE OF GRASSLANDS

Many different kinds of grasses may make up natural grassland and these usually have different feeding values for cattle. Some are readily eaten while others are eaten as a last resort. These are well known to the farmers who take the trouble to study what their cows like to eat. While species are important in deciding the productivity of grassland, farmers usually value it according to the number of acres needed to feed a cow for a year. As we have seen this varies a great deal. The greater number of acres needed to feed a cow the less suitable it is for dairying because the dairy cow cannot produce well if she has to spend a lot of time and energy seeking food. Another way to measure production is to state the yield of digestible nutrients (T.D.N.) in pounds which can be taken from an acre each year. This method is very useful because it allows us to judge the yield of arable crops as well as grass.

Climate and soil have an important effect on the feeding value of grassland apart from the species of grasses it contains. Firstly, rainfall determines the length of time a grass can grow while the natural fertility of the soil determines its yield in bulk. Thus these factors largely determine the weight of dry matter produced from each acre. Secondly, air temperature, together with rainfall and soil, decides the rate at which plants grow and this is important in deciding the nutritive value or quality of the grasses. When grass begins to grow after the onset of summer rains in Central Africa it is relatively rich in protein and the best grassland can supply a milking cow with enough food to produce about three gallons of milk a day. But the combination of moist soil and high air temperature causes grass to grow rapidly from youth to maturity. As grasses grow tall they need strong, woody fibres to support the stem and the plant becomes composed of more stem than leaf. This is unfortunate because the leaf has a much greater feeding value than the stem. Consequently young leafy grass is a valuable food with a high protein, low fibre content which changes as the grass grows. Thus grass is a relatively productive food for dairy cows for a fairly short time (about six weeks); then it loses much of its nutritive value over the next six weeks after which it provides enough nutrients to maintain body weight for a few more weeks. Throughout the winter grass provides insufficient food for the maintenance of body weight. The changes in composition of natural grassland are shown in Table 4. Values for planted pastures are only slightly higher than these. While the amount of crude protein decreases it is accompanied by a much greater decrease in digestible protein. In fact from early April grass contains almost no digestible protein.

The information presented in Table 4 consists of average figures from three representative areas of Central Africa, i.e. Mount Makulu, Matopos and Mazoe. In practice the dairy cow will select for herself the best diet available.

TABLE 4

Seasonal changes in the feeding value of veld grasses in relation to milk production

Time of Year	*Crude Protein* %	*T.D.N.* %	*Digestible Protein* %	*Possible yield from cow eating 30 lb. D.M. of this diet*	
				D.P. for	T.D.N. for
Mid November to Mid January	9·0	57·0	4·7	2 gall.	3 gall.
Mid January to End of February	7·6	48·0	3·1	1 gall.	2 gall.
March	5·3	45·0	0·75	0	1 gall.
April	3·5	45·0	very little	0	1 gall.

The nutritive value of the diet might well enable her to produce up to 25 per cent more milk than the possible yield shown in Table 4. There is a great deal of local variation in what is likely to take place. For example mention has been made of productivity on sandy soil derived from granite in the high rainfall, highland regions. The Grasslands Research Station at Marandellas is situated in such an area and it is here that new species of grasses and legumes are being developed. At this site grazing is said to supply the dairy cow with enough food to produce three gallons a day to the end of January and two to 2½ gallons until the end of March. Farmers have to assess the productivity of their pastures from experience. There is a tendency for the feeding value of grass to be over estimated more often than otherwise. Careful examination of milk yields in many herds in Central Africa shows that there is a fall in herd yield in mid-January every year where grass is expected to supply part or all of a cow's food. This fall in milk yield can be prevented only by beginning to feed extra food in the middle of January and that a full winter diet should be offered by the end of March. It is the custom to begin full winter feeding on 1st May in many herds rather than according to the feeding value of the grass available. If herd milk yield is allowed to decline it is difficult to stop the process effectively later in the season. The result is short lactations and low milk yield. Both factors reduce the profitability of dairy farming. Winter feeding will be considered in detail in Chapter 6.

5.0 Crops for Winter Feeding

5.1 INTRODUCTION

The climate of Central Africa prevents grass from providing enough nutritious food for the milking cow for more than a few weeks of the year. To feed a productive cow in the dry season crops must be planted in summer which can be conserved or saved for feeding in winter. Briefly, these are hays, succulents (silage and pumpkins) and grains. A brief description is given of crops which are commonly grown in Central Africa. Details of the cultivation of these crops and many others may be had from one of the texts suggested as further reading in the book list.

5.2 GRASS HAYS

It must be clear already from Section 4.7 that the earlier grass is cut for hay the higher its feeding or nutritive value will be. Unfortunately grass is at its best when between six to 18 inches high. If cut for hay at this stage it is difficult to pick up and the yield an acre is usually too small for the effort involved. To secure good yield and quality, hay-making should take place when the grasses are at the early-flower stage, i.e. the seed heads are formed and the flowers are beginning to open. In Central Africa this occurs towards the end of January when rain can be expected on most days. Not only does rain wash out some of the nutrients in the hay but the moist conditions it brings encourages rotting and moulding. Thus hay often has to be made in April or May from grass which is mature. It contains little or no protein and is coarse and fibrous. This is not a suitable food for dairy cows.

The problem can be overcome to some extent if the area intended for hay is first grazed until mid-January and left to grow again until April or May when it can be mown. In this way hay of fair quality can be produced in late season when the chance of rain falling is small. As an alternative to grazing, the area can be closed from the beginning of the rains and cut for ensilage in mid-January.

The feeding value of hay is lower than that of the grass from which it is made. While cut grass is drying out it continues to breathe and so uses up some of the plant carbohydrates as energy to do this. Again, as the leaves dry they become brittle and break off easily when handled. Rain washes out carbohydrates, proteins and minerals while the sun destroys much of the carotene. Finally, if hay is stacked before it has dried out properly or if it is wet from rain, the stack will become hot and the digestibility of the hay will be reduced. These losses in feeding value may be as much as one-third if the hay is badly made but usually amount to one-fifth of the original nutrients present.

Yields of veld hay vary considerably but on average will be about 700 lb. an acre on sand-veld and 1,000 lb. on red soils in the 30 inch rainfall areas. Yield declines with rainfall and may be as low as 300 lb. in some areas which receive less than 20 inches rain in a year. The yields of planted pastures are usually higher because they are often established on arable land and fed with fertiliser. For example Star grass on fertile soil can yield from four to 5½ tons an acre of hay or one to 2½ tons on infertile soil according to the amount of nitrogen used. From 0 to 180 lb. of nitrogenous fertiliser was put on the land in the examples given.

5.3 LEGUME HAYS

Compared with grasses the legumes are rich in protein, minerals and vitamins and for this reason they are valuable foods for dairy cows. In making them into hay the same problems are met as described for grasses. Hays can be made from delichos and velvet bean vines, cowpea, sunnhemp, soyabean and dahl which are the common legumes of Central Africa. They should be cut for hay when they have most leaf, i.e. when about one-third of the crop is in flower. Greater care is needed to make legumes into hay compared with grasses because legume leaves are very thin and break off easily. Legume hays are worth the extra trouble required to preserve their high feeding value. It is probably better to make a small quantity of high quality hay from a small area than a lot of poor hay from a large acreage. This can be done if the legume is cut and allowed to dry for one or two days according to the weather. It may then be put into small heaps or arranged on simple racks or poles. Hay which has been lightly stacked in this way continues to dry satisfactorily and is protected from spoilage by the weather. Once dry the hay can be carted away—preferably in the first few hours of the day while the leaves are still damp with dew. While damp the leaves do not break so easily and few are lost. Legumes which grow upright, e.g. sunnhemp and soyabean, can be tied in bundles and several of these stood up together. The crop thus dries out gradually and leaf loss is reduced. With all legumes it is important to make sure that the stems are dry before the crop is stacked otherwise heating and rotting take place. Heavy yields of legume hay are not common in Central Africa and vary from ½ to 1½ tons to the acre in average conditions. Much interest has developed in special hay strains of the soyabean and some of these show promise for local conditions.

5.4 ENSILAGE

This is the process by which green forage crops are preserved in a succulent condition for feeding to cattle in winter. The preservation is carried out in a container known as a silo and silage is the name given to the product when it is ready for use. When forage is packed into the silo bacteria and air go with it. Both bacteria and forage use air for breathing and as a result the temperature of the mass rises. The more air trapped with the forage the higher the rise in temperature. The bacteria feed on some of the plant sugars and in doing so produce mild acids. Eventually, so much acid is produced that the bacteria can work no longer. In fact no micro-organism can work in an acid environment. Consequently it is the acid which preserves the silage and it will continue to do so provided that neither air nor water enter it. It is important to understand these principles because if they are not applied the crop will be spoiled.

The quality of the silage depends mainly on the kind of forage put into the silo but also on the kind of fermentation which takes place. Mature forage is dry and stemmy and traps a great deal of air when packed. This results in excessive heat which "burns up" the most nutritious parts of the forage and causes the silage to become dark brown in colour and sweet to the taste. It is of low feeding value and may become mouldy. On the other hand if young sappy forage is tightly packed into the silo it will trap little air and insufficient heating will take place. In such conditions an evil-smelling and unpalatable silage which tends to rot is produced. Between these two extremes a moderate rise in temperature can be encouraged (about 120°F. or 49°C.). This produces

a silage with a yellow-brown colour, sharp acid taste and smell and which is highly palatable. It is also very similar in feeding value to that of the crop as it was ensiled. A general discussion of maize silage making follows.

The kind and size of silo. Various kinds of silo are in use throughout the world but each farmer must decide for himself which suits his purpose, and his pocket, best. Towers are popular in North America and parts of Europe but these are expensive to build and need to be filled by mechanical equipment. Bunkers are also popular, particularly in the United Kingdom because grass can be dumped in from trailers and because cattle can be allowed to "self feed" from the ends. In Central Africa trenches and pits are most popular because of the ease with which they can be excavated, filled and emptied. Silage can be made in a stack but waste of the forage is high and consequently stacks are not recommended.

The dimensions of a silo will depend on the amount of silage a farmer intends to feed each day and on the amount needed for the season. Too much silage must not be exposed to the air otherwise its feeding value declines. This can be avoided if at least two inches is removed from the working surface of the silage each day. Therefore the end section of the pit or trench (i.e. what will be the working surface) must be related to daily feeding requirements. Tables 5 and 6 show the relationship between the amount of silage in a two inch layer and the size of the end section or working surface of pits and trenches respectively.

TABLE 5

The approximate weight of layers of silage in relation to the end sections of pit silos

End Section (Diameter) of pit	*Weight of Silage for each foot of depth*	*Weight of Silage in a 2" layer*
ft.	lb.	lb.
5	800	130
6	1,100	200
8	2,000	300
10	3,100	500
12	4,500	750

The Tables have been constructed on the assumption that a cubic foot of silage weighs 40 lb. Consideration of the Tables shows that the farmer who feeds 150 lb. silage a day (say five cows) should dig a pit which has a diameter of five feet. If he intends to feed for 200 days then 30,000 lb. of silage is needed and the pit would have to be about 36 feet deep. Obviously the farmer would dig three pits which were 12 feet deep. At the other extreme a farmer who feeds 50 cows a ration of 60 lb. silage for 200 days needs 600,000 lb. silage. He might choose a 21 ft. x 9 ft. trench silo and this would have to be 80 feet long. Again it might be preferable to have two or three silos instead of one large one.

TABLE 6

The approximate weight of layers of silage in relation to the end section of trench silos

End Section (Width and Breadth)	*Weight of Silage for each foot of length*	*Weight of Silage in 2" slice*
ft.	lb.	lb.
9 x 5	1,800	300
12 x 6	2,800	400
15 x 7	4,200	700
18 x 8	5,700	900
21 x 9	7,500	1,200

Drainage. Silage must not become waterlogged otherwise it becomes unfit to feed to cattle. A well-drained site should be chosen which is not likely to be waterlogged in summer. Otherwise late rains may fill pits and trenches and in these circumstances silos are not available for use when the crop is ready to cut. Any slight crest or rise in the ground can be chosen as a silo site because this will reduce the chances of waterlogging. A trench dug into the

side of a hill forms an ideal site. This should be provided with a drainage channel down one side and the floor of the trench sloped towards it.

Filling the silo. Grasses and legumes are ready to be ensiled when they begin to flower and maize is ready when the grain is just "doughy". Cutting at these states gives a reasonable balance between nutritive value and weight of nutrients from the acre. Clearly if plants are cut when they are young they will have a higher feeding value than plants cut at the early flower stage, but less bulk will be cut from each acre.

On many farms there are not the resources of men and machines to cut all the silage crop at exactly the right stage of growth. Each farmer must decide for himself how much time it will take to harvest his crop. He may decide to spread the time by means of two sowings six weeks apart. Even so he may be well advised to begin cutting about 10 days early so that most of the crop is ensiled near the right stage.

When the first cutting of the crop is made only one end of a trench silo should be filled. Cutting might well occupy, say, a Friday and Saturday morning. The forage should then be left in the silo until it has heated to about 120°F. (49°C.). The temperature of the silage can be measured by a thermometer or judged by pushing the hand to a depth of three feet. The correct heat is just as much as the hand can bear comfortably. If the temperature rises too quickly then the forage needs more consolidation. i.e. pressure by trampling or tractors, and filling should be continued and carried out as

fast as possible. If heating is slow, then once it does rise sufficiently, filling should be continued but less consolidation given.

Too rapid a rise in temperature may be due to the difficulty of giving enough consolidation to a mature crop. Chopping into short lengths helps consolidation but when a crop such as maize has become too dry, water must be sprinkled over the forage to help consolidation to take place. At the opposite extreme if the forage is very young and juicy and will not heat up sufficiently, it will have to be wilted on the land. Cutting in the morning and loading in the afternoon should be all that is required. Experience shows that five or six feet should be added to the mass each day and, with sufficient trampling, this ensures that the correct temperature is maintained. When maize is chopped into small lengths by machine there is little need for trampling although a man must be set the task of spreading the forage. In this way loose patches can be attended to and evenness in filling can be controlled. Care must be taken that forage at the sides of the silo is as well compacted as that in the centre otherwise air pockets form and a considerable amount of waste takes place. Allowance must be made for ensiled forage to settle. When the silo has been filled to more than capacity it should be consolidated a few times a day for two or three days. The silage will settle to about two-thirds of its original height. The silo should then be filled again and consolidated.

Covering silage. A soon as silage making is over the forage should be covered with a thick layer of coarse grass or other unwanted plants. Then a six inch or more layer of earth is needed to help seal the silage from the air. Silage is usually ready six weeks after sealing the pit, and, if properly made and covered, will keep for several years.

The feeding value of silage. Feeding values for the various kinds of silage are listed at the back of the book. It can be calculted that for body maintenance a cow must eat up to 6 lb. for each 100 lb. liveweight when grass or maize silage is of average quality. If the silage is above average quality then 5 lb. will do and a cow weighing 1,000 lb. would require 50 lb. of silage each day.

5.5 PUMPKINS AND MELONS

These succulent foods are greatly relished by cattle particularly in the hot weeks before the advent of the summer rains. Although their feeding value is low due to their high water content many farmers believe they have a beneficial tonic effect on cattle. Consequently, when they are added to winter diets mainly composed of dry roughages, a small rise in milk yield often occurs. This may be due to their effect of loosening the bowels which speeds the passage of food through the stomach and so permits the animal to eat more food.

Pumpkins and melons should certainly be grown where silage cannot be made for winter feeding. Pumpkins are suited to fertile soils in the high rainfall areas and on average yield nine tons to the acre. Melons do well in the lower rainfall areas and need less fertile soil than pumpkins. Between 15 and 20 tons of melons can be grown to the acre. The feeding value of melons is about half that of pumpkins and both are poor sources of minerals.

About 15 wagon loads of kraal manure to the acre should be ploughed into the soil before planting. Then small heaps of manure should be placed over land at 12 feet spacings each way and either dug or disced in. Four seeds can then be planted at the site of each heap as soon as the soil is moist. Alternatively these crops can be grown in with maize by planting after the first hoeing. They can be planted at 12 x 12 ft. spacings or every tenth row of maize omitted at planting and a row of pumpkins or melons sown in place. The fruit fly causes serious damage to pumpkins and melons in most areas. These may be controlled by spraying with a modern insect killer, e.g. malathion or a bait can be prepared which will poison the fly. A common bait can be made by mixing 2 oz. sodium flurosilicate with 3 lb. sugar and 4 galls. of water. The bait should be sprayed finely on the leaves from about three weeks before the first fruit ripens and thereafter each week (and after each rain). Both crops may be harvested when the vines are dry—the vines being cut off about 2 in. from the fruits. A cool and airy place must be chosen for storage where the fruits can be stacked.

5.6 MAIZE

The basis of any successful dairy industry is an abundant source of cheap food. In some other parts of the world the climate is ideal for the growth of grass but we have seen this is not true here. In the high rainfall areas of Central Africa (30 in. and over) the climate is ideal for maize growing and average yield of grain is higher than anywhere else in the world. Also, maize grown for silage outyields all other crops in dry matter and digestible nutrients produced to the acre. Although both maize grain and maize silage are low in protein content this is made up for by the abundance and quality of the total digestible nutrients the crop yields. For these reasons the maize crop must provide most of the food of dairy cattle in Central Africa and is worthy of special attention.

Maize can be used in several ways—as green forage, for ensilage or the grain can be ground and fed as meal. It is not customary to feed green maize in the summer so consideration of this food will be given later along with other crops of irrigated lands. Maize silage has been described already. It remains to outline the uses of maize grain and the stalks which remain after harvest, and which are generally referred to as maize "stover".

Maize is noteworthy because the grain is richer in T.D.N. than nearly all of the other cereal grains. It has a low fibre content, is easily digested by cattle and farm animals find it to be most palatable. While roughages such as hay and silage are important parts of the diet, it is unlikely that dairy cows can be profitable producers unless they are offered grains. Maize, unfortunately, is low in protein content so it should be fed together with either legume hay or green forage which are fairly rich in protein. Maize grain should be ground medium-fine ($\frac{1}{8}$ in. screen) otherwise between 20 and 35 per cent passes through the animal undigested. Nowadays many farmers grind the complete cob as it is harvested from the plant, i.e. husk, grain and cob which has a lower feding value than maize meal but it is still a suitable concentrate for dairy cows.

Maize stover is a low quality roughage similar in feeding value to poor grass hay. However, when the maize crop is cut and dried in bundles to mature (i.e. stooks) before harvest, the feeding value of stover is slightly improved. It is common practice with dairy farmers to allow cattle to graze stover after the grain has been harvested. In spite of the low feeding value of stover the milk yield of the herd generally rises slightly, i.e. by 1 to 2 per cent. This is probably due to the fact that after harvest between one and two bags of maize grain are left on the ground and cattle quickly find it.

Maize bran is a by-product from the preparation of mealie meal. It is composed of the outer skin of the maize grain together with the hull and tip cap and thus has a high fibre content (15 per cent). It is also light and flaky and when mixed with powdery meals improves their physical state, i.e. reduces their tendency to become pasty when chewed. Maize bran can often be bought cheaply and in these circumstances is worth including in farm mixtures.

Few other cereal grains are available for feeding to cattle in Central Africa and, as their price is usually much greater than maize, are not worth using. The millets, munga and rapoko, are grown locally while barley and oats are imported. All are suitable grains for cattle feeding when available at a price comparable with maize. Most cereals have a slightly higher protein content than maize but contain less T.D.N.

5.7 OTHER SEEDS AND THEIR BY-PRODUCTS

The roughages, succulents and cereals which have been described are usually low in protein content. It is necessary, therefore, to balance the dairy cow's diet with a food which is rich in protein. Legume hays have been mentioned but in high rainfall areas they are rarely good enough to supply the amount of protein required. Many farmers think it is better to buy protein concentrates than to attempt to grow them. Such foods are usually by-products of the oil seeds industry. Groundnuts, cotton seed, soyabeans, linseed and sun flowers are some of the seeds from which oils are extracted. The oil in the seed is either squeezed out mechanically or the seeds are roughly ground and the oil dissolved out with special solvents. These two processes may be carried out in different ways and the seeds may or may not have the outer shell or husk removed so that the by-products have different feeding values. The farmer should rely on the protein content declared by the miller rather than on those in a table of feeding values. The residue left from the oil extraction is generally sold as a meal which is rich in protein if the husks of the seeds have been removed. Decorticated (no husks) groundnut meal contains 36-42 per cent of digestible protein, while the undecorticated (husks present) meal contains about 26 per cent D.P.

5.8 CROPS FROM IRRIGATED LANDS

Only brief mention can be made of those crops which are particularly valuable foods for dairy cattle. Unfortunately irrigation schemes require a great deal of capital and a high degree of skill to make them provide cheap cattle food.

The main purpose of irrigation on the dairy farm is to produce forage of high feeding value in winter. Some farmers have been successful in growing grass and clover pastures with beneficial effects on milk yield and health. However, the grazing cow tends to waste much of such pastures through trampling and fouling. It is more common to grow crops which can be cut and carried to the cows and so reduce waste.

Lucerne. Lucerne has a similar dry matter content to grass but it is richer in protein and mineral content. It is so palatable that cattle eat it greedily and this may cause their stomachs to swell with gas (bloat) causing death. The greatest danger from bloat occurs when the lucerne is young and is growing rapidly. It can be avoided if the forage is wilted before being fed. Uusually lucerne is safe if cut in the morning and fed in the afternoon.

Lucerne grows best on deep, fertile soils but much can be done to improve average land by heavy dressing of kraal manure, sub-soiling and liming. Like other legumes certain bacteria must be present in the soil for lucerne to grow vigorously. To ensure that the correct species of bacteria are present it is customary to buy a culture of these bacteria and to make up a solution for treatment of the lucerne seed at planting time. Similarly lucerne needs the element boron in the soil and this is usually broadcast by hand or spread with other fertilisers at the rate of 20 lb. of borax to the acre each year. Seed has to be planted thickly in Central Africa to ensure a dense cover which will choke weeds and smother unwanted grasses. This can be achieved by planting 20-30 lb. of seed to the acre by hand in 6 in. rows. On the average lucerne can be cut six or seven times each year and an acre will yield at each cut $\frac{3}{4}$ ton of hay or 3 tons of green forage if taken at the early flower stage. This is when about 1/10th of the crop is in flower. Double this yield is possible under favourable conditions of soil, climate and management.

Usually lucerne dislikes the wet conditions of December and January in high rainfall areas. Leaves become affected with various diseases so that growth is poor and no forage can be cut for two months or more. At this time grasses and other weeds become established easily. They grow so vigorously that they often reduce the useful life of a lucerne land to two or three years. Lucerne growth can be improved and therefore weed encroachment checked by top-dressing with a compound fertiliser at the beginning of the rains. At the University College farm a dressing which provides 80 lb. P and 60 lb. K is used. Practice must vary with inherent soil fertility, availability of kraal manure, kind of soil and so on.

Other green crops. In districts subject to heavy frost in June and July lucerne grows very slowly and some farmers sow an area of frost-hardy plants such as oats and barley to fill the lucerne shortage. They may be grown separately or together or with hairy vetch. The cereals grow in the cold weather and can be cut two or sometimes three times in the season. With warm weather in August cereals run to seed and produce little forage. Hairy vetch makes rapid growth as cereal growth slows down and two or three cuts can be taken before the main rains begin. Any surplus cereal or vetch should be carefully put on racks and made into hay because this is particularly suitable for very young calves.

Maize is a useful crop to plant after winter cereals on irrigated land. For the best results a thick plant population is desirable (over 40,000 to the acre), which ensures thin stalks which are readily eaten and not wasted by cattle. Unfortunately maize does not grow again after cutting nor will the crop thrive in areas subject to frost. For the latter reason irrigated maize is not planted before September.

6.0 Feeding the Dairy Cow

6.1 GENERAL CONSIDERATIONS

Food, and the way it is made up into a cow's ration, is a very important part of successful milk production. We know that each animal needs a certain amount of protein and energy in order to live and to produce. These nutrients must be combined with certain vitamins and minerals while the cow's stomach must have enough bulk to keep it working poperly. Milk yield will be very disappointing unless the cow is fed correctly according to the feeding standards and principles outlined in Chapter 3.

Some farmers doubt the practical value of feeding standards. They point out that many herds were correctly fed and milked well long before these standards came into general use. This is quite true, but it is also true to state that the feeding and production of many other herds left much to be desired. Where nutritious forages can be grown and are fed abundantly and cheaply there is probably little need to understand much about feeding standards. Unfortunately the climate of Central Africa limits the amount of good quality roughages which can be grown in abundance. In general the problem of feeding a dairy herd is to know how much of our average to low quality foods can be fed and to know when expensive, concentrated foods should be given. This can only be done through the use of feeding standards or by the application of "rule of thumb" methods. The latter are simple guides which are either based on practical experience or feeding standards or a combination of the two.

No attempt will be made to pretend that an ideal ration can be calculated from modern feeding standards and tables of nutritive value alone. In the first place the standards have been calculated for average cows under average conditions. In the second the farmer has to guess if his foods have similar feeding values to those shown in Table 19 page 142. This means that even after careful calculation he is left with a ration which is only nearly correct. Nevertheless the system is a very useful and important one because it brings us to the stage where skill in stockmanship begins to operate. In other words, having devised a ration that is nearly correct, the farmer uses his own skill to ensure his cows are properly fed. He feeds the ration and then watches the cows to see how they respond to it. The food should be readily eaten and the cows must do well on it. A ready appetite is easy to see and needs no further explanation. To "do well" not only means that a cow should milk well but also that she should look healthy. According to the herd's response to the ration so the skilful stockman will increase or decrease the amount of food he feeds. Thus feeding cattle successfully is based on theoretical and practical knowledge. Used together we can achieve the aim of high milk yield and healthy cattle.

6.2 APPETITE

There is a limit to the amount of food a cow's stomach can hold. This varies according to the nutritive value or quality of the food offered, the size of the animal and the milk yield. It is usual to describe appetite as the number of pounds of Dry Matter (D.M.) which can be eaten for each 100 lb. of liveweight. The range is from 1½ to over 4 lb. D.M. each day. These two figures apply respectively to a dry cow eating veld hay and to a cow producing five or more gallons of milk a day and eating a good quality ration. For example, if mature veld hay is offered the cow will eat 15 lb. D.M. a day or less. At the opposite extreme the high producer may eat 40 lb. D.M. of a diet of legume hay, high quality maize silage and mixtures of concentrates.

Quality is most simply measured by the concentration of energy (T.D.N.) in the dry matter of the food. For example, in a diet of veld hay the dry matter contains 50 per cent T.D.N. while a diet for a five gallon cow of legume hay, maize silage and concentrates contains over 75 per cent T.D.N. This mixed diet would contain about 16 lb. of concentrates which are more easily digested than roughages. A high concentration of T.D.N. in a food, therefore, usually means that it has a high digestibility. It must follow that if a cow has to eat a large amount of dry matter (D.M.) then any roughages provided in the diet must be of high digestibility and T.D.N. concentration.

The cow's appetite is also related to her body size and milk yield and, perhaps, to other factors which have yet to be described. Cows in milk that weigh from 800-1,200 lb. liveweight would eat from 20-30 lb. D.M. of average quality diets. On the other hand a dry cow of 1,200 lb. liveweight would eat about 26 lb. D.M. If the same cow were in milk and yielding 50 lb. a day she would probably eat up to 40 lb. D.M. It is not necessary to weigh each animal to decide liveweight—it is enough to assume that mature cows weigh close to the average of the breed and heifers about three-quarter of this.

The quality of home grown foods can be estimated with the aid of Table 19 after taking into account stage of cutting and losses while the crop was being conserved. For example, if hay was cut at the early flower stage but was spoilt either by rain or by heating in the stack or both, then its feeding value will be that of mature hay. For practical purposes roughages and succulents can be conveniently classified as "good", "average" and "poor" in nutritive value. The nutritive value depends on the stage of growth at which the plants were cut and also on the success with which they were conserved. In general "good" indicates that young plants were harvested while the losses in nutrients during conservation were small. "Poor" indicates that mature plants were harvested or that important losses of nutrients occurred in the conservation of young plants. "Average", of course, describes food where the nutritive value lies between these extremes and is representative of the nutritive value of a given food on most farms.

6.3 THE FEEDING VALUE OF SIMPLE DIETS

A few calculations must be made in order to learn something of the feeding value of different foods for dairy cows. Let us assume that we wish to find out how far veld hay can supply the nutritive requirements for maintenance (Section 3.7) of a dry cow which weighs 1,000 lb. liveweight. About 1½ lb. of D.M. from this kind of hay could be eaten for each 100 lb. of liveweight (Section 6.2). This animal could eat, therefore, about 15 lb. D.M. Hays in general contain 90 per cent D.M. so that 16-17 lb. veld hay could be eaten.

The nutritive value of the common feeding stuffs available in Central Africa have been listed in Table. 19. From these the nutritive value of mature grass hay is:—

D.M. 90% D.P. 1·0% T.D.N. 45%

In other words 100 lb. hay contains 90 lb. D.M., 1 lb. D.P., and 45 lb. T.D.N. The nutrients supplied by 17 lb. of this hay can be calculated as follows:—

	D.M.	D.P.	T.D.N.
	lb.	lb.	lb.
If 100 lb. hay contains	90·0	1·0	45·0
then 1 lb. hay contains	90·0÷100	1·0÷100	45·0÷100
	= 0·9	= 0·01	= 0·45
so 17 lb. hay contains	0·9 x 17	0·01 x 17	0·45 x 17
	= 15·3	= 0·17	= 7·65

The nutritive requirement for maintenance of a 1,000 lb. cow (Section 3.7) is:—

D.P. 0·6 lb. and T.D.N. 7.0 lb.

Although the diet of 17 lb. of hay supplies just enough T.D.N. there is a great shortage of D.P. This cow will lose weight, she may even have a difficult calving and will milk poorly afterwards.

The example of a cow which cannot satisfy its needs on a diet of mature hay shows very clearly that this low quality food is of little value on its own. Supposing that 7 lb. of the hay can be replaced by 30 lb. maize silage of average quality, then the nutritive value of the diet can be calculated in the same way as before.

From Table 19 average quality maize silage contains:—

D.M. 27% D.P. 1·0% T.D.N. 17%

	D.M. lb.	D.P. lb.	T.D.N. lb.
If 100 lb. silage contains	27·0	1·0	17·0
then 1 lb. silage contains	27·0÷100	1·0÷100	17·0÷100
	= 0·27	= 0·01	= 0·17
so 30 lb. silage contains	0·27 x 30	0·01 x 30	0·17 x 30
	= 8·1	= 0·3	= 5·1

The nutritive value of the diet will be:

	D.M. lb.	D.P. lb.	T.D.N. lb.
10 lb. grass hay (mature)	9·0	0·1	4·5
30 lb. maize silage (average)	8·1	0·3	5·1
	17·1	0·4	9·6

The diet is still far too low in digestible protein and indeed this is likely to be true of any diet which is made up of average to poor quality roughages in Central Africa. These diets have been chosen to show as clearly as possible that mature hay in particular and poor quality foods in general are not even good enough to maintain body weight in dairy cows. It is true that if the 1,000 lb. cow could be persuaded to eat 60-70 lb. of the silage her maintenance requirements for D.P. would be met but this would lead to unnecessary waste of T.D.N. Dairy farmers must use feeding stuffs as carefully as possible otherwise they will be unable to make a satisfactory profit out of milk.

The only way to use our rather poor quality roughages is to introduce a food which is relatively rich in protein. The most common food of this kind is legume hay and its usefulness, which was pointed out in Chapter 5, will be shown in the following diet:—

Diet 1

Maintenance for 1,000 lb. cow.

3 lb. legume hay (average)
30 lb. maize silage (average)
7 lb. grass hay (mature)

The nutritive value can be calculated in the same way as before.

	D.M. lb.	D.P. lb.	T.D.N. lb.
If 100 lb. legume hay contains	90·0	8·0	50·0
then 1 lb. legume hay contains	0·9	0·08	0·5
so 3 lb. legume hay contains	2·7	0·24	1·5

As 1 lb. maize silage contains	0·27	0·01	0·17
so 30 lb. maize silage contains	8·10	0·30	5·10
As 1 lb. grass hay contains	0·9	0·01	0·45
so 7 lb. grass hay contains	6·3	0·07	3·15

The nutritive value of the diet will be:—

	D.M. lb.	D.P. lb.	T.D.N. lb.
3 lb. legume hay (average)	2·7	0·24	1·50
30 lb. maize silage (average)	8·1	0·30	5·10
7 lb. grass hay (mature)	6·3	0·07	3·15
	17·1	0·61	9·75

This diet contains just enough D.P. and too much T.D.N. in theory but with the foods available it is satisfactory. When cows are fed poor to average quality roughages the energy in the diet is not utilised very well. The extra T.D.N., therefore, is an advantage in the circumstances. As the diets have been changed from hay alone to hay with silage and legume hay, the D.M. to be eaten has increased. The extra D.M. is well below the cow's ability to eat it. As the quality of the food increases so does the cow's appetite increase (Section 6.2). The D.M. of mature veld hay consists of 45 per cent T.D.N. while that of Diet 1 contains 56 per cent T.D.N.

The calculation of maintenance diets for cows of different sizes is the same as above. The nutritive needs of each size of animal will be different of course. For example an 800 lb. cow needs 0.5 lb. D.P. and 6.0 lb. T.D.N. for maintenance. If she is fed about 8/10ths of the quantities of food in Diet 1 her needs will be met.

Diet 2

Maintenance for 800 lb. cow.

	D.M. lb.	D.P. lb.	T.D.N. lb.
2½ lb. legume hay (average)	2·25	0·20	1·25
25 lb. maize silage (average)	6·75	0·25	4·25
5 lb. grass hay (mature)	4·50	0·05	2·25
	13·50	0·50	7·75

Similarly the needs of a 1,200 lb. cow should be met if she is given 12/10ths of Diet 1. She needs.—0.7 lb. D.P. and 8.0 lb. T.D.N. for maintenance.

Diet 3

Maintenance for 1,200 lb. cow.

	D.M.	D.P.	T.D.N.
	lb.	lb.	lb.
3½ lb. legume hay (average)	3·15	0·28	1·75
35 lb. maize silage (average)	9·45	0·35	5·95
8½ lb. grass hay (mature)	7·65	0·08	3·82
	20·25	0·71	11·52

6.4 DIETS FOR PRODUCTIVE COWS

In this chapter so far attention has been given to the way in which diets can be made up and to the way their feeding values can be calculated. Maintenance diets have been used to illustrate the main points. Although the idea of maintenance is useful in theory, such diets have little practical value because all dairy cattle should be producing something. Young cattle should make liveweight gain, dry cows should have a calf growing inside them and lactating cows should produce milk. Consequently the minimum diet needed is one which provides for maintenance (M) and the production of one (1) gallon of milk or one pound of liveweight gain. The quantity of nutrients which have to be supplied for these productive purposes are about the same. It is convenient to write "M + 1" as a short way to represent such diets.

Poor quality foods which have a low protein content are of little value on their own to productive animals. This is because the proportion of D.P. to T.D.N. is much higher for productive purposes than it is for maintenance of body weight. In fact, if only poor quality roughages are available on the farm then there is little hope of productivity in the dairy herd. Purchased concentrates can help to remedy this situation but they are usually expensive. Consequently, if milk and milk products are to be produced economically in Central Africa, then farmers must provide "M + 1" from roughages.

Feeding by rule of thumb. A simple guide to cattle feeding enables the farmer to decide the amount of food each animal needs according to its size and productivity. It is important to have a guide of some kind because the dairy farmer must look after growing calves and heifers as well as milking and dry cows. A simple guide or "rule of thumb" also provides a basis for estimating the area of the various foods to be planted. Again, when the crops have been harvested and the farmer knows how much he has on hand, he can easily work out how to ration the food so that it will not be eaten before the winter ends. If there is insufficient food he will have to decide whether to buy extra or whether to reduce the number of cows he keeps.

A useful rule of thumb to use in making an "M + 1" ration from average quality legume hay and maize silage is to allow each cow of whatever size 9 lb. of legume hay daily. Maize silage at 5 lb. to each 100 lb. of liveweight will make up the rest of the diet. The rule can be checked if we consider the needs of an 800 lb. cow that gives one gallon of milk a day. The milk of small breeds usually contains 5.0 per cent butterfat. From Chapter 3 the nutritive requirements are as follows:—

		D.P. lb.	T.D.N. lb.
M.	800 lb. cow (maintenance)	0·5	6·0
P.	1 gallon milk (5·0% B.F.)	0·61	3·7
		1·11	9·7

Diet 4

800 lb. cow M + 1 (5·0% B.F.)

	D.M. lb.	D.P. lb.	T.D.N. lb.
9 lb. legume hay (average)	8·1	0·72	4·50
40 lb. maize silage (average)	10·80	0·40	6·80
	18·9	1·12	11·30

A further check on the rule of thumb can be made by considering the needs of a 1,200 lb. cow giving 1 gallon of milk a day at 3.5 per cent butter fat. The nutritive requirements (Chapter 3) are:—

		D.P. lb.	T.D.N. lb.
M.	1,200 lb. cow (maintenance)	0·70	8·0
P.	1 gallon milk (3·5% B.F.)	0·51	3·0
		1·21	11·0

Diet 5

1,200 cow M + 1 (3·5% B.F.)

	D.M. lb.	D.P. lb.	T.D.N. lb.
9 lb. legume hay	8·10	0·72	4·50
60 lb. maize silage	16·20	0·60	10·20
	24·30	1·32	14·70

These diets meet the requirements of the two cows so the rule of thumb is correct. Both diets contain less D.M. than the animals can eat. Provided they have access either to grazing or to poor quality hay it is not necessary to provide for D.M. exactly.

The purpose of calculating D.M. in a diet is to make sure that it is not *mcre* than the stomach can hold. D.P. and T.D.N. are calculated to make sure that the cow does not receive *less* nutrients than she needs. In practice we are not concerned with the very small amounts of nutrients indicated by the second place of decimals. These have been calculated exactly for readers who wish to check the calculations made. Normally it is sufficient to correct to the first place of decimals provided this benefits the cow. For example, the 1,200 cow needs 1.15 or D.P. for "M + 1". To correct this it is sufficient to decide that 1.2 lb. D.P. will do. This correction is to the cow's benefit in that she is given slightly more than her requirements of D.P.

6.5 SIMPLE DIETS WITH VARIOUS FOODS

Legume hays are not grown on all dairy farms and in medium rainfall areas maize silage does not usually yield enough D.M. an acre to provide cheap food. The diets which follow show the use of other foraegs in combinations suitable for production. The examples are for cows that weigh 800 lb. and 1,200 lb. liveweight which are the weights of mature cows of the two main dairy breeds. Diets for cows of different sizes can be worked out in the way described already.

800 *lb. liveweight:* M + 1 (5.0% *B.F.*)

Diet 6

25 lb. green lucerne (early flower)
7½ lb. grass hay (average)
20 lb. maize silage (average)

1,200 *lb. liveweight:* M + 1 (3.5% *B.F.*)

Diet 7

7 lb. legume hay (average)
40 lb. pumpkins
10 lb. grass hay (average)

Diet 8
12 lb. legume hay (average)
30 lb. sorghum silage

Diet 9
50 lb. sunnhemp silage
10 lb. grass hay (average)

Diet 10
25 lb. green lucerne (early flower)
10 lb. grass hay (average)
30 lb. maize silage (average)

Diet 11
5 lb. legume hay (average)
50 lb. pumpkins
15 lb. grass hay (average)

Diet 12
12 lb. legume hay (average)
40 lb. sorghum silage

Diet 13
60 lb. sunnhemp silage
10 lb. grass hay (average)

These examples show that "M + 1" diets can be provided from farm crops. Indeed it is of great importance that every farmer should plan for a gallon of milk to be produced from each cow each day from farm roughages. If a farmer is unable to grow food for dairy cows cheaply and abundantly it is doubtful if he should continue to try to make a living out of dairying.

6.6 THE USE OF ROUGHAGES FOR MAINTENANCE

In the high rainfall areas some farmers do not think it is worth while to grow legume hay. Apart from the uncertainty of making hay of high quality due to weather, the yield of T.D.N. from an acre of land is low. When 10 tons of maize for silage is harvested from an acre of land about 3,400 lb. T.D.N. will be ensiled. A legume crop would have to yield about 3½ tons of hay to the acre to produce as much T.D.N. as this. Such yields are uncommon—½ to 1½ tons to the acre being the yields expected under farm conditions. In these circumstances many farmers prefer not to grow legumes and put all available fertiliser or kraal manure or both on the maize lands. Maize silage and grass hay then have to be used to provide a body maintenance diet which, in general, will be too low in protein content. The shortage is usually made good by feeding a mixture of concentrates which is rich in protein (15-16 per cent) at the rate of 4 or 5 lb. for every gallon. An example of such a diet is given below.

Diet 14

800 lb. cow, maintenance.

	D.M. lb.	D.P. lb.	T.D.N. lb.
10 lb. grass hay (poor)	9·00	0·10	4·0
30 lb. maize silage (poor)	7·50	0·24	4·50
	16·50	0·34	8·5

Add			
5 lb. concentrates (15-16% D.P.)	4·5	0·77	3·5
	21·0	1·11	12·0

Diet 14, without concentrates, is too low in D.P. When 5 lb. concentrates are added to the grass and silage the diet becomes sufficient for body maintenance and a gallon of milk. The protein in grass hay makes a small contribution to the diet. In practice poor quality hay should not be rationed but made freely available so that cows may help themselves to its most palatable and nutritious parts.

6.7 MIXTURES OF CONCENTRATED FOODS

Cereal grains and legume seeds are called "concentrates" because most of their weight is composed of digestible nutrients. For example, maize grains contain 80 per cent of T.D.N. whereas poor grass hay contains only 40 per cent. This can be explained in another and very important way. To supply T.D.N. from maize means that a cow has to eat exactly half of the D.M. that would be eaten were she to eat hay. It also implies, in a general way, that a cow can produce much more milk from concentrates than she can from roughages. Indeed, the higher the yield of milk the more concentrates the cow must eat.

Balanced concentrates. A cow needs a certain amount of nutrients in order to produce a gallon of milk. Any mixture of meals which can supply these needs is usually called a "balanced" concentrate. Such mixtures have to be fed in amounts which depend on the fat contents of the milk given by the cow. The rate is 4 lb. to the gallon of milk containing 3.5 per cent of butterfat and 5 lb. a gallon for milk containing 5 per cent butterfat. Where farm roughages of poor to average quality are grown, concentrates should contain 15 to 16 per cent D.P. Experience in Central Africa shows that farm roughages usually contain little protein. Thus it is customary to mix concentrates with a content of 15 to 16 per cent D.P. A few examples are given in Table 7 of mixtures based largely on maize meal and purchased oil cake meals. Other mixtures containing 12-13 per cent D.P. are shown in Table 8 for farmers who have good quality roughage available. Some farmers prefer to buy a protein rich meal which is ready to mix with their own maize. Most stock-feed manufacturers will sell these meals which may be mixed with equal parts of maize or twice the quantity of maize according to recommendation. Other farmers prefer to buy a proprietary meal or cube and many excellent concentrates of this kind are on the market.

Meal mixtures ought to be palatable and this is usually true of those which contain a high proportion of maize. Some farmers believe that a mixture which contains a variety of different meals is superior to a simple mixture like Mixture 1. Provided the nutritive value is the same there is no evidence to support the idea. However it is wise to include a "bulky meal" in a mixture designed for cows which have to eat a large quantity of concentrates. Wheat bran is the meal of choice because it is palatable and balanced for milk production. It also has a laxative or loosening effect which helps to move food

TABLE 7

Concentrate Mixtures containing 15-16% D.P.

Ingredients	*Mixtures*					
	1 lb.	2 lb.	3 lb.	4 lb.	5 lb.	6 lb.
Maize grain (crushed) ..	73	33	50	65	50	50
Maize corn and cob meal	—	—	20	—	—	—
Maize bran	—	—	—	—	—	20
Groundnut meal (dec.) ..	27	—	30	25	25	—
Groundnut meal (undec.)	—	67	—	—	—	—
Cottonseed meal (dec.) ..	—	—	—	—	—	30
Sunflower head meal ..	—	—	—	—	25	—
Lucerne meal	—	—	—	10	—	—
Bonemeal flower	2	2	2	2	2	2
Salt	1	1	1	1	1	1

These mixtures are suitable for cows fed hays and silages of poor quality.

TABLE 8

Concentrate mixtures containing 12-13% D.P.

Ingredients	*Mixtures*					
	7 lb.	8 lb.	9 lb.	10 lb.	11 lb.	12 lb.
Maize grain (crushed) ..	80	60	60	60	74	60
Maize corn and cob meal	—	—	—	10	—	10
Maize bran	—	—	20	10	—	—
Groundnut meal (dec.) ..	20	—	20	—	16	20
Cottonseed meal (dec.) ..	—	15	—	20	—	—
Sunflower head meal ..	—	25	—	—	—	10
Lucerne meal	—	—	—	—	10	—
Bonemeal flour	2	2	2	2	2	2
Salt	1	1	1	1	1	1

These meals are suitable for cows fed on average to good quality legume hay and maize silage.

through a cow's digestive tract. A useful substitute in this respect is corn and cob meal but it is low in protein compared with wheat bran. No more than 20 per cent should be included in mixtures for high yielding cows. Up to 60 per cent can be used in mixtures for cows producing two or three gallons of milk a day.

Mineral content of concentrates. To ensure that dairy cows eat enough minerals it is customary to add them to the concentrate mixture. The minerals can be placed in boxes so that animals help themselves. In practice this is often less satisfactory than mixing them with concentrates because the boxes tend to get broken, the contents fouled and filling may be forgotten about. A useful mixture is made up as follows:—

20 lb. bonemeal flour
20 lb. common salt
10 lb. limestone flour

This can be added to the concentrates at the rate of 3 lb. to 100 lb. of mixture. Care must be taken to ensure that thorough mixing is carried out otherwise some animals will receive too much mineral and others too little. The correct weight of minerals should be mixed with about six times its weight of meal. This is then added to the rest of the ingredients and all mixed together.

Mixing concentrates. As an example, suppose 1,000 lb. of Mixture 1 were to be prepared we would need 10 x 3 = 30 lb. of the mineral mixture. Seven hundred pounds of maize meal and 300 lb. of decorticated groundnut meal are also required. About 150 lb. of maize meal should be made into a flat heap and the minerals sprinkled over it. A shovel can be used to turn this over three times when it will be mixed well enough to go with the rest of the ingredients. A separate heap should then be started by adding in turn some of each of the other meals, i.e. three shovelfuls of maize, one of groundnut meal and one of maize and minerals. This process is repeated until one large heap of partly mixed meals has been made. The heap must then be shovelled into a fresh heap three times to make a thorough mixture.

6.8 DIETS FOR HIGH YIELDING COWS

So far attention has been given to the "average" cow i.e. that which yields two to three gallons of milk a day. Such animals are easy to feed because they can produce milk from large quantities of average quality roughages and comparatively small quantities of concentrates. The reverse is true of high-yielding cows. Such cows must eat large amounts of food if they are to consume the nutrients they need. In well managed herds of large cows (1,200 lb.

liveweight) the best cows will yield over five gallons or more of milk a day at the peak of lactation. Such animals need skilful feeding to prolong their period of high productivity. They must be fed individually according to yield of milk and fat.

Many farmers make the mistake of feeding all cows the same amount of concentrates per gallon irrespective of actual yield. Reference to Section 3.7 shows that the higher the yield the greater the amount of T.D.N. which must be supplied per gallon of milk produced. If these recommendations are not applied the high yielders are underfed and cannot realise their potential milk yield. This also happens when all cows are not fed according to yield and receive the same quantity of food. In these circumstances the poor producers are overfed and food is wasted.

If we assume that a cow's maintenance needs can be supplied from roughages grown on the farm then the nutrients required for milk production can be met by feeding either 4 lb. or 5 lb. concentrates (Tables 7 and 8) per gallon for milk and 3.5 and 5.0 per cent butterfat respectively. This rate of feeding applies to cows which yield three gallons of milk a day or less.

We have seen that as yield increases so the efficiency of digestion decreases. Consequently above three gallons a day more T.D.N. per gallon must be fed. This can be achieved with cows yielding 4-6½ gallons of milk containing 3.5 per cent fat by feeding at the rate of 4½ lb. of concentrate for each gallon produced. Similar cows which produce seven or more gallons a day should be fed at the rate of 5 lb. per gallon produced. Where cows produce four gallons or more of milk containing 5 per cent fat the allowance should be 5½ lb. concentrate per gallon of milk.

The above allowances are based on the concentrate mixtures given in Tables 7 and 8. Some proprietary dairy concentrates contain between 70 and 72 per cent T.D.N. Consequently the above allowances should be increased by a quarter of a pound per gallon.

7.0 Feeding, Management and Milk Production

Successful milk production is not simply the result of feeding according to theoretical nutritive requirements. Careful plans must be made to provide certain amounts of food according to the stage of productivity that a cow is in at any particular time. Such plans allow a cow to milk at her best and to use her food economically. Several other factors affect milk yield and all are important because they lead to profitable milk production.

7.1 LEVEL OF FEEDING AND STAGE OF PRODUCTION

So far it has been convenient to assume that cows should be fed nutrients according to liveweight and the amount of milk produced. This general theory is useful provided it does not lead to the belief that a cow will produce milk exactly in proportion to the nutrients she is fed. In fact when cows are fed according to feeding standards an increase in the amount of nutrients fed increases the amount of milk produced but to a lesser degree. The greater the amount and quality of food eaten the quicker it passes through the digestive system. Because of this shorter time in the gut, there is less time for digestion and so there is a decline in the amount of energy absorbed from the food. Energy is thus lost in the droppings. Again, cows eating large quantities of food produce much body heat and gain weight leading to further losses of the food energy supplied for milk production.

The tendency for less milk to be produced in proportion to increased amount of food eaten can be prevented to some extent. The way a cow will respond to extra food depends on the time or stage of lactation when it is given—the earlier in lactation, the greater the response. Not only is there a response to feeding in the first few weeks of lactation but there is also a response to concentrates fed in the dry period (Section 7.2).

The yield of milk a cow is producing at a given time has an important effect on response to extra food. In general if two cows are fed according to feeding standards the cow which already produces most milk will give the greatest response to increased feeding. The kind of food offered is also important. Increased nutrients offered in roughages give less response than if they are offered in concentrates. This is because when roughages are digested they give rise to products which need a great deal of energy to be converted to productive use in the body.

All of these factors add together to have an important effect on lactation milk yield. An animal which has been poorly fed before lactation starts and in the early weeks of her lactation, cannot reach her maximum daily yield. This will reduce her ability to respond to a future increase in the level of feeding. The practical meaning of these factors will be discussed in the pages which follow.

7.2 PREPARING THE COW FOR LACTATION

In the last two months of pregnancy a cow needs food for the maintenance of her body, for udder development and for growth of the unborn calf. The heifer needs food for her own growth as well. If too little nutrients are provided for even short periods at this time, the quantity and quality of milk in the next lactation will be reduced. Unless extra nutrients are provided throughout lactation these undesirable effects last. They cannot be corrected by the normal practice of feeding according to daily milk yield. Correction can be made, however, if the cow is given extra food after she has calved. This procedure is expensive in comparison with adequate feeding before calving.

In lactation a cow will produce between three-quarters and $1\frac{1}{3}$ lb. extra milk for each pound of concentrates fed daily above normal feeding standards. Since underfeeding in late pregnancy can cause a loss of 1,000 lb. milk in lactation ($\frac{1}{2}$ gallon in peak yield) between 650 and 1,300 lb. of concentrates will be needed to correct the loss. This is much more expensive than feeding up to 250 lb. concentrates in the weeks before calving which is enough to ensure the cow receives enough food for her needs.

The practice of feeding concentrates before calving is known as "steaming up". The amount of meal fed depends on the condition of the cow and allows for the fact that the unborn calf grows at the rate of $\frac{1}{2}$ to $\frac{3}{4}$ lb. a day in the last few weeks before birth. Condition is not easily explained but a cow in "good" condition will be well-fleshed and even slightly fat. A cow that is at her peak of condition on an "M + 1" diet will need little extra concentrates before calving while a thin cow needs between 250 and 300 lb.

Suggested patterns of concentrate feeding in the weeks before calving are shown in Table 9 for cows in poor, average and good condition. The patterns assume that the cow is already eating an adequate diet for her own growth and for that of the unborn calf, i.e. the M + 1 diets suggested in Section 6.5. One of the concentrate mixtures (15-16 per cent D.P.) shown in Table 8 should be used for steaming up. It is not possible to provide an adequate diet for a cow in the last few weeks of pregnancy with the kind of roughages which are usually available in Central Africa.

TABLE 9

Steaming-up Concentrate Allowances for Cows according to Body Condition

Weeks Before Calving	*Poor*		*Average*		*Good*	
	lb./day	*lb./wk.*	*lb./day*	*lb./wk.*	*lb./day*	*lb./wk.*
6	4	28	2	14	—	—
5	4	28	2	14	—	—
4	6	42	4	28	2	14
3	6	42	4	28	3	21
2	11	77	6	42	4	28
1	11	77	6	42	4	28
		294		168		91

Some farmers believe that too much steaming up leads to difficult calving because large calves are produced. So far as we know steaming up can increase calf birth weight by 2-3 lb. only. Such increase seems too small to account for calving difficulties. Nevertheless there is some evidence that if very well-fleshed cows or heifers are heavily steamed-up foetal growth across the withers is enhanced and calving difficulty follows. The best course of action is to ensure that cows are always properly fed throughout their lives so that the need for a large steaming up ration does not arise.

7.3 THE LEVEL OF FEEDING IN EARLY LACTATION

The aim of feeding in early lactation is to encourage a cow to reach as high a daily yield of milk as quickly as possible. Total lactation yield is closely related to peak daily yield so that the cow which gives a high daily yield is also likely to give a high lactation yield. A high daily yield is encouraged by steaming-up.

Heifers in their first lactation are still growing and should be encouraged to reach the mature size for their breed as quickly as possible. In general heifers should be fed according to yield together with an allowance to provide for about one pound of liveweight gain a day. The diet should be made up from farm roughages so far as possible for economy and to encourage the development of the digestive system. Each farmer should decide on the performance he wishes his heifers to achieve and feed accordingly. A reasonable peak daily yield for heifers to reach is 2-2½ gallons a day for small breeds and 3-3½ gallons for large breeds. Very roughly lactation yield is two hundred times the peak daily yield so, on these recommendations, lactation yield would be 500 and 700 gallons respectively.

Once a dairy cow is mature, i.e. fully grown, she should be encouraged to reach her highest potential daily yield. She can only do this if she has been steamed up (Section 7.2). After calving her ration should be increased gradually until she is eating enough nutrients for half a gallon of milk *more* than she is giving, i.e. 2 lb. concentrates. This scale of feeding should be carried on for as long as the cow's yield continues to increase, i.e. for the first four to six weeks of lactaion. During this time increases in concentrate rations should be made at least once but preferably twice each week to encourage maximum yield. As soon as the cow has reached peak daily yield the extra 2 lb. of concentrates which is in excess of yield can be stopped. As yield declines with advancing lactation the concentrate ration should be reduced accordingly. By mid lactation, when the dry matter content of the ration is unlikely to be a factor limiting production, a greater use of roughages can be made.

7.4 THE EFFECT OF FOOD ON MILK PRODUCTION

Milk production at the beginning of lactation is an essential part of a mother's life and will be carried out even when the diet is insufficient to support it. Food has little effect on milk composition while maternal urge to produce milk is strong. As lactation proceeds and the nutrient requirements of the offspring can be met in other ways, the urge to produce milk declines. It is at this stage that food can have an important effect on milk composition.

The composition of milk is of practical importance because of legal requirements which govern the sale of whole milk. In Central Africa the minimum content of Total Solids (B.F. and S.N.F.) in whole milk offered for sale must not be less than 12.0 per cent. For each 0.1 per cent below this figure 0.1d. is deducted from the price paid for a gallon of milk, i.e. milk containing 11.5 per cent Total Solids would realise 0.5d. less than milk which contained 12.0 per cent Total Solids. At the same time a bonus is paid at the same rate when the legal minimum is exceeded. Both penalty and bonus are restricted to either a maximum deduction or payment of 2d. a gallon.

Milk of low fat content is produced by cows on balanced rations which contain only a small amount of "long hay", i.e. hay which has not been finely ground. Fat content can fall below 40 per cent of normal in this way. It is usual to recommend that each cow receives not less than 7 lb. hay daily. Although fat content falls when too little hay is fed, milk yield is not affected.

When cows are fed below the rates suggested in the feeding standards both solids-not-fat and yield decline. This is largely, but not entirely, due to a shortage of energy in such diets. Even on balanced diets some cows produce milk of low S.N.F. content. This is often marked towards the end of winter feeding when cows are fed entirely on conserved foods. An increase in the amount of energy above normal feeding standards in the diet often improves the S.N.F. content of milk from such herds. However such improvement does not take place if low S.N.F. content is due to heredity (Chapter 9). The diets which have been recommended in Chapter 6 have been designed to ensure that milk yield and quality are not limited by feeding.

7.5 FEEDING PRACTICE

Milk yield rises rapidly to a peak in about the sixth week of lactation and then declines slowly until the cow is dry at about 43 weeks from calving. Consequently, in any well-managed herd, there will be cows producing three to five gallons or more of milk a day and others producing a gallon or less. The amounts of nutrients required by each cow in a herd will differ, therefore, but a wide range of diets need not be provided. A basic diet can be designed to supply maintenance or "M + 1" for all cows and then each individual can be rationed to requirements on balanced concentrates.

For example, Diet 14 (Section 6.6) shows how a diet of poor quality roughages needs the addition of protein rich concentrates (15-16 per cent D.P.) to provide enough nutrients for an 800 lb. cow that yields a gallon of milk (5.0 per cent butterfat) a day. The complete ration for "M + 1" is:—

7 lb. grass hay (poor)
30 lb. maize silage (poor)
5 lb. concentrates (15-16% D.P.)

Cows which produce more than one gallon would have to be given more concentrates, e.g. 2 gallon cow: roughages plus 10 lb. concentrates.

In the above situation it is easy to arrange that each cow receives her share of food. If hay has to be carefully rationed then it should be weighed into the hayracks each day. Sufficient racks should be provided to allow all cows to feed at once otherwise the most determined cows will take the lion's share. The danger with silage feeding is that cows do not get enough because silage is heavy and labourers often neglect this job. If the silage is weighed into sacks of standard size this can be prevented. If 50 lb., say, is put into each sack the farmer can weigh a few sacks when the chore is over. After a few days he will be able to tell at a glance if the correct amount of silage is in the bag.

Concentrates are usually fed at milking time and it is best to weigh each cow's ration accurately. This ensures that each cow receives the correct amount and prevents waste of meal which results from inaccurate measurement. On many farms a scoop is used as a measure and this is satisfactory provided the quantity of meal it holds is known. There is plenty of evidence that many farmers feed their cows wastefully because their feeding scoops are the wrong shape. A bowl-shaped scoop holds about 50 per cent more when heaped with meal than when the meal is level with the top of the rim. Consequently concentrate measures should be cylindrical in shape so that the risk of overfeeding from heaping can be reduced. Again a scoop of any given size does not hold the same weight of every kind of meal. For example a scoopful of maize meal weighs about twice as much as a scoopful of bran. Thus if a change of concentrate mixture is made the weight of the scoopful must be checked to ensure accurate rationing.

7.6 PLANNING THE CROPS FOR WINTER FEEDING

A dairy farmer must know how much food his herd may need for winter feeding so that he can plan a cropping programme. It will be a rough estimate because crop yields vary from year to year with changes in the seasonal rainfall. Provision for a poor growing season should be made by building up a reserve of fodder such as maize silage which will keep for several years.

Let us assume that food must be provided for a herd of 20 cows, one bull and 20 head of young stock and that the cows weigh about 800 lb. liveweight. For this kind of rough estimation it is convenient to assume that two young animals need as much food as one adult. There are, therefore, 31 "adults" to be fed in this herd. Any of the diets suggested may be used. Let us feed Diet 4 (Section 6.4) which provides maintenance and a gallon of milk, i.e.

9 lb. legume hay
40 lb. maize silage

If this diet is fed for 300 days (10 months) each animal needs:—

9 lb. x 300 (days) ÷ 2,000 lb. (1 ton) = 1⅓ tons (approx.)
40 lb. x 300 (days) ÷ 2,000 lb. (1 ton) = 6 tons (approx.)

As there are 31 adults then the total quantities of food needed are:—

31 x 1⅓ = 40 tons hay (approx.)
31 x 6 = 200 tons silage (approx.)

Each farmer must use his local knowledge of crop yields in order to work out acreage from tonnage required. For the purpose of illustration we can assume that 1½ tons legume hay can be harvested from each acre and 10 tons of maize silage. The acreage needed will be:—

40 tons hay ÷ 1½ tons/acre = 27 acres
200 tons silage ÷ 10 tons/acre = 20 acres

Thus each cow needs about an acre of legume hay and ½ acre of maize to provide silage.

Allowance must be made for maize grain to form the basis of concentrate mixtures. As Diet 4 provides for the production of one gallon of milk we must calculate for milk produced in excess of this. An 800 lb. cow should yield about two gallons each day on the average so, with Diet 4, concentrates must be provided for one gallon a cow a day, i.e. 5 lb. (Section 6.7). Some cows will produce a great deal of their milk in summer so less concentrates will be required. However, it is best to over-estimate the amount of maize meal needed because the surplus can always be sold.

The total amount of concentrates needed is:—

31 adults x 5 lb. x 300 days ÷ 2,000 lb. = 70 tons (approx.)

If we choose Mixture 1 (Section 6.7) then three parts of maize meal are needed to one part of groundnut meal, i.e. about 50 tons of maize or 500 bags are required. On average 30 acres should be enough to grow this quantity.

The total area of crops will be:—

Legume for hay	= 27 acres
Maize for ensilage	= 20 acres
Maize for grain	= 30 acres

These averages are not representative for the whole of Central Africa and have been arrived at from an exercise in calculation. Farmers in maize areas who can afford to apply heavy dressings of fertilisers should be able to reduce the maize acreage above by half in a normal season.

8.0 Rearing Young Cattle

8.1 CALF REARING PROBLEMS

In the world of dairy farming it is well known that many calves die before they reach the age of 12 months. This does not mean that a certain number of calves which are born each year will die no matter how well they are treated. Some farmers lose very few calves (1 to 2 per cent) while others lose many (over 50 per cent). These figures suggest that the skill and knowledge of the farmer is of very great importance to the well-being of the calf.

The most common trouble with calves is failure to "do well", i.e. general ill-health and poor growth. The calf looks miserable, lacks energy and is not interested in food. It usually dies sooner or later although no particular cause can be found. Calves of this kind may have been born in a feeble state because their mothers were not fed properly before calving. In other cases the mother may have given the calf a good start in life but the calf is kept in dirty conditions and picks up some disease. This may result in calf "scours" (diarrhoea) which is often fatal. Wrong feeding is another cause of scours which is the greatest single cause of calf losses.

There is no doubt that large, well-reared heifers give more milk in the first two years of milking life than small, poorly-reared animals. Strong, healthy animals stand up to the strain of milk production well and when surplus heifers are sold, it is the well grown animal which makes the best price. Such animals are not necessarily the result of expensive or extravagant feeding. They are the result of the farmer's ability to look after the young calf. How this can be done is the subject of this Chapter.

8.2 CARE OF THE DRY COW

Diet. The start of any successful rearing system is a calf which is born strong and healthy. Normally this can be done by attention to the diet of the dry cow. Good pasture should be enough in summer for a mature animal but at other times of the year she should be fed as if she were producing a gallon of milk. During the last two months of pregnancy the unborn calf makes rapid growth and at the same time the cow must build up her strength for the strain of lactation which lies ahead. A cow on a maintenance diet cannot provide for either the calf or herself. The result will be a poor calf and a poor milk yield. Either fresh green forage or legume hay having a green colour, should be included in the diet so that the cow can store Vitamin A in her body. This will make sure that when the dry cow calves, her first milk (colostrum) is rich in Vitamin A. Vitamin A is an essential part of the calf's diet which helps to protect it against disease. The practice of feeding extra concentrates to dry cows to improve lactation yield has been described in Chapter 7.

Calving. A cow will calve about 280 days after service although variations of ten days either way are known. Dates of service should be recorded so that preparations can be made for calving. Calves can be born out of doors in Central Africa without any harmful effects. But the same place must not be used for calving year after year. When this is done disease tends to build up on the pasture and cow and calf may become infected. Ideally calving should take place in a special room, or "loose box" as it is called, which has a concrete floor and smooth, cemented walls. A box of this kind is easy to disinfect before and after use and attention can be given to the cow if she needs it.

If loose boxes are used the cow should be brought indoors a few days before she is due to calve to allow her to become used to her surroundings. Between 12 and 24 hours before calving takes place the cow may become uneasy; the vulva enlarges and becomes flabby and the tailhead loosens. The cow should be left undisturbed to calve on her own. After the calf has been born the cow will lick the calf's coat dry and the calf will struggle to its feet to suck. The calf's navel should be disinfected to prevent "navel ill"—a common infection of newly born calves.

8.3 THE CARE OF YOUNG CALVES AT BIRTH AND NURSING

Colostrum. Colostrum is specially designed by nature to meet a calf's immediate dietary needs and to give protection against disease. It contains special health factors (antibodies) which protect the calf against the diseases to which its dam has been exposed. Colostrum also has a laxative effect and so cleans the calf's digestive system of matter which collected before birth. Further, colostrum is richly supplied with energy, protein, vitamins and minerals. Without it calves die sooner or later. Clearly, colostrum is of great importance to the calf's health. The calf should be allowed either to suck its mother or to drink her milk for three to four days by which time the udder produces normal milk.

Rearing by nurse cow. There is little doubt that calves grow quickly and well when they are reared naturally, i.e. suck a cow. But this is an expensive way of rearing and has little commercial value because as much milk as possible should be sold. However, it happens sometimes that a valuable cow loses a quarter as a result of mastitis. This animal may be kept for breeding but with only three quarters she is a nuisance to milk by machine. In machine milked herds such animals can be used profitably to nurse three calves at once. Usually one calf sucks in the first week, two in the second week and three in the third. They stay with the cow for about 13 weeks and are weaned in turn or according to growth. If the cow has enough milk a new calf is added to the group as each calf of the first group is removed. A regular supply of ten day old calves is needed to make the best use of the cow's milk. The method requires a good deal of skill and personal attention by the farmer to see that the cow accepts new calves, that each gets a share of the milk and that feeding takes place regularly. It is usual to keep the calves in a pen and to take the cow to them twice each day. Weaning is sudden with this system so calves should be offered concentrates at about four weeks of age. They should be encouraged to eat between 2½-3 lb. a day by weaning otherwise they suffer a check of growth. Good quality hay should also be offered.

Feeding milk in buckets. The most common way of rearing calves is to teach them to drink milk from buckets. This is by far the most economical way of using milk but skill and attention to detail is required of the farmer. Unless this can be assured then slow growth, sickness and deaths in the calves is a certainty. Nevertheless "bucket feeding" as the system is called, can be used for many different methods of rearing. The pedigree breeder who wants to produce a bigger than average calf on milk can feed a gallon a day for six months if he wishes. In fact this is commonly done by many commercial dairymen in Central and Southern Africa today. However, falling milk prices have obliged many to adopt more economical methods of calf rearing. Well grown calves can be produced from 100 gallons of whole milk fed over the course of three months. Satisfactory calves, which grow out as well as any others, can be reared on an "early weaning" system where as little as 15 gallons of whole milk is required. Before various diets are described the principles on which successful calf rearing are based must be outlined.

8.4 THE RULES FOR CALF REARING

1. The calf must have its dam's colostrum for the first four days of life. If this is not available from the dam or another freshly-calved cow, feed the following at blood heat three times a day for the first three to four days of life.

1 egg whipped in ½ pint of water
1 pint of whole milk
½ teaspoon of castor oil
1 pinch of antibiotic (chlortetracycline)

(On the first day two teaspoons of castor oil should be used but once the calf's droppings are normal it can be stopped altogether.)

2. Housed calves must be kept singly or in small lots in clean, freshly littered pens to reduce the spread of disease. Draughts must be avoided in cold weather and an even temperature always provided. Young calves do not thrive when air temperature falls below 55°F. (12°C.) because they have to use a considerable amount of food energy to keep warm instead of for growing. Night frosts are common in many parts of Central Africa so that suitable housing is important.

3. Calves must be fed at regular, set times from clean buckets or digestive upsets occur and scours spread rapidly. "Clean" means that the bucket has been carefully washed and then sterilised (freed from bacteria) by boiling or steaming.

4. Over-feeding with whole milk must always be avoided otherwise either scours occur or a hard, cheesy lump forms in the stomach and blocks it. The calf should be fed milk three times daily for the first ten days and then twice a day. No more than 1 lb. of milk should be fed for each 10 lb. of body weight until the calf is over four weeks of age.

5. If a calf begins to scour starve it for 24 hours but provide clean, warm water containing ¼ oz. salt to 3 pts. of water.

6. All changes in diets must be made gradually. For example if a change is to be made from whole milk to milk substitute then the milk should be reduced while the substitute is increased each day (See Table 10). Unless this change is made gradually over a period of five to seven days scours are likely to occur.

7. Good quality hay and concentrates should be offered early (14 days) to encourage stomach development and to bring the calf to the stage when it can do without milk. At 12 weeks of age a calf should eat 2½ to 3 lb. hay and 2½ to 3 lb. concentrates.

8. All food offered should be fresh. When the calf is learning to eat concentrates it is important to take away what has been left from a previous meal. This will probably be wet from saliva and if left will sour quickly in warm weather. The calf will be discouraged from eating which is not what is wanted. If, through hunger, any sour food is eaten digestive troubles follow. Fresh hay

should be offered two or three times a day. The calf likes to lick the leaf in hay and to leave the stem. Consequently small quantities of fresh hay should be offered two or three times a day rather than filling the hay rack once every few days.

9. Clean fresh water should be freely available to calves from three weeks of age. This is particularly necessary in warm climates in the hot months of the year. It encourages a better appetite for hay and concentrates and so leads to greater liveweight gain.

8.5 THE DIFFERENT METHODS OF CALF REARING

Whole milk diets. Examples are given as a guide (Table 10) but calves vary in birth weight according to breed and individuality so the examples do not meet the needs of every calf. Some farmers prefer not to feed more than one gallon of milk a day while others may feed up to two gallons. It depends on the calf's progress and whether or not rapid liveweight gain is wanted regardless of cost.

TABLE 10

Milk and Milk Replacer Diets for Calves

Whole Milk (80-90 *gallons*)			*Milk Replacer*	
Age (Weeks)	*Milk (pints/day)*	*Meal (lb./day)*	*Milk (pints/day)*	*Replacer (pints/day)*
1	5—6	—	5—6	—
2	6—8	—	6—8	—
3	8	—	6	2
4	10	—	6	4
5	12	¼	4	8
6	12	¼—½	2	10
7	12	½—¾	—	12
8	10	¾—1¼	—	12
9	8	1¼—1¾	—	12
10	6	2	—	12
11	4	2—2½	—	Decrease
12	2	2½—3	—	Decrease

(Hay and meal are offered in the third and fourth weeks.)

These diets are meant for a calf weighing 60-75 lb. at birth and provides for a gain of 1-1½ lb. each day.

Milk replacers. These are popular in Central and Southern Africa because they are cheaper than whole milk. They are usually made up of dried skim milk (50 per cent), dried whey (10-15 per cent), dried blood (10 per cent), cereals, oil cake meal, vitamins and minerals. One pound of milk replacer is usually mixed with 9 lb. of water (9/10ths of a gallon). The liquid is fed in the same quantities as milk. Good growth can be made on milk replacers if care is given to correct mixing, temperature of the liquid and cleanliness of the bucket.

Skim milk diets. Skimmed or separated milk (Section 1.7) is often fed to calves on farms where cream is sold. Whole milk can be replaced in calves' diets by skim milk at three weeks of age (see Table 11). Skim and separated

TABLE 11

Skim Milk Diet

Week		
1	Milk—whole	(8-10% of body weight)
2	Milk—2 parts whole 1 part skim	
3	Milk—1 part whole 2 parts skim	Offer cereal

Subsequently: Skim milk at 8% of body weight, cereal at ¾ lb. a gallon, e.g.:—

Week	*Skim*	*Cereals*	*Concentrates**	*Hay*
	pts.	lb.	lb.	
4	8	¾	—	Offer
6	10	1	—	increasing
8	12	1¼	—	
10	14	1½	—	2½ lb.
11—14	15	1½	Offer	
15—16	16	1½	1½	Increasing
17—18	8	1	3	
19	Wean	—	6	

*If average quality roughages are provided then one of the concentrate mixtures 1-6 (Section 6.9) should be offered. Mixtures 7 to 9 are suitable foods with good-quality legume hays and silages.

milk is short of energy because the butterfat has been removed. This can be replaced by crushed maize at the rate of ¾ lb. to the gallon of skim milk. The cereal can be added to the skim milk until the calf will eat dry meal. The vitamins A and D have also been removed with the butter fat. In the open housing systems of Africa calves usually get enough Vitamin D from the action of sunlight on the skin. Vitamin A must be supplied either by injection (100,000 i.u.A) or a commercial preparation may be mixed with the maize meal (3.25 million I.U. per ton). Because a diet of skim milk and maize meal is cheap it is often fed for 16 or more weeks. The sample diet given provides for 2 galls. of skim milk at 16 weeks of age although some calves can drink 3 galls. at this age.

Early weaning. The proteins and other nutrients in milk replacers are expensive in comparison with those in meal concentrates. It is not surprising that calf rearing systems have been devised which encourage calves to eat meal so that milk can be taken from the diet at an early age. As well as reducing the cost of rearing, these systems reduce the risk of scours which is always a danger when calves are fed on liquid diets. Again early weaning reduces the time when skilled attention is needed in the calf house.

There are many early weaning systems but all are based on similar principles. The calves must have colostrum as usual. They are fed two to four pints of milk a day and this is increased to an amount which is about eight per cent of body weight at seven days. No further increase in milk is given but early weaning meal is offered from the eighth day with leafy hay of good quality and water. The calf can be taught to eat meal by sprinkling it into the milk bucket just before it has finished drinking. Once concentrates are eaten then meal should be kept in front of the calf always. A little should be offered several times a day rather than all at once. If the meal becomes wet with saliva it should be removed and fed to yearlings or other older stock.

When the calf is three weeks old milk feeding is stopped altogether, although this can be delayed for a few days more if the calf needs it. Small calves, especially those from heifers, need milk for longer than calves of normal size. The amount of meal eaten should increase rapidly. A calf should eat from 4 to 6 lb. a day at eight weeks and up to 10 lb. a day at 12 weeks. When the calf is 12 weeks old a more simple concentrate mixture can be used to replace the early weaning meal, e.g. 85 per cent cereals, 15 per cent groundnut cake with minerals. Hay of good quality should be offered from three weeks of age (Section 8.4, Point 7).

The early weaning meal itself must contain easily digestible and palatable foods to encourage the young calf to eat a lot and make quick growth. These meals usually include 10 per cent of dried skim milk, 10-15 per cent of oil seed meals together with vitamins A and D, minerals and antibiotics. An average gain of $1\frac{1}{4}$ lb. a day should be expected up to 12 weeks but large calves may gain 2 lb. a day. Some early weaned calves look "rough" by the time they are three months old. If good quality roughages and concentrates are given for the next three months the calves will grow out of this without ill effects.

The last word has yet to be written on early weaning systems. Trials at Henderson Research Station, Mazoe, have led to the development of a system of early weaning onto a complete diet which enables calves to make rapid and economical gains. A novel feature is the inclusion of 15 per cent of milled Rhodes grass hay in the diet. This has been shown to stimulate appetite and consequently, live weight gain.

Under the Henderson system calves are fed whole milk at the rate of 8 per cent of birth weight (i.e. 8 lb. for a 100 lb. calf) in two equal feeds daily. This quantity is not increased as the calf grows. Whole milk is replaced gradually over the next few days with a commercial milk substitute in such a way that when the calf is 21 days old it receives one pound of milk powder mixed with 9 lb. of water i.e. a gallon of milk substitute. When this quantity is reached it may be offered in one feed daily without ill effects and labour is thereby reduced. A complete diet (Table 12) is made freely available to the calf from the first week of life. When the calf is 45 days of age milk substitute is discontinued abruptly.

A calf which weighs 75 lb. at birth would have consumed approximately 9 galls. of whole milk, 30 lb. milk substitute and 780 lb. of the complete diet

TABLE 12
The Henderson Research Station Calf Diet

Maize meal	53
Voermol	5
Groundnut meal	22
Fish meal	3
Milled Hay*	15
Salt	1
Minerals†	1
Vitamin A (I.U. per ton)	3·25 million

*screen ½ to ¾″
†Proprietary mixture

at 150 days of age. It would have gained at the rate of about 1.68 lb. a day and should weigh 318 lb. At six months of age the calf should weigh over 380 lb. which is up to the standard recommended in Section 8.7.

Rearing on pasture. This is successfully practised in New Zealand where nutritious grass/legume pastures keep their feeding value for most of the year. The calves are reared on whole milk and separated milk to 16 or 18 weeks. They are turned out to pasture from three weeks of age. Small paddocks are required because calves are very particular grazers and will starve on poor pasture. The paddocks are grazed by the calves about a week in front of the dairy cows. This reduces the chance of worm infestation but, nevertheless, they are drenched against worms every three weeks. As the system depends on high quality pasture and freedom from worms it would be difficult to establish in this country. In fact it is best to keep young heifers of European dairy breeds in either calf houses or kraals until they are one year old. If shelter and a dry floor cannot be provided during the rains then the calves will have to be turned out but they should still be brought in each day for concentrate feeding.

8.6 ROUTINE ATTENTION TO YOUNG CALVES

Ear marking. All calves should have an identification number and they should be marked with it soon after birth. Breed and Milk Recording Societies usually have a system of numbers which are tattooed into the ear. Many farmers

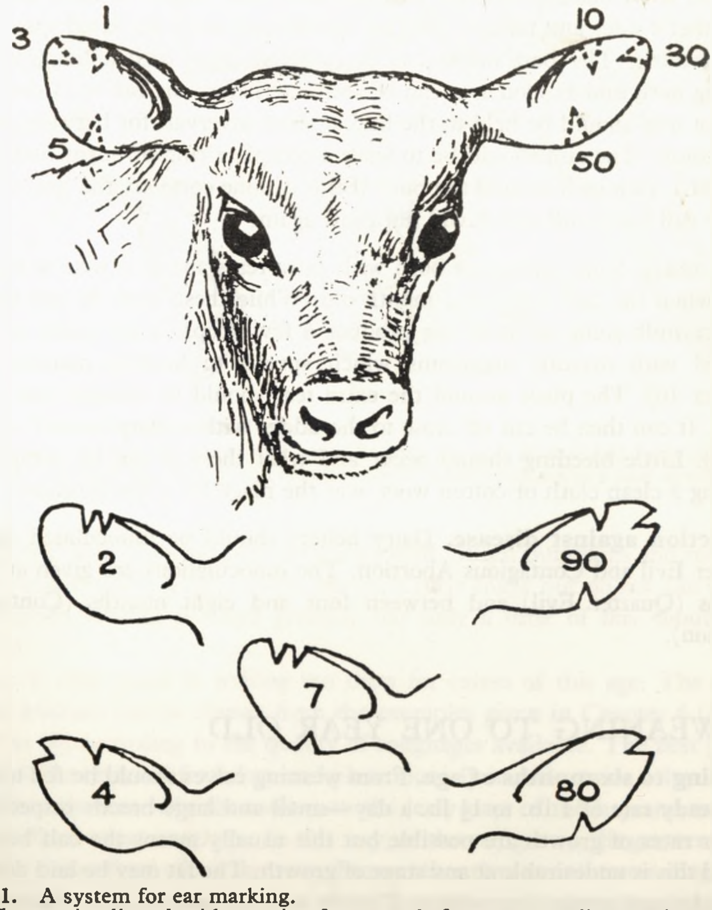


FIG. 1. A system for ear marking.
The ear is clipped with a pair of ear-notch forceps according to the number required.

have a private system of either ear tags or ear notches. Tags with closed ends sometimes get pulled out, tearing the ear and making it unsightly. Open-ended tags are less likely to be torn out. A system of ear notches is less expensive, permanent and more practical for commercial farmers. The code is illustrated in Figure 1. The right ear of the calf is used for numbers 1 to 9 and combinations are used for the numbers which are not illustrated (e.g. 1 and 3 are used to show 4: 5 and 3 shows 8 etc.). The calf's left ear is used to show tens, while a hole punched in the centre of the ear indicates 100.

Dehorning. It is wise modern practice to prevent the growth of horn in dairy calves. This procedure is somewhat loosely called "dehorning"—a term which is also used more appropriately to describe what happens when horns are removed from mature animals. Hornless cows are unable to horn and tear each other's sides and udders, they are quieter and need less kraal space than horned cattle. The best method is to cauterise (sear with a hot iron) the growing horn bud as soon as it can be seen, i.e. before the calf is 21 days old. The hot iron should be held to the bud at short invervals for between five to ten seconds. The aim should be to leave a complete ring of burnt tissue to a depth of 1/16th inch around the bud. If this is done correctly the bud's blood supply will be cut off and it will not grow again.

Extra teats. Some calves are born with extra teats and it is wise to remove these when the calf is about a month old. While these teats do not usually produce milk some of them can produce a few drops. They easily become infected with mastitis organisms which spread to healthy quarters (see Chapter 10). The place around the extra teat should be cleaned and disinfected. It can then be cut off close to the udder with a sharp pair of scissors (fig. 2). Little bleeding should occur and what there is can be stopped by pressing a clean cloth or cotton wool over the place for a few minutes.

Protection against disease. Dairy heifers should be innoculated against Quarter Evil and Contagious Abortion. The innoculations are given at three months (Quarter Evil) and between four and eight months (Contagious Abortion).

8.7 WEANING TO ONE YEAR OLD

Weaning to six months of age. From weaning calves should be fed to grow at a steady rate of 1 lb. to 1½ lb. a day—small and large breeds respectively. Higher rates of growth are possible but this usually means the calf becomes fat and this is undesirable at any stage of growth. The fat may be laid down in the udder and around the ovaries. The one leads to poor milk production and the other to poor breeding. Good quality hay and 3 to 4 lb. concentrates a day

FIG. 2. The removal of extra teats.
The skin around the extra teat must be cleaned and disinfected with surgical spirit. The teat can then be cut off close to the udder with a sharp pair of scissors.

must be the basis of feeding for normal growth. Sliced pumpkins and melons will be eaten readily. Young calves will eat a little silage but do not like a lot. Wilted green lucerne is eaten greedily but only a little of this should be provided.

There is little point in writing out diets for calves of this age. The concentrate mixture can be chosen from the examples given in Chapter 6 (Mixtures 1 to 10) according to the quality of roughages available. The best grass hay should be reserved for calves and placed loosely in racks twice a day. This allows the calves to help themselves to the leafy part of the hay and so encourages them to eat roughage. In this way, as the calf grows, the greater part of the diet comes from cheap farm roughages rather than concentrates. Legume hays may be wasted unless the ribs of the hayrack are so close together that the calf can just get its tongue between them. This works well provided the hay is not packed tightly into the rack; otherwise legume hay should be chaffed and fed in troughs to reduce waste. If silage or sliced pumpkins are fed the trough must be cleaned out each day to prevent the collection of sour food.

Feeding from six months to one year. Calves must continue to gain from 1 to $1\frac{1}{2}$ lb. a day in this period. This can be done by feeding 4 lb. of concentrates daily (15 per cent D.P.) and as much good quality farm roughages as the calf can eat. If legume hay and maize silage are good enough to be relished by the calf, 2 to 3 lb. of concentrates will be enough. In fact by the time the calf is nine months old the concentrate may be replaced by corn and cob meal. On the other hand if only poor veld hay and poor silage is offered the calves will not get sufficient nutrients for their needs. If they are to be big enough for service at 15 to 20 months of age then 5 to 6 lb. (15 per cent D.P.) of concentrates will have to be fed each day. Unless this is done service will have to be put off until the heifer has grown sufficiently.

In summer, yearlings on veld may gain 1 lb. or more in weight each day yet young calves seem to be unable to thrive on the same grazing. It is best, then, not to allow young calves that are less than a year old to exist only on veld grazing. If suitable kraals are not available concentrates should be put in troughs on the veld. The best management is to bring the calves into a hut at night for feeding so that they can be warm and dry. After a rainy day on the high veld a calf is wet, cold and miserable and receives much benefit from

being warm and dry at night. Maize meal should be fed (4-6 lb. a head a day) from the beginning of the grazing season until the feeding value of the grass declines in March. At this time the winter feeding programme should begin.

8.8 THE GROWTH OF YEARLING HEIFERS

At some time in their second year of life dairy heifers should be got in calf. The size of the young heifer at first service and its rate of growth up to calving have an important effect on yield of milk in the first and second lactations. If early calving is combined with underfeeding in the rearing stage then the heifer may be permanently stunted and its milk production low. It is of great importance, therefore, to aim at a steady rate of growth for the heifer until it first calves.

TABLE 13

Recommended Growth of Dairy Heifers in Africa

Age	*Liveweight*			
	Jersey		*Friesland*	
	Body weight	*Daily gain*	*Body weight*	*Daily gain*
(mths)	(lb.)	(lb.)	(lb.)	(lb.)
Birth	40		90	
		¾		1¼
3	105		205	
		1½		2
6	260		385	
		1¼		1½
9	375		520	
		1		1½
12	465		655	
		¾		1½
15	530		790	
		¾		1
18	595		880	
		¾		1
24	725		1060	

Some farmers like heifers to calve when they are two years old. To be sufficiently well grown heifers have to gain from 1 to 1½ lb. a day according to breed from birth to one year. In practice it is customary to encourage a fairly high rate of gain until the calf is about 12 months old. After this the calf should be able to grow satisfactorily on good quality roughages together with a little concentrate. The figures in Table 13 show the growth recommended for calves of different ages in Central Africa. Such animals can be served when they are 15 months old and when they calve at two years they will be well grown.

Although calving at two years of age often occurs, many dairy farmers prefer heifers to calve from the age of 27 to 30 months. All dairy farmers agree that size or weight for age is more important than age itself in its influence on lactation yield. Farmers usually arrange for service when they consider the heifer to be big enough. Date of service should be delayed on farms where food quality is poor. Although some animals receive very poor feeding they continue to grow until they reach mature size for their breed. The longer this takes the longer these animals will be in reaching full milk production. The advantage of the steady growth which has been recommended, therefore, is to bring the heifer into full milk production at an early age.

Too much importance cannot be given to the need for regular gain in weight of young heifers. Too many calves are turned out to grazing too soon in summer. This poor management often produces calves that have gained no weight after five months on grass. The result is stunted heifers which calve on reaching weights of 500 to 700 lb. for small and large breeds respectively. This is why yields in the first lactation are disappointing in many herds in Central Africa.

In general a big cow will give more milk than a small one simply because her important organs are bigger, i.e. large stomach, large udder etc. Consequently heifers must grow to the mature size for their breed if they are to produce near to the average yield of milk for that breed. The remedy, previously mentioned, is to keep calves in kraals until they are a year old or make some provision for concentrate feeding. Experience at the University College Farm has shown that growing Jersey heifers need 3-4 lb. of maize meal each day to gain 1 lb. a day in the summer grazing season.

Young heifers need a full winter diet from 1st March. If no legume hay or fresh green forage is available then 4 lb. concentrates (15-16 per cent D.P.) should be fed daily together with 5 lb. of silage for each 100 lb. liveweight. Grass hay should be freely available. This diet will provide for about 1 lb. gain daily. If legume hay is on hand then it can be used to replace all or part of the concentrates at the rate of 2 lb. hay to 1 lb. concentrates. Some examples of diets for yearlings of different sizes are shown in Table 14.

There is a limit to the amount of poor dry roughage an animal will eat unless it is chaffed and made more palatable with a solution of molasses (one part molasses to two parts water). If appetite is still poor 1 or 2 lb. of maize meal will be needed as a readily eaten source of energy.

TABLE 14

Diets for Yearling Heifers

Diet	*Food*	*Quantities of food for animals of different sizes*		
		400 *lb.* *liveweight* *lb.*	600 *lb.* *liveweight* *lb.*	800 *lb.* *liveweight* *lb.*
1	Meal (15% D.P.) ..	4	4	4
	Maize silage (ave.)..	20	30	30
	Grass hay (ave.) ..	*	*	*
2	Meal (15% D.P.) ..	2	2	2
	Legume hay (ave.)..	4	4	4
	Maize silage (ave.)..	20	20	30
	Grass hay (ave.) ..	*	*	*
3	Legume hay (good)	7	7½	7½
	Pumpkins	10	—	—
	Melons	—	20	—
	Maize silage (ave.)..	—	—	20
	Hay (poor)	*	*	*

*=feed to appetite

These diets provide for a liveweight gain of about 1 lb. a day. If pumpkins and melons are not available for the third group of diets feed 1-1½ lb. concentrates instead.

9.0 Dairy Cattle Breeding

9.1 BREEDS SUITABLE FOR DAIRYING

There are many different breeds of dairy cattle and most farmers believe that the particular breed they keep is superior to all others. For all practical purposes none of the true dairy breeds is superior to other breeds if, by superior, we mean that one breed produces more milk from a given quantity of food than another. While it is true to say that cows of large breeds (1,200 lb. liveweight) produce more milk than cows of small breeds (800 lb. liveweight) they need much more food to enable them to do so. On the average three cows of a small breed weigh as much as two cows of a large breed and, for roughly the same amount of food, will produce about the same quantity of milk. This is because the amount of food a cow needs is related to liveweight and to the amount and fat content of milk produced. The most important factor in profitable milk production is not breed but the ability of the farmer to select cows and to manage them economically. No matter which breed is chosen the able farmer can make a living out of dairying.

In Central Africa most of the world's dairy breeds are to be found but only Frieslands and Jerseys are important numerically. Both of these breeds are highly adaptable and are able to thrive under a wide range of conditions, provided they are properly fed and managed. Space does not permit a description of all the dairy breeds but their main production characteristics are listed in Table 15. A few remarks about the two main breeds, however, are necessary.

TABLE 15

The average yield of registered cows of the main dairy breeds in South Africa

	Yield lb.	*Fat %*	*Days in Milk*
Ayrshire	8,500	3·9	294
Dairy Shorthorn	6,575	3·8	295
Friesland..	10,500	3·6	297
Guernsey	8,775	4·5	298
Jersey	7,075	5·1	296

Friesland. This is the largest of all the dairy breeds (1,200 lb. liveweight) and came from Holland originally. Various countries have developed their own particular type of Friesland, e.g. British Friesian, the Holstein Friesian of the U.S.A., the Friesland of Southern Africa and, the most recent strain, the Israeli Friesian. Frieslands are noted for their ability to produce large quantities of milk which is somewhat low in butterfat content. Friesland breeders have been aware of this and, for a number of years, have tried to improve butterfat. The popularity of the breed increases annually. This is mainly due to high milk yields but also to the reliability of pure-breds as milk producers. The breed is also remarkable because steers fatten readily to provide choice beef suited to modern markets.

Jersey. The breed takes its name from the island in the English Channel where it was developed. Pure-bred Jerseys give milk with a higher butterfat content than any other breed. The butterfat has a rich colour and forms a deep layer of cream which is readily seen when milk is sold in bottles. This looks attractive and many consumers in towns are prepared to pay an extra penny a pint for Jersey milk. It is, therefore, a popular breed with farmers who sell direct to the consumer. It is probably the most economical producer of butterfat of the dairy breeds and Jerseys are often to be found in herds of other breeds in order to raise the butterfat content of herd milk. Also Jerseys are popular in districts and countries where cream is sold for butter making. Unfortunately the Jersey steer will not fatten economically and is of little value.

9.2 BREEDING, INHERITANCE AND MILK PRODUCTION

If the dairy farmer is to breed cows of high milking capacity it is important for him to understand something of the way parents pass these productive characters to their offspring. Animal breeding is a complicated subject and space permits only a broad outline of what takes place. Books for further reading are given in the book list.

Inheritance. Hereditary controlling substances called "genes" are passed from parents to offspring by the sperm of the male and the egg of the female. When a sperm enters the egg the latter becomes fertilised and begins to grow to a pattern or plan according to the genes it contains. Thus genes are organiser substances which direct the development of the fertilised egg cell. The general pattern of development in animals is always the same for any sort or species, i.e. cattle always produce calves and not lambs. But no two cattle are exactly alike. The appearance and productivity of each animal depends on the genes it receives from its parents and on nutrients and other environmental influences which can modify the gene "master" plan for development. The need to provide the best possible food and environment has been emphasised in earlier chapters.

The genes in the fertilised egg have been received equally from the parents so that half of an animal's inheritance has come from its sire and half from its dam. From each parent a sample of genes is passed to the offspring by a process of chance assortment. It is thus largely a matter of luck what genes the offspring receives and, consequently, what its hereditary or potential possibilities for productivity will be. (Hereditary potential means what an animal can produce given a favourable environment). Unfortunately the characters of economic importance are not controlled by single genes. If this happened it would be a fairly simple matter to breed animals with the potential for high productivity. In fact many genes acting together govern characters such as milk yield and butterfat production. This statement is obvious when we think of milk production as the end result of a well developed body, digestive system, blood supply, udder and so on. Nevertheless, when a highly productive cow is mated to the son of a similar cow, the chances are that the offspring will be highly productive as well. This fact has been known from ancient times and is contained in many sayings, e.g. "Mate the best to the best". At the same time, there is a tendency for the sample of genes an offspring receives to be nearer to the average of the breed population as a whole than to those of its parents. The offspring, then, of low-producing parents are likely to be more productive than their parents, while offspring of highly productive parents are likely to be less productive.

Progeny testing. Because of this chance passing on of genes and the tendency for the sample of genes to be nearer to the average of the population than those of parents, men have devised ways by which the element of luck in animal breeding can be removed. It is often said that, "a bull is half of the herd", and this is true in-so-far as a dairy herd is composed of many cows and one or more bulls. If a bull can be found which is known to pass on genes for high productivity regularly, then he will be able to sire daughters whose average potential for production will be greater than that of their mothers. This can be done by the process known as "progeny testing",

Young bulls of suitable appearance should be chosen for test from families noted for high production. They are mated to a group of females and judged on the productivity of the heifers they sire. The test may be done at a "progeny testing station" where the performance of groups of 15-20 daughters of several bulls may be compared. This method is expensive and can only be carried out by Government organisations or very wealthy farmers.

In the past few years a promising new system of rating a bull's merit has been developed. Young bulls of suitable appearance and breeding are held at artificial insemination centres (see Section 9.5) and their semen used to inseminate (fertilise) a number of females in various dairy herds. When the offspring from these inseminations have been reared and completed their first lactations, the bull's merit rating is worked out. The yield of his daughters is compared with the yield of the daughters of other bulls in the same herds in the same year (i.e. their contemporaries). The bull is rated according to the number of gallons of milk his daughters give above or below their contemporaries. Thus a bull may be rated + 100 gallons, i.e. the average yield of his daughters was 100 gallons more than that of their contemporaries. This "contemporary comparison" of bulls, as it is called is usually carried out by an independent organisation serving the interests of farmers, consumers and Government. The money needed for the work is provided by either a direct or indirect levy on milk sales. In this way both farmer and consumer serve their own interests by contributing funds to enable bulls of merit to be found so that milk can be produced more efficiently.

Heredity and environment. The results of progeny testing and contemporary comparisons have served to confirm what was already known. In any population of cattle there are a few bulls (less than 10 per cent) which are able to breed daughters with a higher potential for production than the average. There are a similar number of bulls capable of reducing the productivity of their daughters. The vast majority of bulls breed daughters which have the potential to produce near to the average for the breed. The average farmer, therefore, can do nothing or very little to improve the potential productivity of his cows by trying to breed a superior bull. He is obliged either to rely on the stud breeder for a herd sire or, if available, take advantage of the artificial insemination service. In either case he is unlikely to be sure that what he gets will improve the potential productivity of his cows.

Potential productivity is an important ideal. It means that an animal has a set of genes which, in a favourable environment, will allow it to reach a certain level of production. Because most animals have an average set of genes for their breed then it follows that if the environment (feeding and management) is "right", most animals are capable of producing near to the average for that breed. For example most Friesland cows should be able to produce about 900 gallons of milk in a lactation of 300 days. This has been established as a fact in many herds in many countries of the world. Indeed only 10 per cent of the difference in milk yield between dairy herds is due to hereditary potential for production.

This remarkable information can be stated in another and important way—90 per cent of the milk a herd produces is due to the way it is fed and managed and only 10 per cent is due to differences in breeding. All farmers, then, can make sure their cows produce well if they set about the task in the correct way. The position is rather different when we consider the individual cows within a particular herd. Every cow gives a different yield of milk and 30 per cent of this is due to heredity. This is why it is important to choose the offspring of high yielding cows when purchases are made. Butterfat percentage is more strongly inherited than milk yield, i.e. 30 per cent of the variation between herds is due to heredity. Thus in herds where the butterfat percentage of the milk produced is lower than the average for the breed, a bull must be used from a family noted for producing milk of higher than average butterfat content. Such policy has led to the improvement of the butterfat percentage in milk from many herds of British Friesians in recent times.

For too many years the belief has been cherished that if only the right sire could be found, herd yield would be markedly improved. In the light of modern knowledge of inheritance this belief is mistaken. Most cows have a greater potential for production than is generally realised if only they are fed and managed in the way described in this manual. In this connection an important trial in Denmark is worth mention. Believing that most cows rarely produce up to their hereditary potential, a man named Eskdahl, by careful feeding and management, was able to double the yield of two dairy herds in a year. Average yield a cow rose from 10,000 lb. to 20,000 lb. of milk a year.

The commercial dairy farmer's plan is thus clear. He must choose the best cows he can for dairy appearance from either families or dams known for milk production. He must get the best bull he can afford or take advantage of the artificial insemination service. He has now done all he can to ensure that he has a good sample of the breed of his choice. At this stage begins his real job of feeding and managing his cows to enable them to produce profitably. In fact, so far as the commercial dairy farmer in Central Africa is concerned, a knowledge of breeds and breeding is the factor which contributes least to successful dairying. The best breed and the best breeding policy at the present time is an ample supply of high quality food which has been produced cheaply.

9.3 CULLING

In any herd there will be a number of cows which do not respond to the kind of feeding and management described in this manual. Provided poor performance is not the result of either ill health or lack of size due to poor rearing, then the farmer must assume that such animals are inherently poor producers. While most cows have the ability to produce near to the average for the breed there will be about 10 per cent which produce well below average. These cows must be culled because they cannot respond to normal management and are likely to be unprofitable. For example if the "average" Friesland has a peak daily milk yield of 5¼ gallons then four such cows would produce 21 gallons each day between them. Where peak yield is only three gallons a day then seven cows are needed to produce the same amount of milk. In general the amount of food needed to provide for 21 gallons of milk will be the same for the two groups of cattle. But as each cow must be provided with food for maintenance of her body functions, then milk from the low producers is more costly to produce than that from high producers. The extra cost is exactly three maintenance diets. A little reflection will show that three maintenance diets are roughly equivalent to the nutrients needed for the production of five gallons of milk. Careful culling for milk yield will result in a fairly rapid improvement in average yield a cow in the first three or four years it is practised. Thereafter improvement will be slow because the poor cows will have left the herd.

9.4 MILK RECORDING

Neither selection for milk yield nor feeding according to milk yield can be carried out unless records are kept of the milk produced by each cow. The best aid to selection and management is provided by daily records of the milk yield of each cow. The alternative is to record milk yield on one and the same day of each week and to multiply this record by seven to provide an estimate of the amount produced in that week. The daily record is by far the best aid to general management. There is a small, normal variation in daily yield with every cow but when yield at any one milking falls by 10 or 15 per cent (i.e. 3 to 4½ lb. in 30) it generally indicates that something is wrong. It may indicate that the cow is sick so that other symptoms must be looked for. Alternatively, if all cows drop in yield, an error in management may have occurred, e.g. insufficient food or lack of water etc. (See fig. 3).

The importance of providing a cow with sufficient nutrients according to the amount of milk she produces has been stressed throughout this manual. Clearly this can only be done if milk records are kept. When all of the daily records are added together the lactation yield of a cow is arrived at. This enables the famer to compare the performance of the various cows in his herd. By adding together all of the completed lactations in a year and dividing by the number of cows which produced them, a "herd average" can be calculated. This can then be used to compare herd performance with that of other herds operating under similar conditions. Such information helps a dairy officer to find out why a particular herd does well. It also allows him to help other farmers whose herds produce at below the average for a particular breed. Again, when animals are sold, milk records of high producers help the farmer to realise a higher price for his animals.

COW No	CONC FED	SUNDAY AM	SUNDAY PM	MONDAY AM	MONDAY PM	TUESDAY AM	TUESDAY PM.	WEDNESDAY AM.	WEDNESDAY PM	THURSDAY AM	THURSDAY PM.	FRIDAY AM.	FRIDAY PM	SATURDAY AM	SATURDAY PM.	TOTAL	REMARKS.
NORMAL YIELDS						WEEK: 21 - 27th JUNE 1964											
K 2	6	16	13	16	13	17	11	16	13	17	12	17	13	16	13	203	
K 4	6	19	14	18	13	21	15	18	15	20	14	20	14	20	14	235	
K 10	6	16	12	16	11	17	9	14	14	16	11	15	12	16	12	191	
K 20	6	16	12	16	10	16	11	16	12	17	12	17	12	16	20	203	
B 21	4	11	9	11	7	11	9	11	9	11	9	12	9	12	9	140	
B 22	5	13	10	13	10	15	11	13	11	14	9	15	9	15	8	166	
B 24	5	15	12	16	11	15	11	15	11	15	11	16	11	16	9	184	
B 25	6	16	12	16	11	17	12	15	12	16	11	16	12	18	11	195	
B 26	6	16	12	17	11	17	11	16	12	17	12	17	12	17	11	198	
B 27	4	11	8	11	8	10	9	11	9	13	8	13	9	12	9	141.	
YIELD CHANGES IN SICK COWS											FEB & MAR 1960						
K 5	4	11	9	11	9	11	9	12	9	11	9	12	9	11	9	142	WEEK 1.
	4	11	7	11	5	10	7	10	6	*6	4	3	4	6	5	95	2 *TREATMENT
	4	7	5	6	5	8	5	7	5	7	5	9	7	9	6	91	3.
N 23	6	16	14	18	13	18	11	*10	6	11	7	12	7	16	10	169	WEEK 6 *TREATMENT
		15	11	16	12	15	12	15	12	14	12	15	12	15	12	188	7

FIG. 3. Daily milk yield in healthy and in sick cows.
The yield of K4 began to drop on Sunday PM but she was not treated (for gall-sickness) until Thursday AM by which time her yield had dropped by half. On the other hand N23 was treated for the same disease immediately her yield fell (Wednesday AM). In consequence, her loss in yield was small and her recovery rapid. The value of daily recording in prompt treatment of disease is apparent.

9.5 ARTIFICIAL BREEDING

As the title implies, artificial breeding means breeding by other than natural means. In cattle, bulls are persuaded to serve into an artificial vagina so that their semen can be collected into a glass tube. The semen can be diluted with special fluids so that the fruits of one service can be used to fertilise or inseminate about 300 cows. By these means one bull can provide enough semen for the insemination of 10,000 cows each year. Semen can be stored for many years so that today it is possible for a bull to sire offspring long after his death. Artificial breeding or artificial insemination (A.I.) holds out promise that as bulls are found which pass on superior genes for production, the greatest possible use will be made of their semen. Although the practice is ancient it is only in the last 20 years that it has been used extensively in dairy farming. At first breeding authorities thought that the widespread use of A.I. would lead to the rapid improvement of the hereditary potential of dairy cattle. This has not taken place because of the scarcity of, and difficulty of identifying, bulls which are better than average. However it has stimulated a keener interest by farmers in dairying which has led to improved management and so improved production in many countries. It is a blessing to the owner of a small herd who can dispense with a bull and keep a productive milking cow in its place. Conception rates (number of cows that conceive) is the same for A.I. as it is for natural service when skilled workers are at hand. If a cow is seen to come on heat in the afternoon she should be inseminated early the next day, i.e. about 12 hours after the onset of heat. Similarly a cow which comes into heat in the morning is usually inseminated in the evening. The greatest chance of conception taking place is about 10 hours after a cow's season or heat has come to an end.

9.6 REGULAR CALVING

The cow comes into season or on heat each 20 days on the average, although this time can vary one or two days each way. While she is "on heat" she will take the bull and probably conceive. The heat period lasts for about 18 hours but can be of very short duration under certain circumstances, i.e. very high or low temperatures or very low level of nutrition. Putting heifers in calf presents no difficulty when they run with the bull or are kept in a kraal next to his and put in with him as needed. Cows can present difficulties and it is important to get them into calf regularly otherwise the intervals between their calves are too long and annual production is reduced. Furthermore cows must be got in calf fairly early in lactation because they become increasingly difficult to settle in calf after the fourth heat after calving.

In the tropics it is probably best to have a cow served at the third heat after calving because it gives the animal a good chance of calving again within the year. It is important for the farmer to make a record of when each animal comes into season so that he can make a note to look out for it. This is useful at times when animals are on heat for a few hours at night and heats may be missed. This difficulty may be partly overcome if cows due to come into season are put with the bull overnight. Again when a cow has been served she must be watched when her next heat falls due in case she did not hold to service. If a cow is not pregnant and her heat periods are short and occur at night, several months may pass before the farmer realises she has not conceived. Many valuable cows have been spoilt in this way through lack of attention. There is no easy way to ensure high fertility in a dairy herd. Adequate feeding helps and especially an adequate ration of fresh green food daily—lucerne being the crop of choice. But careful observation of cattle and recording of their heats must be carried out conscientiously.

Carefully kept service records are needed so that cows can be properly dried off before steaming up begins (Section 7.2). It is usual to dry off lactating cows eight weeks before they are due to calve. A shorter period than this does not allow the cow enough time to recover from the strain of lactation and so leads to lower yield in the next lactation. Some cows go dry well before they are due to calve. Others milk right up to the time their next calf is due and must be made to go dry. Such persistent milkers pose a problem in some herds because farmers know that udder troubles arise unless these cows are handled carefully. It is now well established that the best way to dry off a cow is to stop milking altogether. The concentrate ration should be stopped a few days before the cow is to be dried off but she should continue to graze or have roughages according to season. On the day of drying off the udder should be protected in the way described in Section 10.6 and the cow fed a diet of hay and restricted water (two or three buckets a day). The reduction of food and build-up of udder pressure when milking is discontinued, stops further milk production. The old method of milking once a day for a time followed by milking on alternate days, has been shown to result in more mastitis than simply stopping milking and reducing the cow's diet.

9.7 CARE OF THE BULL

Bulls need careful feeding and management in the same way as other dairy animals. Their rate of growth is usually expected to be higher than that of heifers so that feeding must be generous (see Section 8.8). Good pasture in summer and good quality roughage in winter should be the basis of the diet. Enough concentrates should be given to ensure rapid growth in young bulls. Usually the working dairy bull does not need much concentrate if quality roughages and lucerne are available. If the bull shows a tendency to put on too much flesh the concentrates can be reduced to a handful each day. However, many farmers like to feed some concentrates because this practice provides an opportunity whereby the bull may be tied up each day and handled. In this way he becomes used to the discipline of his master.

A well grown bull can be used for service when he is one year old provided he serves no more than one or two cows a week. There is no rule on this because much depends on the individual bull's keenness and stamina. When fully grown, bulls should be able to serve twice a day for three or four weeks but need a rest afterwards. When at service the bull needs about 30 lb. of green forage and 10 lb. grass hay each day. Concentrates should be offered at the rate of ½ lb. for each 100 lb. of liveweight a day or according to the bull's condition. Some farmers believe that no more than 15 lb. of silage should be fed daily otherwise the bull will become paunchy and therefore slow and clumsy at service.

9.8 BEEF FROM THE DAIRY HERD

Once a holding is fully stocked only a small number of heifers from the best cows should be needed for replacements each year. Unless there is a profitable market for surplus heifers and steer calves the natural annual increase of the herd can become an embarrassment. In fact over the past few years many calves have been slaughtered soon after birth because this was the most economical way to deal with them. A world shortage of beef has drawn attention to the need to prevent these surplus dairy calves being wasted in this way.

Calves of the Ayrshire, Guernsey and Jersey breeds are quite unsuitable for profitable beef production. Dairy cows of these breeds, whose calves are not required for herd replacements, should be got in calf with a beef bull. A cross with an improved indigenous breed is likely to impart hardiness and vigour to the calf and is suitable where a moderate plane of nutrition is to be provided. Where calves are intended for rapid fattening then a cross should be made with a breed noted for its ability to put on flesh rapidly. Investigations into the beef breed most suitable to cross with these dairy breeds are in progress. At the present time the Charollais breed of France is probably the most suitable because of the large, well-fleshed cross-bred it produces. Unless artificial insemination services are available few farmers will be able to use this cross. The farmer must then use the best bull that is available locally. Calves of the Friesland breed can be fattened for beef readily but they need plenty of food. Like all European breeds whether beef or dairy they must be fed properly throughout the year.

Naturally, when a bull from a large breed is mated to a cow of a small breed, the calf will be slightly larger than usual. This may result in difficult calvings which all dairy farmers try to avoid. Experience has shown that these rarely occur with mature cows provided they are well-grown for the breed. However, bulls of large breeds should not be used on heifers of small dairy breeds.

10.0 Milking Methods

The art of milking is as old as time and until comparatively recently cows all over the world were milked by hand. Most cows in Africa are still milked by hand but as living standards improve and the cost of farm labour rises, then machines will replace hands at milking time. No matter which method is used there will always be a need to understand the art of removing milk from the udder. Not only does skilful milking lead to increased milk yield but the way it is carried out has an important effect on the health of the udder. Our new knowledge of feeding and managing dairy cattle has made high lactation yields of milk more common today than at any previous time in the history of dairying. Milking method also contributes to high productivity in dairy cows and provides the content of this chapter.

10.1 UDDER STRUCTURE AND MILK MANUFACTURE

The udder is composed of several kinds of tissue. It hangs from the pelvis by means of a central band of tough, fibrous tissues to which are attached

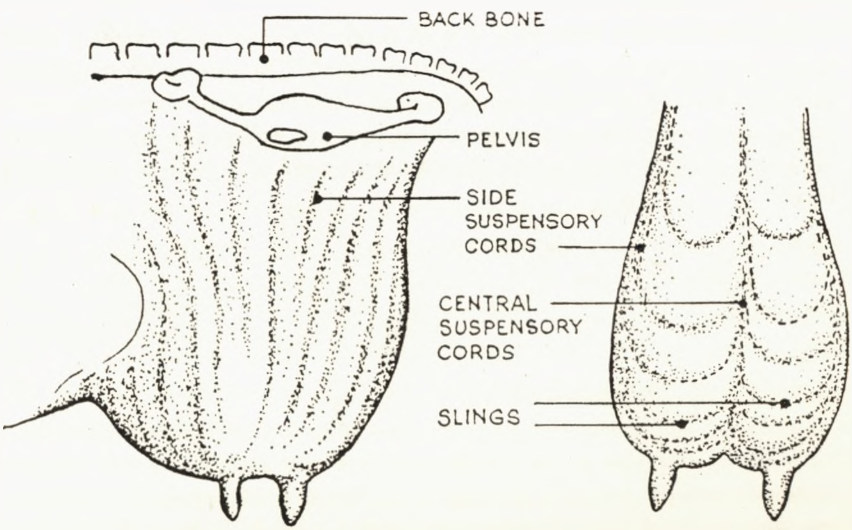


FIG. 4. The suspension of the udder.

a series of slings (Fig. 4). This arrangement, within the four quarters, makes a series of compartments which protect the milk producing tissues from pressing down on each other and so limiting the amount of milk which can be contained. The milk producing tissue is composed of a large number of tiny cells called "alveoli", (Fig. 5). Each alveolus has a supply of blood and lymph and is surrounded by muscles. The alveoli open into small ducts (tubes) which join up to form large ducts which lead into the milk cistern (reservoir). The

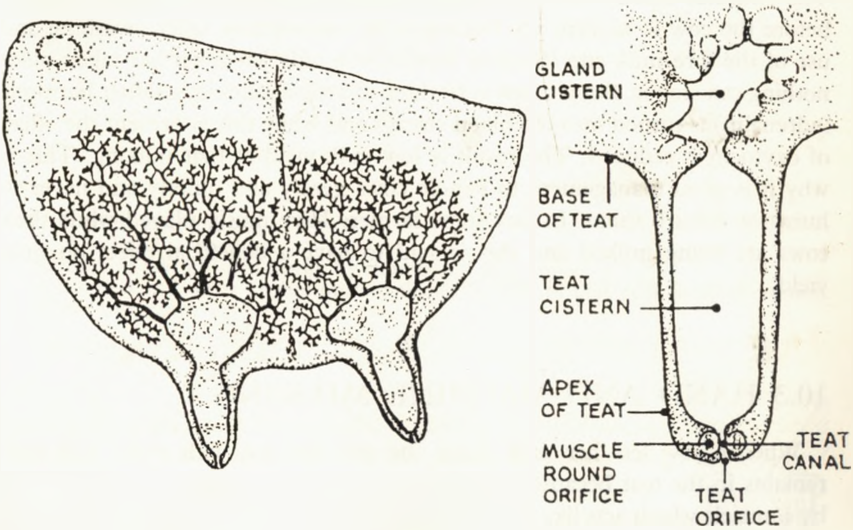


FIG. 5. The structure of the udder and teat.

way in which milk is manufactured in the udder is not properly understood. Milk is thought to be produced by the alveolar cells which draw raw materials from the blood (possibly by filtration), and change them into milk. Some of the milk constituents come from the blood unchanged.

All of the milk which can be drawn at a milking is present when milking begins. Milk production is a continuous process in the lactating cow so there is nothing the milker can do to increase the production of milk during the time when the cow is being milked. He can influence the amount of milk which can be removed and this will be described in the pages which follow.

10.2 MILK REMOVAL

A series of events must take place before milk can be removed from the udder. Sucking of teats by the mouth of the calf or massaging by hand causes nerves in the teats to send a message to the brain which causes a substance (the hormone oxytocin) to be released into the blood stream. When this reaches the muscles surrounding the alveoli it causes them to contract and this forces the milk they contain into the ducts and milk cisterns. Milk can then be drawn out of the udder readily.

Cows can be taught to release or "let-down" their milk by several different "stimulae" as they are called. Which stimulus is used does not matter but it is important that the stimulus should be a strong one and that it should be given just before milking takes place. The effect of oxytocin does not last long so that milking should begin as soon as milk has been let down into the udder. The stimulus can be made strong if several operations are carried out just before the cow is milked, i.e. feeding with concentrates, udder washing and use of the fore-milk cup (Section 10.6). Once milk let-down has taken place nothing can stop it. But if a cow is frightened before milking, another hormone (adrenalin) is turned into the blood stream and while this is present the effect of oxytocin is reduced. The result is low milk yield at that milking. This is why it is good management to handle cows gently and quietly and never to hurry or disturb them. In fact some farmers have music played while their cows are being milked and this is said to have a beneficial effect on milk yield.

10.3 HAND AND MACHINE MILKING

When a cow lets her milk down the teat fills out with milk. The milk remains in the teat because the opening or teat orifice (Fig. 5) is surrounded by a muscle which acts like an elastic band and so keeps it closed. The purpose of this muscle is not only to prevent milk running out but also to prevent bacteria from entering the udder and causing udder illness (mastitis). If the muscle is destroyed by injury milk runs out of the teat whenever milk let-down takes place.

Nursing by the calf. When the calf wants to drink milk it wraps its tongue around the teat and holds the teat firmly against the palate of its upper jaw. An airtight compartment is formed in this way and, by jaw movements, the calf is able to suck milk from the teat.

Hand milking. Several different methods of hand milking are practised but there is only one correct way. This method is called "full hand milking" and is illustrated in Fig. 6. Other systems of hand milking may lead to damage of the delicate tissues of the teat, setting up irritation which may lead to mastitis. A common method is to grip the base of the teat between thumb and index finger and to pull hard so that milk is forced out as the grip slides down the teat. Other grips are used for the same purpose—the most damaging is index finger and thumb knuckle which never should be used.

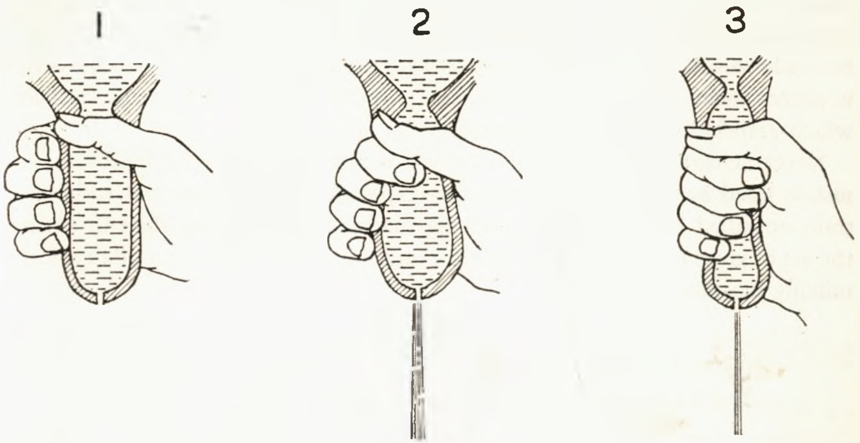


FIG. 6. Full hand milking.
1. The hand in position.
2. Base of teat gripped firmly by thumb and first finger.
3. Second and other fingers pressed firmly in turn so that milk is squeezed out of the teat sinus.

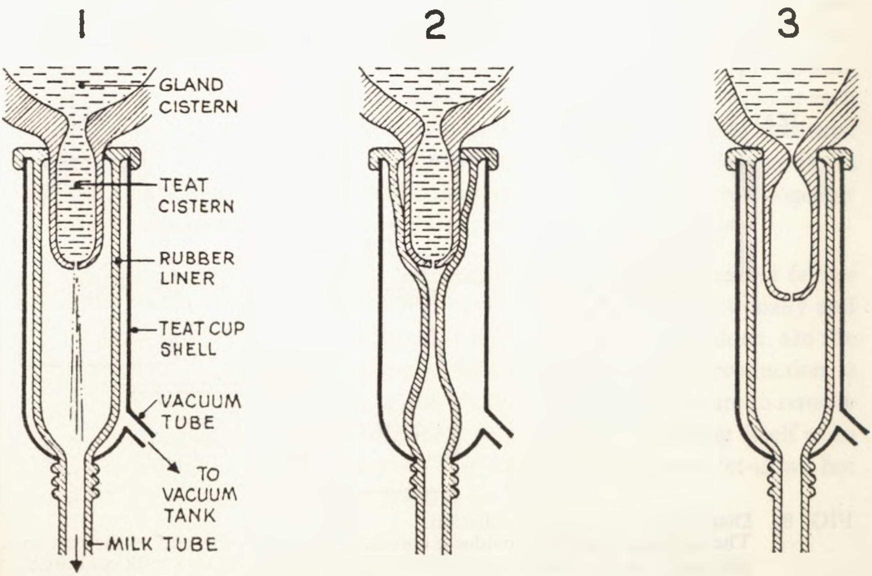


FIG. 7. The action of the teat cup.
1. Negative pressure ('vacuum') inside liner changes tension of muscle around teat orifice and milk flows.
2. Atmosphere enters space between rubber liner and teat cup shell so that liner collapses around teat. Milk flow virtually ceases and pressures on teat relaxed.
3. Towards end of milking teat drawn further into cup ('teat cup crawl'). The orifice between the teat cistern and the gland cistern is closed and milk flow almost ceases. Hence practise of pressing down on clawpiece with some machines to allow gland cistern to be emptied ('machine stripping').

Machine milking. The action of the milking machine is broadly similar to the action of the calf when it sucks. Unfortunately milking machines have to be made to suit the "average" cow—whatever that may mean. Consequently it cannot make adjustments to suit the particular size of teat or teat orifice which each individual cow possesses.

Nevertheless, when used correctly, the results of milking by machine are just as good as those by hand. In fact experience shows that it is easier to train unskilled labour to use a milking machine satisfactorily than to teach the art of good hand milking. Figures 7 and 8 illustrate the action of a typical milking machine.

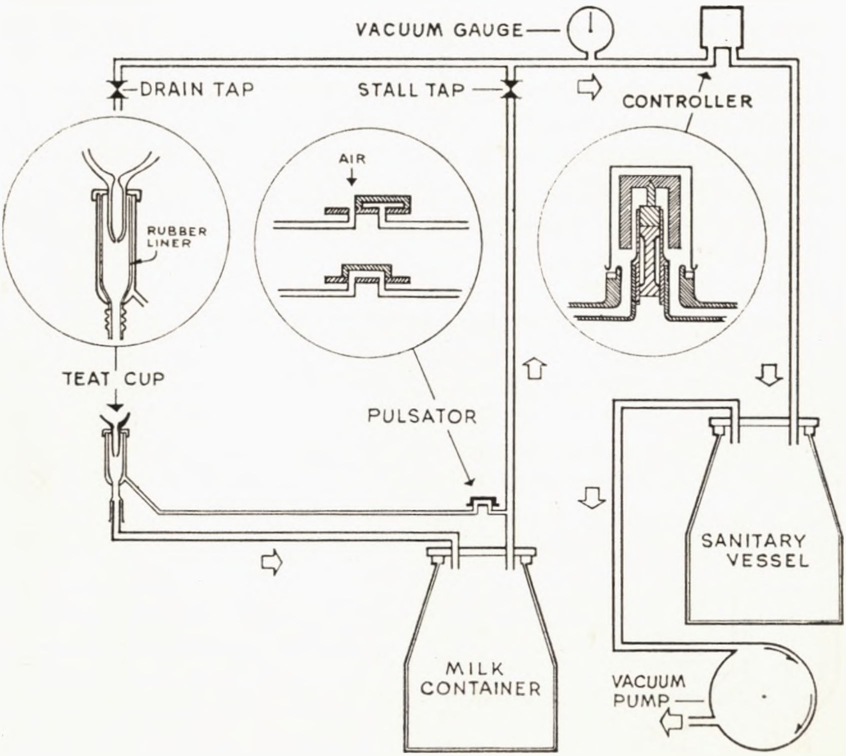


FIG. 8. Diagram of a milking installation.
The milking machine provides a constant vacuum to the end of the teat so that milk can be drawn out of the udder and conveyed to a milk container. A pulsator provides a periodic squeeze to the exterior of the teat in order to maintain blood circulation. A vacuum gauge gives an indication of the vacuum in the pipeline system to provide a check that the vacuum pump and controller are operating correctly. The vacuum controller ensures that the vacuum pump is supplied with a constant amount of air otherwise the amount of air extracted from the system by the pump would not be constant and vacuum would fluctuate. The sanitary vessel protects the vacuum pump from being flooded in the event of the milk container becoming flooded. It also acts as a reservoir for fluids which are drawn through the teat cups to disinfect the vacuum system. Drain taps fitted to provide an outlet for condensation products in the system.

Hard and easy milkers. The size of the teat orifice is different for each cow. If the orifice is small the cow is hard to milk, i.e. the fingers have to be clenched strongly and this can be tiring. On the other hand some cows have large teat orifices and these are easy to milk. Thus cows may be referred to as "hard" or "easy" milkers which is really comment on teat orifice size. Hard milkers tend to be a nuisance to labour and can upset the milking routine in milking parlours because they take a long time to milk. Easy milkers can be milked quickly and this ability is inherited.

10.4 MILKING FREQUENCY AND COMPLETENESS

Most cows are milked twice each day but it is well known that milking a herd three times a day leads to an increase in milk production; similarly milking four times a day brings a further increase in yield. No-one can agree on the amount of this rise in milk yield. All cows do not respond in the same way but between 5 and 25 per cent increase in yield can be expected for three, compared with two milkings a day. A further increase of about 10 per cent can be expected for four milkings compared with three. The increase in milk production might be due to some beneficial effect that more frequent milking has upon the cow's milk-producing organs. Again cows are usually fed at each milking and frequent feeding is known to lead to more efficient use of nutrients. Some farmers feed extra food when they begin to milk more frequently, in anticipation of increased yields. All of these three factors may operate together to bring about increased milk production.

The udder must be milked out thoroughly at each milking because failure to do so reduces yield at that milking. If this only happens occasionally and the udder is milked properly at the next milking, little harm is done. On the other hand if cows are incompletely milked regularly, milk production is reduced and the cow dries off more quickly than she should. Failure to remove all the milk available at a milking may be due to poor milking itself or to incomplete milk let-down by the cow. The need to train a cow to let-down her milk effectively was discussed in Section 10.2.

10.5 HOW MANAGEMENT AFFECTS MASTITIS

Mastitis means inflammation (swelling) of the mammary gland or udder. Inflammation, in the sense of departure from health, can be caused by injury through horning, butting or kicking by other cows. Such injuries may lead to a simple bruise with little or no effect on milk yield. At the other extreme severe bruising may occur, with extensive bursting of blood vessels, leading to discharge of blood with the milk and to loss of milk yield.

Mastitis as a result of injury is not common but the mastitis caused by the invasion by bacteria of the milk producing tissues is all too common. The amount of mastitis in our herds varies just as greatly as their milk yield. In some herds few or none of the cows are affected while in others 50 per cent or more of the cows have mastitis. Like milk yield, therefore, the amount of mastitis in any herd is the result of management. In most of the advanced dairying countries the loss of milk produced as a result of mastitis has been estimated to be at least 10 per cent. When to this is added loss of abnormal milk unfit for sale and the cost of treatment, the price for this disease is startling. The treatment of mastitis is usually expensive. It is often left so late that milk yield has fallen, udder tissue has been damaged and so future yield limited before the veterinary surgeon is called. Consequently the veterinarian is not given a fair chance to effect a cure. Prompt treatment, according to veterinary advice, is of first importance in mastitis as with any other disease.

Infection and mastitis. Mastitis which is the result of bacterial infection, usually affects one quarter at a time but two or more quarters may be diseased. Bacteria attack the milk producing tissue of the udder like a tribe of warriors intent on pillage and destruction. Mastitis bacteria can enter a quarter only through the teat orifice. Once inside they try to occupy the milk producing tissue and may stay there for several lactations. Such an occurrence is known as an "infection" and this may have no noticeable effect. On the other hand there may be a decline in yield and a decrease in the butterfat and S.N.F. content of the milk. Whatever happens the infected cow is a source of danger to the rest of the herd. An infected quarter acts as a reservoir from which bacteria can be spread to other cows and lead to a serious mastitis problem in the herd.

Symptoms. Why some cows become infected without much apparent damage is not fully understood. However some cows become infected and almost immediately the quarter becomes hard and inflamed and the nature and composition of the milk becomes radically altered. This event is called mastitis. The quarter becomes hard and swollen because it is filled by blood and lymph (a body fluid) which carry bodily defences to the affected part. The invasion by bacteria may be driven back and the quarter return to normal in a few days. In contrast the invasion may succeed and lead to extensive damage to the quarter which may never produce milk again. The cow may develop a high body temperature and refuse her food and water. The quarter may rot and actually drop off while so much poison may be made by the bacteria that the cow dies.

Between these extremes mastitis is often first noticed in well managed herds as a swelling or hardness in the affected quarter when milking is completed. In about half of such cases "clots" (Plate 3) appear in the foremilk. (Foremilk is that which is drawn immediately before milking begins

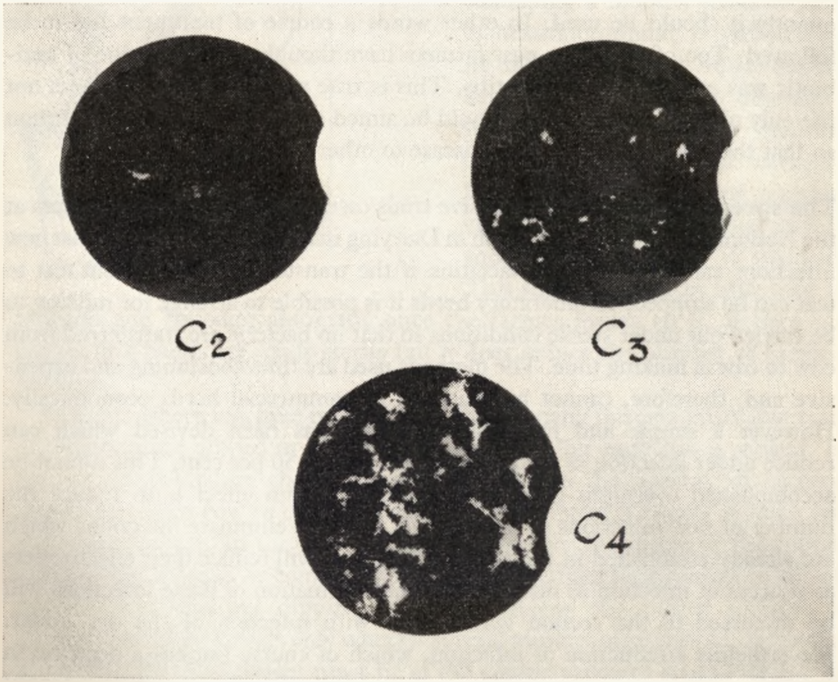


PLATE 3. Clots on the foremilk cup from mastitis milk.
C2. A few small clots which may indicate mastitis or a temporary upset not connected with mastitis.
C3. Well-defined clots indicating mastitis in a quarter.
C4. Clots from a severely affected quarter where the secretion was composed of clots and a watery fluid.
(Photograph by courtesy of The National Institute for Research in Dairying, Shinfield.)

for the detection of clots.) Clots are made of the tissue wreckage and corpses from the battle between bacteria and body defenders (phagocytes). Thus while clots usually indicate mastitis, they occur in milk after inflammation has taken place. Inflammation is detected by quickly feeling each quarter when milking is over. The liquid drawn from the udder in such cases is no longer milk. It may be thin and watery because of a decline in fat and S.N.F., it may contain blood or it may become thick with pus.

10.6 MASTITIS CONTROL

Treatment. Treatment of mastitis cases varies but the old, tried remedy of milking the quarter every two or three hours together with the frequent application of hot cloths should always be carried out. It is more common today to put an antibiotic into the affected quarter. This is wise provided the veterinarian's instructions are followed. He will use his experience and knowledge of the herd to decide which antibiotic, how much and how frequantly it should be used. In other words a course of treatment has to be followed. Too often in the past farmers have thought that one tube of antibiotic was enough to cure mastitis. This is true sometimes but a cure is not the only objective. Treatment should be aimed at the elimination of infection so that the cow does not spread disease to other cows.

The spread of infection. Extensive trials carried out by research workers at the National Institute for Research in Dairying in England have shown that new infections can be reduced in lactation if the transfer of bacteria from teat to teat can be stopped. In laboratory herds it is possible to arrange for milking to be carried out under sterile conditions so that no bacteria are transferred from cow to cow at milking time. The methods used are time consuming and expensive and, therefore, cannot be practised in commercial herds economically. However a simple and inexpensive routine has been devised which can reduce udder infection in the majority of herds by 50 per cent. This cannot be accomplished overnight because the routine's main effect is to reduce the number of new infections in lactation. It does not eliminate infections which are already established in the udder although it will reduce their effectiveness as sources of infection to other cows. The elimination of these infections will be discussed in the section which deals with infection of the dry udder. Nevertheless a reduction of infection, which of course implies a decrease in mastitis, indicates a remarkable achievement and represents a substantial advance in dairy husbandry.

Preventing the spread of infection. Bacteria are spread from cow to cow at milking time by the things which touch the udder and teats i.e. hand, udder cloths and teat cups. Various routines have been tried over the years to try to ensure that these items are sterile but success has been limited. Such routines have been successful only in herds where milkers are highly skilled and are prepared to pay a great deal of attention to detail.

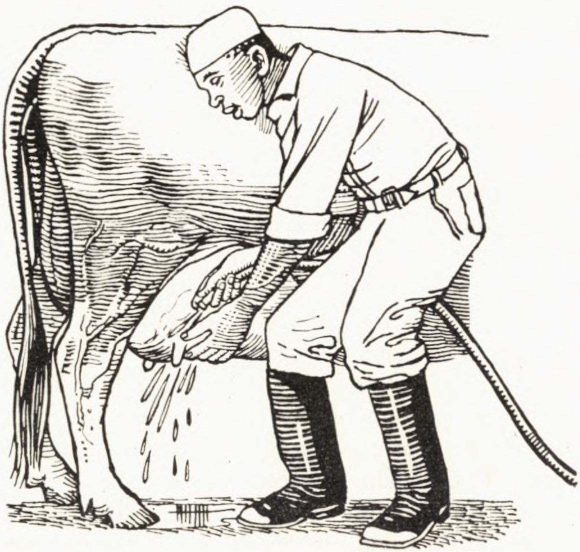
The hands of milkers are usually chapped and calloused, provide suitable homes for bacteria and cannot be sterilised easily. Ideally milkers should wear thin rubber gloves which can be disinfected readily and so the spread of bacteria can be reduced substantially. Unfortunately, in the African context, rubber gloves are expensive, have a short life when used by relatively un-

skilled labour and therefore farmers cannot afford to introduce their use. The alternative, although not entirely satisfactory, is to ensure that hands are thoroughly scrubbed and disinfected at the beginning and end of milking. A proprietary soap containing a modern sterilent such as hexachlorophine, is satisfactory. At milking time each milker should have his own bucket of detergent/sterilent (Section 11.2) solution made up to udder wash strength. Hands should be rubbed together vigorously in this solution before and after each udder is touched. This small chore takes little time to perform and becomes automatic once the farmer insists on it. It does not ensure that hands are made sterile but it does reduce the number of bacteria on them.

In herds where machine milking is practised many farmers insist that teat-cup clusters are dipped in a solution of sterilent after each cow is milked. In theory this procedure should substantially reduce the number of bacteria transferred from cow to cow. In practise it is doubtful if cluster dipping has the desired effect. In the first place to be effective the inside of the rubber teat-cup liner should be completely covered by sterilent long enough to kill-off bacteria. Most cluster dipping techniques expose the rubber surfaces to sterilent for a few seconds only whereas several minutes are required. Secondly, to be effective the sterilent must be at the correct strength recommended by the manufacturer. As milking proceeds the sterilent becomes diluted and looses its strength and therefore its effectiveness. Thirdly, rubber deteriorates relatively quickly in the tropics so that its surface becomes irregular (cracks, spongy surface, etc.). Such blemishes harbour bacteria which are difficult, if not impossible, to remove by cursory dipping in sterilents of uncertain strength. Tradition dies hard with some dairymen and, for those who insist on some form of cluster treatment after each cow is milked, the best method is to detach the cluster from the machine, attach its milk tube to a water tap and to flush it through.

Udder cloths are the third item which can spread bacteria at milking time. In the interests of clean milk production (Chapter 11) statutory regulations usually specify that the udder and teats should be washed clean before milking begins. Modern custom decrees that a detergent/sterilent solution be used for this purpose. This seems to be an unnecessary expense. In theory the procedure should help to disinfect the udder. In practise, unless the washing cloth is free from bacteria and the washing solution is at the correct strength, an udder cloth becomes a potent source of bacterial contamination. This situation has been recognised for a number of years. Some people try to solve the problem by having two cloths in a bucket of washing solution and use them alternately. In this way each cloth is immersed in the sterilent for at least five minutes after use. This is not sufficient to sterilise the cloth (i.e. free it from bacteria) but it will reduce the numbers substantially *if* the solution is at correct strength. Other farmers provide individual udder cloths for their cows which are used once and then sterilised by either boiling or steaming after milking. This is the ideal system but is too costly to operate in the tropics.

An effective alternative to the ideal is available. First of all farmers should try to ensure that udders do not become excessively dirty. This implies ample



bedding in cattle kraals and that animals lie dry in the rainy season. A hard approach route should be built to the entrance of the milking shed otherwise this becomes extremely muddy and udders are splashed or even sometimes dragged through mud. In the dairy udders should be washed with the bare hand while a gently-running hose pipe is held between the fingers. Vigorous rubbing will remove all caked mud and faeces and leave the udder clean. It should then be wiped with a disposable paper towel which has been wetted in a bucket of sterilent. The paper towel should then be gently squeezed free of moisture and the sole of the udder and teats damp-dried.

In rural areas water may often be in short supply for part of the year and in any case may have to be carried to the milking shed. Herds in these areas will usually be small. A modified, if somewhat less satisfactory, system must be used. About half a gallon of water per cow should be used to wash the udder with the bare hand. This water should be thrown away when the udder is clean. The udder should then be wiped with an udder cloth which has been standing in a detergent/sterilent solution, the cloth should then be squeezed free of moisture and the udder and teats damp-dried. If this system is followed carefully in a small, hand-milked herd, there is a good chance of keeping the detergent/sterilent solution up to strength. Furthermore the cloth will be in the sterilent at least five minutes before it is needed for the next cow and should be reasonably well freed from bacteria.

TABLE 16

The effect of a hygienic routine on the course of a mastitis outbreak in a dairy herd

	Oct.	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*
No. cows in milk	53	49	54	63	63	60	62	63
No. cows with mastitis	6	5	11	19	14	8	4	4
No. quarters with mastitis	6	5	13	23	24	10	4	6

The figures for mastitis in October and November show the usual amount found in the herd. A rapid increase took place in December and January. From 7th to 23rd February udders were washed with clean water then again with a sterilent solution. After each cow was milked the teat-cup cluster was dipped in a separate bucket of sterilent and the cow's teats were immersed in neat sterilent. The normal antibiotic treatment for mastitis was used throughout the entire period.

From: *Annual Report*, 1957. National Institute for Research in Dairying, Shinfield, U.K.

When milking is over, irrespective of which of the above systems is chosen, each teat should be immersed in a teat disinfectant similar to those advocated for use after milking. The success of a hygienic routine which includes teat dipping after milking is shown in Table 16.

There is a good reason why emphasis is placed on teat disinfection after milking. So far as we know infection takes place in the intervals between milking and not during milking. Consequently if teats are disinfected immediately after milking and bacteria are either eliminated or substantially reduced in numbers, the chances of infection taking place are also reduced. Unfortunately the skin of teats is not always easy to disinfect because it may be cracked, chapped, carry warts and indeed sores of all kinds. All of these skin blemishes are places where bacteria can thrive and in which they are difficult to kill with disinfectants. Consequently, the greater the number of skin blemishes the less effective any hygiene routine will be. Farmers should try to keep the skin of cows' teats as healthy as possible but this is easier said than done. Many claims have been made about the efficacy of various udder creams in curing teat sores and in keeping the skin of teats reasonably free from blemishes. Nevertheless there is insufficient information available to enable anyone to specify a cream or a combination of cream and chemical which will improve the condition of blemished skin.

All that can be said is to stress the importance of the problem and to enlist the advice of a veterinarian who has more experience than laymen. The sequence of events which lead to the outbreak of mastitis illustrated in Table 16 was associated with an outbreak of teat sores. These arose during a cold winter shortly after the cows had been moved to a new paddock and their route to the cowshed had been changed. This necessitated a walk through a lane where mud was so deep that udders were trailed through it before and after milking. Cows were re-routed to avoid this and to ensure that the benefits of the hygiene routine were not lost.

So far as our limited knowledge goes, disinfectants are likely to help to reduce teat blemishes to a greater extent than ointments of various kinds. It is often true that individual farmers have remedies which appear to give the desired effect. In herds where teat sores are not a problem, success with individual cases has been achieved. The danger arises in herds where teat sores are prevalent, where ointments are introduced and where indifferent labour is employed. In these circumstances ointments and their like may be applied indiscriminately, they may become contaminated from milkers' hands and serve as a vehicle for bacterial transfer. Ointments should only be used for specific purposes. Quite obviously if a modern routine is to be adopted, which embodies teat disinfection after milking, it is best not to smear all teats in ointment after milking. Otherwise, the teat dip, which should be the final operation after milking will not touch the skin and therefore cannot kill bacteria.

Protecting the dry udder. One of the modern keys to the reduction of mastitis in dairy herds is the protection of the dry udder from infection by bacteria. There is a wealth of evidence to show that infections which arise in lactation often persist in the dry udder until the next lactation. Furthermore many new infections occur during the dry period (Figure 9). No matter when these infections occur they are a common cause of mastitis when the cow calves again.

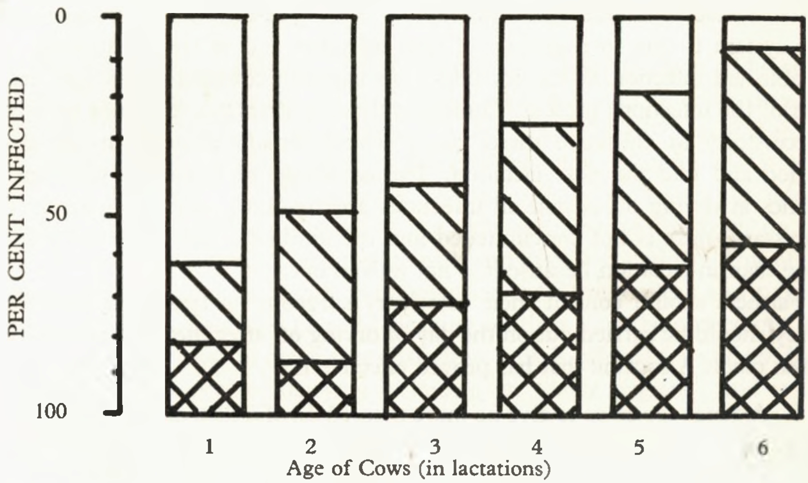


FIG. 9. INFECTION IN THE DRY PERIOD.

Cows infected at drying off.

New infections in the dry period.

(Based on data from 470 cows. Source: An. Rep. Nat. Inst. Res. Dairying 1964)

Records from 50 herds examined in England show that the udders of about 50 per cent of all cows are already infected at drying off. About 25 per cent of all cows contract new udder infections in the dry period. Some of these old and new infections disappear of their own accord but, at calving, about 60 per cent of all cows are still infected. Many of these cows are likely to develop mastitis and all are sources from which bacteria can spread to other cows. This must be prevented if mastitis in lactating cows is to be reduced.

Udder infection present in dairy cows, either throughout the dry period or arising in the dry period, reduces milk yield after calving. The yield of an infected quarter may be reduced by 35 per cent on average. However if the infection has been present from the end of one lactation to the beginning of another, yield may be depressed by 48 per cent. On the other hand if the infection has been eliminated during the dry period, the depression in milk yield of a quarter may be about 10 per cent. In terms of lactation yield per cow this means that if one quarter has been infected throughout the dry period, milk yield can be reduced by as much as 10 per cent. If two quarters have been infected then a loss in yield of up to 20 per cent can be expected. There is every reason, therefore, why farmers should try to reduce infection in dry udders.

The proportion of cows infected at calving can be reduced by approximately 75 per cent if a combination of antibiotic therapy and teat disinfection is carried out at the end of lactation. This treatment is not a mastitis control system in itself. It must be used in conjunction with an effective hygiene system in lactation otherwise cows rapidly become re-infected. The success of the system is due to reduction of new infection and to the elimination of established infection in the dry udder. In lactation cowmen detect less than half of the infections present. Consequently even if antibiotics could be used successfully to eliminate these, many would remain throughout the dry period and into the next lactation. The advantage of treatment with antibiotics at drying off is that all infections are attacked, only one infusion is necessary, milk is not contaminated and the antibiotic can act for a longer time than in lactation because it is not milked out.

Farmers should consult their veterinary surgeons on treatment routines. They should be carried out on the day of drying off after the last milking has taken place. A routine that has proved effective is:

1. Arrange for cows to give no more than 10 lb. of milk a day before drying off. This can be achieved by reducing food and restricting water if necessary.

2. Stop milking abruptly—this is the quickest way to dry off and causes no harm if yield has been reduced.

3. Clean teats thoroughly with an udder disinfectant. Infuse each quarter with an antibiotic recommended by the veterinarian.

4. Dip teats in an approved disinfectant at teat dip strength.

5. Watch for signs of swelling in quarters. The udder should shrink after a few days.

6. Report abnormalities to the veterinarian. If he cannot come at once, strip out the affected quarter, infuse an antibiotic as before and dip the teat in disinfectant again.

11.0 Producing Clean Milk

The milk which a baby sucks from its mother's breast is clean and wholesome. It is the same for the calf and when people buy milk to drink they too expect it to be clean and wholesome. In this sense "clean" means free, or almost free, from bacteria. Milk in the healthy udder is clean and it only becomes "unclean", or contaminated by bacteria once it leaves the udder. Bacteria are found everywhere—on the skin and hair of the cow, on the milkers hands and clothes, on dairy utensils and in milk containers. One of the most important sources of milk contamination is failure to clean and sterilise milk containers. Carefully planned cleaning routines must be carried out day by day by dairy staff to make sure that clean milk is offered for sale by dairy farmers. This aspect of dairying is known as "dairy hygiene" and is the subject of the sections which follow.

11.1 BACTERIA IN MILK

Souring Bacteria. The most commonly found bacteria in milk are those which cause souring (Section 1.10). Warm milk provides them with an ideal environment in which they can grow and reproduce in 20 minutes. This is an astonishing rate of growth when compared with about four years for cattle and 16 years for humans. At this rate one bacterium can develop into millions in 24 hours and so cause milk to turn sour. In such circumstances the milk is said to have a "poor" keeping quality.

Keeping quality test. A count of the numbers of bacteria in milk gives a good idea of how long it is likely to keep (at a certain temperature). As counting takes a long time a simple test is used to give a quick "estimate" of the numbers of bacteria present. This is known as the "methylene blue test". Methylene blue is a dye which loses its colour when oxygen is removed from it. When added to a sample of milk which contains large numbers of bacteria the colour is lost quickly because actively growing bacteria use large quantities of oxygen. Similarly the colour is lost slowly when there are few bacteria present.

Keeping quality payments. The methylene blue test may be used to encourage the production of clean milk. For example a dairy authority might decide that a methylene blue reduction time of three hours in summer and four hours in winter indicated that milk was of satisfactory keeping quality for human consumption. A bonus of ½d. a gallon could then be offered for each half hour above these times that it takes for the dye to lose its colour while below these times ½d. a gallon could be deducted in a similar way. This system is practised in Rhodesia where the maximum payment of deduction for keeping quaity has been fixed at 2d. a gallon. Where milk is of very poor quality the collecting dairy usually refuses to accept the milk and then it is returned to the farmer.

Harmful bacteria in milk. Cows may become infected with tuberculosis in the udder and shed these bacteria in their milk. They may become infected from other cows or from infected persons who handle cattle. Both dairy cows and dairy workers should be tested from time to time so that this disease may be controlled. Undulant fever in man results from infection with the bacteria which causes contagious abortion in cows (Chapter 12). Many other harmful bacteria occur in milk but they usually enter the milk after it has left the cow. Some of these cause fevers (diphtheria, scarlet, typhoid and paratyphoid fevers) and some cause severe stomach disorders (diarrhoea, gastro-enteritis and dysentry). Other bacteria can cause undesirable flavours and others a physical change in milk which dairies refuse to accept. Harmful bacteria, which enter milk after it has left the cow, may come from the droppings of infected cattle or from dirty water used in the dairy or from the hands of an infected human.

Clean methods are necessary at every stage in the production of milk. The possibility of the dairy refusing to accept milk and the bonus available in some countries makes it well worthwhile for the farmer to produce clean milk. At the same time it is his duty to produce a clean and wholesome product.

Water supplies. An ample supply of clean water is essential for the production of wholesome milk from the dairy farm. In this sense "clean" means free from pollution by bacteria which cause disease or undesirable changes in milk. In general, surface water cannot be considered to be free from contamination. If this is the only source then it must be purified by boiling, chemical disinfection or filtration before use. Such treatment is laborious on the farm and experience all over the world has shown that even modern purifying plants can break down and result in outbreaks of typhoid, cholera and other diseases.

The safest course is to use water drawn from a borehole because such water has usually been filtered and so purified through soil and rock on its way underground. Where the cost of a borehole cannot be met a simple well provides the next best source of water. Sources of contamination should be set a distance away from the well, i.e. privies, cesspools, manure heaps and so on. However the most common mode of pollution is through the top of the well. To prevent this a raised, water-tight platform made of concrete should be built to extend from 4½ to 6 feet all round the well. Its surface must slope away on all sides to prevent the soil becoming soaked around the top six feet of the well lining otherwise seepage into the well occurs. A further protection against seepage can be given if the top six feet of the well lining is made waterproof. Finally a protecting wall about three feet high should be built around the well which must be covered effectively.

11.2 CLEANING METHODS

In spite of the wide occurrence of a large variety of bacteria many dairy farmers produce clean milk day by day. Many different systems are followed but success does not depend on complicated routines, expensive equipment or a great deal of skill. Each farmer must get a cleaning routine made out for his own dairy system by the local advisor. The farmer should have the cleaning routine demonstrated to him and he should carry it out himself in front of the advisor so that he understands exactly what has to be done. He should then write out each step in the cleaning routine so that he can refresh his memory when needed. If he employs labour he must explain and demonstrate the system so that staff know what to do. After this he should arrange that certain jobs are done at certain times of the day so that he can supervise the critical stages from time to time.

Cleaning the cow. Udder washing was described in Section 10.6. Farmers should try to prevent udders from getting dirty in the first place. In winter, when cows are kraaled for part or all of the day, the kraals should be kept clean by spreading veld hay each day. This will reduce the amount of dung on udders and save time at milking. In the rainy season cows should be kept away from muddy paddocks and be given a hard approach road to the dairy to reduce the amount of mud they pick up. A concrete collecting yard greatly helps to reduce the amount of dirt carried into the dairy. Udders should be kept free of hair because this becomes caked with dirt which is difficult to remove. Where hand milking is practised it is wise to clip hair from both udder and flanks to prevent it falling into the milk as a result of the milker's movements. After each milking udder cloths must be rinsed in clean water and then washed in a sterilising solution and hung out to dry. Once a day they should be either boiled or steamed to make certain that bacteria are killed.

Cleaning materials. A great deal of dirt including bacteria can be removed from equipment by means of clean water, a scrubbing brush and what is known in some parts of the world as "elbow grease". Because milk fat becomes deposited on dairy equipment it is best to use a hot solution of a detergent (i.e.

cleaning agent). Household soap is the most commonly used detergent in the whole of Africa but it forms a scum in hard water which can be difficult to remove and is not recommended for cleaning dairy utensils. The cheapest detergent for general use in the dairy is ordinary washing soda and it forms the basis of several commercial compounds. For equipment in good repair a thorough scrub in a hot solution of washing soda makes equipment clean in normal circumstances. Unfortunately normal wear creates scratches on metal containers from which bacteria cannot be removed by the hot scrub routine. Again, circumstances are not always normal and some dairies are liable to heavy contamination of milk spoiling bacteria. Consequently there are many compounds on the market which combine a detergent with a sterilent or sanitizer. These modern sterilents are very useful because they kill bacteria rapidly, leave no taints or flavours behind and do not lose their power through storage. For several years quarternary ammonium compounds (Q.A.C's) have been used extensively and more recently "iodofors" have been introduced. Both of these compounds are satisfactory provided they have passed the tests of a Bureau of Standards (U.K. or R. of S.A.).

Brushes and brushing. These must be in working order because their job is to scrub away dirt and bacteria. Each milking machine manufacturer supplies set of brushes specially designed to fit the shape of their own teat cup liners and bore of their own milk tubes. Brushes should be used according to the maker's instructions and renewed at frequent intervals otherwise they will not clean effectively.

11.3 CLEANING DAIRY UTENSILS

These items consist of milking pails, cans and buckets, foremilk cups, udder wash pails, udder cloths, cooler, strainer, lids, i.e. everything except the rubber parts of milking machines. Immediately after the morning milking all these items must be rinsed in cold water to prevent milk drying on the surfaces and so making cleaning more difficult. They should then be scrubbed in a hot solution of detergent—hot means as hot as the hand will bear. The utensils should be rinsed again and steamed in a chest for 10 minutes after the temperature has reached 200°F. (93°C.). If it is not possible to raise the temperature to 200°F. then the equipment must be steamed for a longer time, e.g. 15 minutes at 190°F., 20 minutes at 180°F. and so on. When steaming is completed the utensils must be set aside to dry upside down in a dust free room. Dirty milking equipment is the commonest source from which bacteria spoil milk so that correct sterilising in the steamer is of great importance. After the evening milking the detergent can be replaced by a detergent/

sterilent and steaming omitted. When this is done the hot solution must be at the strength recommended by the maker for this purpose. If there is any doubt about the water's freedom from bacteria then the cold rinse should be omitted and equipment stood to dry. Before use utensils should be rinsed with the detergent/sterilent at the manufacturer's recommendation for

PLATE 4. Cleaning a milk can with a chemical solution.
The inside of the can and lid is scrubbed vigorously with a hot detergent/sterilent.

(Photograph by courtesy of The Rhodesian Farmer.)

rinsing. If a steam chest is not available the utensils should be boiled for 10 minutes after the water in the boiler has begun to bubble.

Some farmers neither boil nor steam and produce clean milk by relying on detergent/sterilents alone. The procedure is to rinse in cold water, brush well with hot detergent/sterilent and leave immersed for 3 minutes. An occasional brushing is given to parts which are not completely immersed (Plate 4). Single cans can be treated in this way but if there are several cans the job would take too long. In such circumstances rinse cans, pour one gallon of hot solution into each, scrub the inside and lid, stand for 30 minutes shaking the solution around the walls and brushing the lid from time to time. Drain and allow to dry, store in a clean place until needed and rinse with solution at rinse strength before use.

Cans showing rust are extremely difficult to sterilise and should be re-tinned or thrown away. In areas where water is hard milkstone may build up and harbour bacteria. It can be removed from time to time by a commercial "remover" or by immersing the equipment for 15 minutes in a hot ¼ per cent phosphoric acid solution. A rinse should follow.

Dairy wash troughs can become heavily contaminated. They should have no seams and should be scrubbed thoroughly each week with a hot detergent/sterilent solution.

11.4 CLEANING MILKING MACHINES

The rubber parts of milking machines are difficult to clean because they do not have smooth surfaces from which dirt and bacteria can be removed easily. These surfaces deteriorate (grow worse) from the time the rubber is manufactured and the process is speeded up by fat which rubber readily takes in from milk. A spongy surface develops in which bacteria thrive and from which they are difficult to remove. Normal brushing in detergent/sterilents is not good enough to remove bacteria while boiling and steaming both speed up the deterioration of rubber. Milking machine rubbers are expensive thus means of sterilising which help to prolong their life will be described.

A common system consists of the lye-rack where the cluster and long milk tubes are flooded with a chemical solution between milkings, (Plate 5). After rinsing the parts are immersed in a hot detergent solution and brushed with the correct brushes supplied by the milking machine manufacturer. They are then arranged on the lye-rack and the tap opened to allow flooding to take place. The cheapest and best "lye" is a 2½ per cent solution of caustic soda but a detergent/sterilent can be used successfully provided the rubber is not too old. If old it becomes cracked as well as spongy and caustic soda does the best cleaning job. Again these chemicals help to remove fat from rubber and so increase their working life.

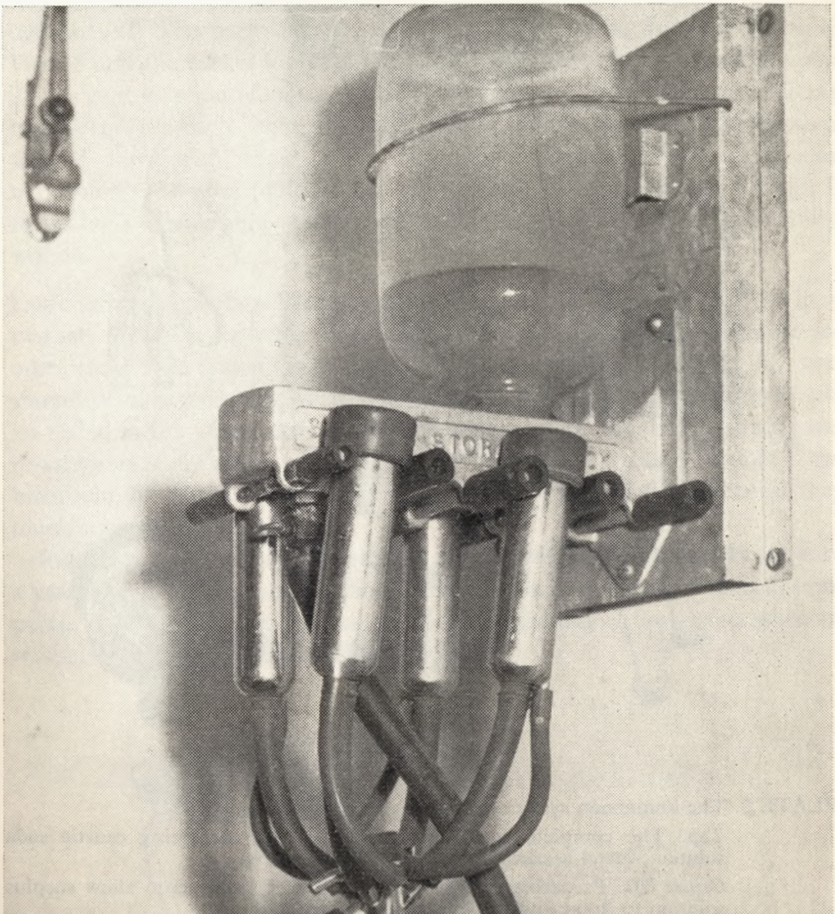


PLATE 5. The lye-rack.
After rinsing, the teat-cup assembly and long milk tube are arranged on the rack and flooded with lye.

(Photograph by courtesy of The Rhodesian Farmer.)

PLATE 6. The immersion system of cleaning milking equipment.

Top: The complete equipment of rubber bin containing caustic soda solution, metal basket and milking machine parts.

Centre left: Preparing for milking—the basket balanced to allow surplus solution to drain into the bin.

Centre middle: The basket and contents hosed with water before assembly.

Centre right: After milking the cluster is rinsed.

Bottom left: The liner on the right has been taken off tension and the short milk tube forced into the metal teat-cup shell so that the sterilent can surround the liners.

Bottom middle: Long milk tubes arranged on rising spiral at side of basket to enable sterilent to bathe tube without air-locks forming.

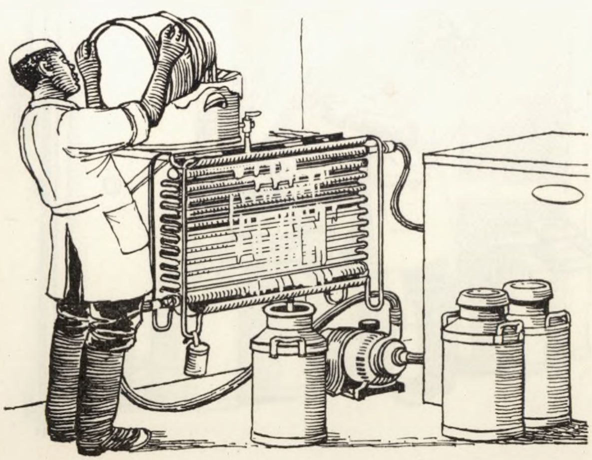
Bottom right: Can lids with rubber gaskets in basket and basket immersed in sterilent.

(Photograph by courtesy of Alfa Laval.)

Immersion cleaning. This method is cheap to run, labour saving, effective and almost foolproof. It was designed for plants where milk goes direct from cow to 10 gallon can. With this system there are a minimum of machine parts to be cleaned, i.e. teat cup cluster, long air and milk tubes and can lid with its rubber gasket. All metal parts must be made of stainless steel. When milking is completed all machine parts must be flushed with cold water and gross dirt brushed off. The parts are then arranged into the wire basket as shown in Plate 6 and the basket lowered gently into the rubber bin which contains a $2\frac{1}{2}$ per cent solution of caustic soda. A few minutes before the next milking begins the basket is stood to drain, placed on the floor and the contents washed down with water. They should then be transferred to a sodium hypochlorite solution (400 p.p.m.) which helps to neutralise the caustic. If this is not available either clean water or a solution of tropical chloride of lime will do.

Looking after rubber. Whatever system of cleaning is used it is wise to have two sets of rubber parts for each milking machine. While one set is in use the other should be soaking in a 5 per cent solution of caustic soda. The sets should be changed every week—those coming from a seven day soak should be boiled in the 5 per cent caustic solution for 10 minutes before rinsing and re-assembly. Care must be taken whenever caustic soda is used because it can burn skin. No harm should occur if workers rinse their hands whenever they touch caustic soda solutions.

Rubber parts must be renewed each six months in warm climates (or once a year if two sets are used) because deterioration is more rapid than in temperate zones. A good time to change is at the beginning of September when air temperature is beginning to rise.



11.5 MILK STRAINING AND COOLING

In hand milked herds it is necessary to strain or clear milk by passing it through either a fine-mesh sieve or cotton gauze filter. The process removes solid matter (dirt, soil, hair, etc.) from the milk but does not affect the number of bacteria in it. Strainers are not generally used in modern machine milking installations.

Above 55°F. (12°C.) bacteria begin to multiply rapidly and the keeping quality of milk is reduced correspondingly. Milk should be cooled to 55°F. or lower as soon as possible to enable it to stay sweet for three to four days. Farmers are obliged to provide a refrigerated cooling plant to do this. Because dairying in rural areas is likely to be in the hands of farmers owning only a few cows, cooling on the farm will be beyond their finances. Consequently any plans to begin milk production and so improve consumption in rural areas must be based on local processing plants. Some success in this respect has been achieved in warm climates in other parts of the world. In such situation it cannot be emphasised too strongly that refrigerated cooling can only prolong the keeping quality of milk which is already clean. It can never take the place of clean milk production at any of the stages through which milk passes from the producer to the consumer.

11.6 TAINTS IN MILK

Milk has a characteristic flavour of its own and a sample which departs from this sufficiently to be objectionable is said to be tainted. Such milks are rejected by milk collecting depots and so are a direct loss to the farmer.

Taints may be due to flavours in particular foods which reach the milk by way of the animal's blood stream. Taints of this kind are not encountered frequently in Central Africa although poorly fermented silage and certain veld weeds can be responsible. The commonest source of taints are bacteria which are found in poor water supplies and on improperly cleaned equipment. Central Africa has a special problem in this respect. Experiments carried out on the University College Farm and others in the Riversdale area show that "psychrophilic" bacteria are common. These micro-organisms are able to grow at the temperature of refrigerated milk so that milk cooling (Section 11.5) does not prevent their multiplication. Many of these bacteria, which produce taints and other spoilage of various kinds, grow freely in soil. In consequence they are often found in water. Even bore-hole water can become contaminated with soil bacteria. This is most likely to occur during the rains in Central Africa. Hence the need for care in rinsing dairy utensils (Section 11.3).

Milk has a great power for taking up odours and for this reason should not be allowed to stand uncovered in places where there is an odour of any kind Fresh paint and carbolic disinfectants are common sources of trouble. Foods with a strong smell should not be offered near to the dairy and this is of particular importance in hand-milked herds. Taints as a result of illness are described in Chapter 12.

12.0 Animal Health

If cattle suffer from disease of any kind we cannot expect them to do well, therefore, disease in cattle is an expensive luxury which practical farmers cannot afford. Farmers know exactly the cost of disease by way of a dead animal or a bill from a veterinary surgeon. It is less easy to guess the cost of slow growth in young stock, reduced milk yield and losses which result from reproductive troubles. The cost of diseases as a whole in Africa is probably some $100 millions each year—an astonishing waste of resources.

The worst diseases are caused by "micro-organisms". Some enter the body through the natural openings, some through wounds and some enter as a result of bites by ticks and flies. Once inside the body either germs or other parasites begin to multiply rapidly. Some produce poisons, some destroy certain parts or organs of the body and some cause irritation. Diseases vary a great deal in the effect they have. Some cause death in a very short time (e.g. Anthrax), others cause severe debility or feebleness which may end in death (e.g. Redwater), while others interfere with an organ or destroy it (e.g. Mastitis).

It is easier and cheaper to keep animals free from disease than to try to cure them when they are sick. The healthy animal is best able to fight or resist disease when it comes. Animals weakened by poor feeding and management usually fall sick easily. Thus farmers must make sure that their animals are properly fed so that calves keep growing and older animals do not lose weight.

A full account of all the diseases which cattle might contract cannot be given in a manual of this kind. Suggestions for further reading are given in the book list. The purpose of this chapter is to describe the means by which the farmer can prevent the occurrence of the common diseases in his dairy cattle.

12.1 DISEASES CARRIED BY INSECTS

Many common diseases are carried to cattle by insects such as ticks and flies. Some of these bite so fiercely that animals become worried and so do not eat all of their food. The wound left from the bite attracts blow-flies and it is from their eggs that screw-worms develop. The more important diseases are described in Table 17.

The tsetse fly is probably the most dangerous fly in Africa. It carries a disease called trypanosomiasis (nagana in cattle, sleeping sickness in man). Tsetse fly is found in between four and five million square miles of the

TABLE 17
Some diseases carried by ticks and flies

Disease	*Carrier*	*Symptoms and control*
East Coast fever (Theileriosis)	Brown tick	Parasites in infected animals attack and destroy blood cells. Early symptoms may pass unnoticed. Temperature rises to 107° F. The muzzle becomes dry, saliva is profuse and tears are shed. The animal becomes dull and listless and keeps away from the herd. A diarrhoea develops which is tarry and slimy. Glands in front of the shoulder and in the groin become swollen. Eventually breathing becomes laboured, the animal thin and weak, lies down and dies when froth may issue from the nostrils. There is no cure for this disease. Dipping every 3-7 days is needed to control these ticks.
Gall-sickness (Anaplasmosis)	Blue tick	Parasites attack red blood cells, body temperature rises (105° F+), anaemia develops and flesh inside natural openings of body becomes pale and finally yellow. Constipation is marked, lack of appetite develops, flesh is lost and milk yield falls. Death may occur at this stage but animals which survive may die later of anaemia and weakness. There is no treatment for tickborne gall-sickness. Sick animals need careful nursing, green food and treatment for constipation. Blue ticks are controlled by dipping at 14 day intervals.
Redwater	Blue, brown and red ticks	Parasites destroy red blood cells causing anaemia and fever. The symptoms are similar to those of Gall-sickness except that the urine is pale red. Constipation is common and so is hard dry dung which is usually yellow-brown in colour. Badly affected animals usually die. Various treatments are available and given promptly prevent deaths and serious loss of milk yield. (See Fig. 4). Cattle born in red-water areas usually become infected and develop resistance when calves. Control consists of regular dipping and the use of preventive vaccine on mature cattle.
Heartwater	Bont tick	Vital organs of the body are attacked, a high temperature follows and nervous symptoms often appear, e.g. jaw movement, muscle twitching, blinking eyelids, shivering, walking in circles, etc. Finally the animal goes down with head pulled back and makes jerky movements with stiff legs. Prompt treatment is essential and rapid recovery may take place as a result of the use of antibiotics. Frequent dipping (5-7 days) is necessary to control this tick.
Sweating sickness	Bont-legged ticks	Calves up to 9 months of age may be affected in Jan.-March. The skin becomes moist and sticky, hair is lost and the mouth and eyes become swollen. A high temperature may develop and some calves die. Calves need careful nursing and veterinary attention. Frequent dipping and hand dressing helps to control these ticks.
Trypanosomiasis (Nagana)	Tsetse fly	Parasites attack the blood and a fever develops leading to anaemia, wasting and exhaustion. This general weakening leads to drowsiness; signs of paralysis may appear in the hind-quarters. Prompt treatment by a veterinarian usually leads to recovery. The only control is to destroy the tsetse fly.
Screwworm	Cattle blowfly	The fly lays eggs in wounds of any kind. Eggs hatch and the maggots enter deeply into flesh of animals. A swelling develops made of maggots and blood. Without treatment more blowflies are attracted and a serious wound develops. Control consists of regular inspection of the cattle and treatment of all wounds with proprietary remedies. Regular dipping aginst ticks helps to controi screw-worm because tick-bites are the most common site of attack.

tropics and most of this is therefore closed to successful animal husbandry.

Ticks are the most troublesome insects which farmers have to control because they are responsible for carrying several serious diseases to cattle. The principal diseases are redwater, gall-sickness, heartwater and East Coast fever. The female tick lays eggs on the ground which hatch in thousands. The young climb blades of grass or shrubs so that they can attach themselves to passing animals. Some kinds of tick can then complete their lives on one animal or "host" but need to be attached for three weeks to do so. Others need two and others three hosts in which to reach the adult stage. The latter drop to the ground after five or six days on each host. To "control" or reduce the number of ticks they must be removed from their hosts often enough to prevent egg-laying. Thus for some ticks control measures are necessary every 14 days and with others control is necessary each five to seven days. A list of the important ticks is given in Table 17 together with the diseases they carry and the dipping interval recommended for their control.

The best method of tick control is by dipping or spraying cattle with a liquid which kills ticks. Most frequently a dip tank is used (Plate 7) into which cattle plunge, swim a short distance and then walk out at the opposite end. A more modern development is the spray race. Here dip from a small tank is

PLATE 7. Cattle going through a dip tank.

pumped under pressure through holes in pipes set in a covered section of the race. In both methods cattle are thoroughly soaked in dip which will kill ticks if it is at the correct strength. Tanks must be carefully sited and constructed to prevent the entrance of storm water which reduces the strength, and therefore the value, of the dip. Splash walls should be provided together with a drainage race to ensure that little dip is wasted. Several chemicals can be used as dips today, whereas, at one time arsenic was commonly used. Although arsenic cannot be used in the spray race because of the danger of poisoning, the race has an advantage over the tank. A relatively small quantity of chemical is needed for a spray race compared with what is needed for the dip tank. Consequently it is much easier to use different chemicals in turn and so improve tick control.

When neither dip tank nor spray race is available dip can be sprayed on cattle by means of a hand pump (Plate 8). For success this method needs great care and attention. It is laborious and therefore only suitable where small numbers of cattle have to be sprayed. Hand-dressing, which is sometimes a useful practice, consists of putting dip, engine oil or a commercial "tick grease" on parts of the body where ticks prefer to gather. These are the places

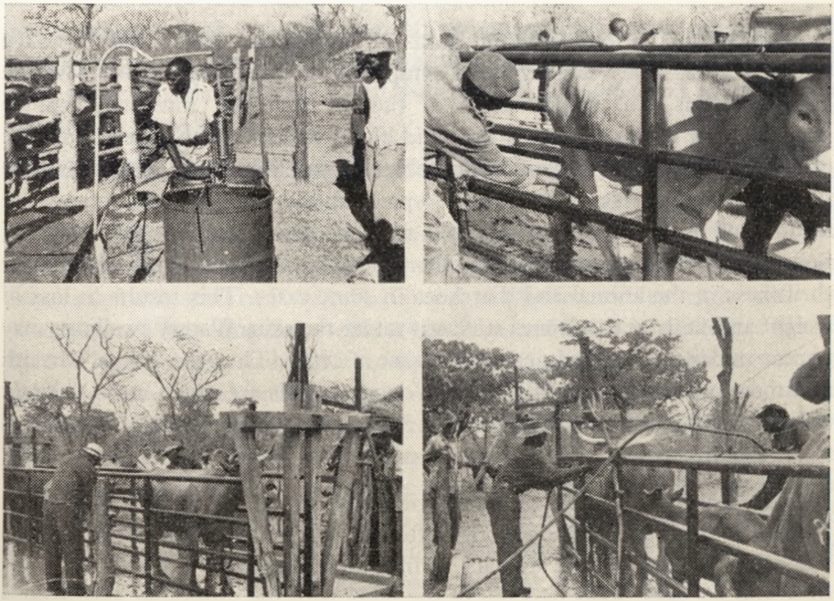


PLATE 8. The control of ticks by hand spraying.
Photograph by courtesy of the Department of Conservation and Extension, Ministry of Agriculture.)

from which ticks are unlikely to be brushed off by bushes, removed by birds, etc., i.e. inside the ears and around the anus under the tailhead. This system is particularly popular with some dairy farmers at times of the year when only the bont tick is seen. Grease can be smeared on the appropriate parts of the body while the cows are being milked. If this procedure is carefully carried out it can be used in place of one of the frequent dippings needed to control bont ticks.

Thus dipping, aided by intelligent hand dressing, is the way in which ticks are controlled. It also helps to keep under control a range of other insects which irritate cattle such as body lice and mange mites.

12.2 WORMS, FLUKES AND TAPEWORMS

Worms, flukes and tapeworms live inside the animal body and take their nourishment (food) from their host. They are known as internal parasites. They are found all over the tropics and are a grave source of loss to farmers as a result of reduced health and deaths in livestock. A brief description follows of the main internal parasites, their effect on the animal and their control.

Roundworms. Several different kinds of roundworm live in the digestive tract of cattle. They cause general symptoms of disease known as parasitic gastro-enteritis, i.e. inflammation of the stomach and intestines due to parasites. For example, hookworms and blood suckers cause anaemia or lack of blood. This results in debility or feebleness and even death. Others irritate the bowel lining which causes food to pass rapidly through the animal. As a result food is not properly digested and the animal suffers from lack of nourishment. In general, however, there is an increasing loss of condition or thriftiness in the animal and diarrhoea in some cases. This results in loss of weight and flesh so that bones stick out under the skin. Watery swellings may appear under the jaw and near the brisket of cattle. Thus the animal's health and therefore production falls away. Young animals are much more severely affected than adults and when a calf is weaned is a particularly dangerous time. This accounts for much of the slow growth in young cattle in the tropics.

Cattle become infected by swallowing eggs or young worms along with their food and water. Young worms often move through parts of the body to reach, and to settle in, the stomach or intestines. Here they grow to maturity, mate and lay eggs. Eggs pass out of the body with the droppings and, after a time which depends on climate, hatch and are ready to be taken in by other animals once more.

Control of worms, therefore consists of trying to reduce the number of eggs on the ground. This will result in fewer young worms being taken in by the animal. Whether this can be done depends on climate and stocking, i.e. the number of animals in the area. Hot, dry conditions kill eggs and young worms while hot, moist conditions favour them. Many animals in an area mean many, many eggs on the ground. If the grazing area can be rested from livestock the young worms will fail to find a host and die. The ideal would be to move cattle to fresh ground every 3-7 days in the wet season when stocking is heavy. In this way cattle would leave the area before young worms were ready to infect them. A hot, dry spell kills most of these in a few days but in the rainy season two to three months may be required. In many parts of Africa it is not possible to rest pasture for so long. It is thus best to graze a small area heavily and to move cattle on, than to graze a large area throughout the year. Consequently farms must be fenced into a number of small paddocks which can be grazed in turn. This is often an impossibility because of lack of capital and low income. However an attempt should be made to graze young stock ahead of the adults because they suffer most from the effect of worms.

Fortunately there are several drugs available which can be given to cattle as a medicinal drink or drench. These kill the parasites and so prevent egg-laying. No harm comes to the animal if the drench is at the correct strength. In Central Africa it is customary to drench all cattle before the rains begin and to repeat this after the last rains of the season. These times are important because eggs on pasture die in the hot, dry weeks before the rains begin. If adult worms inside cattle are killed the cycle of egg-laying and re-infestation cannot be started again.

Flukes. These are flat worms found in the livers of affected animals. The damage caused to the liver results in loss of condition, anaemia and sometimes in death. Eggs are laid inside the animal and pass out in the droppings. If the eggs reach water they hatch in about 10 days and the young fluke must then enter a suitable snail or it will die. Here it multiplies and leaves the snail six weeks later. The young fluke settle on herbage and then change into a special kind of egg or cyst. Animals become infected by eating the herbage or by drinking water which contains young flukes. Thus liver-fluke disease can be controlled by keeping animals away from marshy places where the snails live. The snails can be killed by treating marshy areas with copper sulphate. Drenching cattle with a drug (hexachlorethane) usually kills many fluke. This should be done after cattle have been obliged to graze marshy areas and again three months later. Where possible water should be piped into drinking troughs and cattle should not be allowed to drink from open water.

Tapeworms. There are many different kinds of tapeworm but these rarely cause disease in cattle. However cattle and pigs are hosts to the very young tapeworms whose adult stage lives in the gut of man. Meat found to contain these tiny tapeworms is said to have "measles" and is not used for sale to humans. Consequently it realises little money and the farmer is out of pocket. Eggs are passed in human droppings and when hatched are taken in with grazing by cattle and pigs. Man is infected by eating pork or beef which has not been cooked long enough to kill the young tapeworms. Tapeworm infection is fairly easy to control. Humans should use latrines instead of the open veld and their manure should not be spread on the land. All meat should be properly cooked.

12.3 PROTECTING ANIMALS AGAINST DISEASE

Some animals are able to resist the attacks of certain micro-organisms which cause disease. This ability is known as "immunity" and is due to the presence of certain factors (antibodies) in the blood. Immunity is specific, i.e. the factors which protect an animal against one disease will not protect it against others. Also, immunity may last for a lifetime, for a certain period of time or may be partial or incomplete.

When the tissues of an animal are entered by micro-organisms the substances they produce cause the animal body to manufacture antibodies which, in sufficient strength, neutralise the action of the bacterial substances. Immunity may be acquired as a result of vaccination. There are several different ways of producing vaccine and similar protective agents. Many are produced by injecting an animal with the blood or serum of another animal that has suffered from the disease. The new-born calf receives as many antibodies as its mother possesses when it drinks colostrum (Section 8.3). It is thus protected against the common diseases and begins to make its own antibodies. This is why imported cattle often fail to thrive while indigenous stock are better able to stand up to tropical diseases. In this respect there is even a local superiority because strains of some diseases occur in some localities and not in others. Consequently when cattle are bought from another area farmers should keep them separated from their own cattle for three to four weeks by which time the symptoms of most diseases will appear if the animals are infected. Sick animals may then be treated and the spread of disease to healthy animals prevented. Such precautions are well worthwhile although they may be difficult to carry out on many farms. Isolation facilities must be provided. Of even greater importance is the need for farms to be securely ring-fenced to prevent cattle from making contact with those on neighbouring farms.

12.4 CONTAGIOUS DISEASES

As the title suggests these diseases are passed from cow to cow by contact. These may be due to direct contact between animals or due to drinking water or eating food which has been contaminated with excretions (droppings, urine) or discharges from infected animals. The chief diseases are listed in Table 18 together with information about their control. All affected animals need veterinary attention. Most contagious diseases spread rapidly so that many animals in the herd may become infected. The Government employs a special staff of veterinary surgeons to deal with such diseases. When these diseases are suspected a report must be made to the nearest Government veterinarian. Mastitis has been discussed in Chapter 10 because the spread of this disease occurs at milking time.

TABLE 18

Some of the Common Diseases Transmitted through Contact

Disease	*Mode of Infection*	*Symptoms and Treatment*
Black Quarter (Quarter Evil)	Infected food	Fever, lethargy, lameness—due to swelling, usually high up hind leg. Swelling enlarges. Affected animals die in a few days, no effective treatment. Protection given by vaccinating calves when 5-6 months old and again at 18 and 30 months of age in areas where disease occurs. Carcass should be burnt or buried six feet deep and covered with quick lime. All young stock should be vaccinated to prevent this disease.
Anthrax	Infected food	Infected animals usually found dead but high fever and shivering occurs when the disease is seen. When treatment with antibiotics can be given in time it is usually successful. Prevented by annual vaccination of cattle in affected areas for three successive years. Carcass is highly infective and should not be opened because of the danger of setting free anthrax "spores". Carcass should be burnt or buried and limed.
Brucellosis (Contagious Abortion)	Infected food	Abortion usually in the seventh month of pregnancy but at any time from the fourth. Cow may hold to next service but Brucellosis can cause a great deal of temporary and permanent sterility. In the past the productivity of dairy herds has been entirely disrupted. There is no specific treatment for C.A. This disease can be successfully prevented by vaccination of all heifers between 4-8 months and again before their first pregnancy. All young female stock should be vaccinated to prevent this disease.
Vibriosis	During mating	Abortion at any stage of pregnancy and general interference with breeding, e.g. failure to hold to service, irregular heats, weak or dead calves and retained afterbirth. Only successful treatment is prevention, i.e. buy clean bulls from clean herds. Infected bulls must be slaughtered and cows got in calf by A.I. otherwise they will infect a new and healthy bull.

Tricho-moniasis	During mating	Abortion early in pregnancy. Most cows recover spontaneously in time while bulls remain infected permanently. Control is by slaughtering infected bulls and A.I. of cows.
Calf scours	Infected food	Bacteria from droppings contaminate food containers and surroundings hence the need for cleanliness, (Section 8.4). Paratyphoid infection attacks calves between 2 and 12 weeks of age—accompanied by high temperature, general disease symptoms and offensive greyish droppings; calf usually dies. Vaccination should be undertaken on known infected premises. White scours usually attack calves in the first few days of life. Certain drugs can affect a cure if given in time.
Foot-and-Mouth disease	Infected food and environment	Round blisters which turn into sores found on mouth and tongue and between the hooves of two-toed animals, i.e. cow, sheep, pig. Body discharges highly infective. Organism causing disease survives for only a few days outside animal body, e.g. on grass, etc., but animal products, hides, wool, meat, etc., may remain infective for some time. Causes serious loss in milk yield and growth. Prevented by restricting the movement of cattle, i.e. isolation of farm to prevent spread. No treatment. It is most important that all suspected cases of this condition be reported at once to Government authorities.

12.5 DISORDERS OF THE BODY

A number of illnesses or disorders arise as a result of faulty feeding (including poisons) which lead to disturbances of bodily functions. These are usually called "metabolic" diseases because they interfere with the body metabolism, i.e. the processes by which raw materials (food, water and air) are used by the body for reproduction, growth and lactation.

Milk-fever. This disease occurs shortly after the cow has calved, produces paralysis and is caused by shortage of calcium in the blood. If there is a shortage of calcium in the diet the pregnant cow is able to use the calcium from her own bones to provide for the needs of the calf growing inside her. If these circumstances persist to the time of calving the sudden drain of calcium to colustrum causes an acute shortage of calcium in the blood of the mother and she goes down with milk-fever.

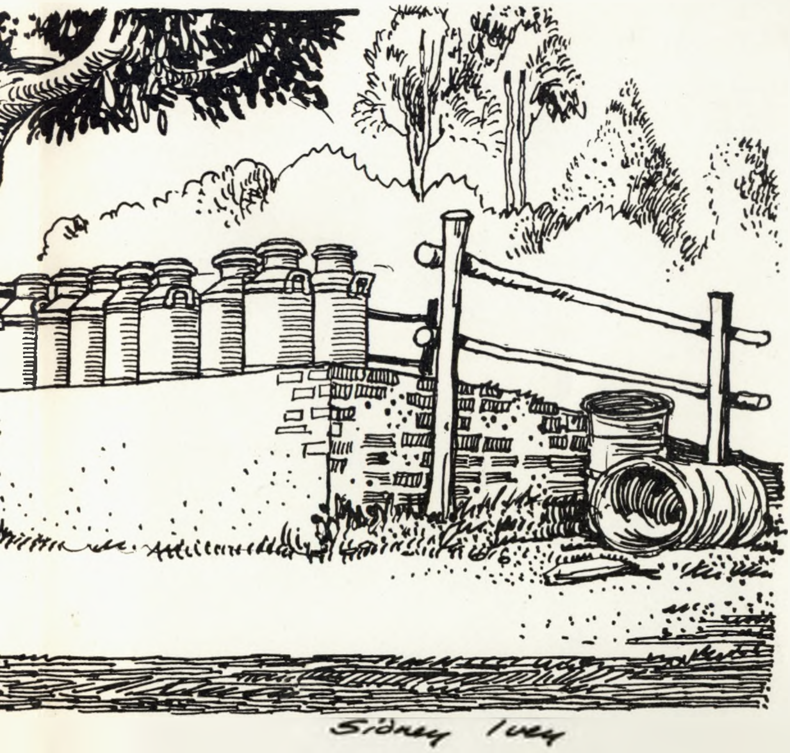
Milk-fever occurs 1-4 days after calving. Affected cows become unsteady on their legs, become weak, fall down and cannot get up. The lying position on the brisket with the head swung back is characteristic. Treatment is simple and usually produces an immediate response. A proprietary injection containing calcium borogluconate must be given. If recovery is not complete in 6-8 hours a second dose should be given. Some cows are prone to milk-fever and need to be watched for symptoms each time they calve.

Acetonemia (Ketosis). This disorder may occur during the first few weeks of lactation and is shown by nervous symptoms and a sweet smell in the breath and milk. Several signs may occur, e.g. unsteady walking, pushing out and curling of the tongue, neck twisting, etc. Affected animals may eat bark off trees, soil and chew stones while they refuse normal food. Treatment consists of injecting 2-3 oz. glucose in a pint of boiled water every 24-36 hours. Recovery usually takes place after 2-3 doses. Sometimes the symptoms of this disease are similar to those of milk-fever. In this case the treatments for both disorders can be given without harmful effects.

Bloat. The digestion of food in the stomachs of cattle is accompanied by the production of gas. This is usually got rid of by frequent belching. Sometimes gas accumulates in the stomach more quickly than the cow can get rid of it. When this happens the first stomach (rumen) swells and presses against the lungs until the animal dies from suffocation. Young, rapidly growing lucerne is a frequent cause of bloat and for this reason it is usual to recommend that lucerne must be cut and wilted before it is fed.

The symptoms of bloat are distress and a swelling of the rumen. This is seen on the left side of the cow between the hip, the last rib and the spinal column. Affected animals look as if a football was being blown up under the skin. Treatment of mild cases consists of gently walking the animal about for half an hour. If no improvement can be seen a drench should be given of either a proprietary mixture or one pint of turpentine. If this is not effective a hole must be pierced through the skin to the rumen to allow the gas to escape. A trocar and cannula (see glossary) should be used for this purpose and should be inserted in the centre of the swelling, i.e. at a point centrally between hip, last rib and spinal column.

Plant poisoning. A variety of plants occur in Central Africa which produce poisons after they have been damaged either by frost or wilting. Poisoned animals breathe deeply and rapidly with neck extended and mouth open. Trembling or bloating are common and as the animal becomes more affected it staggers, falls, rises and so on until it falls and dies of suffocation and brain paralysis. If the animal can be caught in time it will respond to a drench of one pint of carron oil, i.e. half lime water and half raw linseed oil. In areas where plant poisoning is prevalent it is worthwihle to add 7 lb. of sulphur in each 100 lb. of mineral mixture.



GLOSSARY

ALVEOLUS (pl. alveoli)
The part of the udder tissue in which milk is produced.

AMINO ACIDS
These are the materials which link together to form proteins. In digestion, food proteins are broken down into amino acids and these are linked together again in different combinations by the animal to make body protein.

ANTIBIOTIC
A chemical produced by bacteria which can kill other bacteria, usually those which cause disease. Penicillin was the first antibiotic to be discovered.

BACTERIA
Tiny living things which cannot be seen with the naked eye. There are many different kinds—some are harmful and cause disease. Others are useful and produce antibiotics which can kill harmful bacteria. Some of the most important are soil bacteria which cause decay of plant and animal material so releasing food substances for the use of plants.

CARBOHYDRATES
A group of substances found in plants which are important sources of food energy to man and animals. The group includes substances which vary from easily digested sugars, e.g. glucose and lactose to more complex substances, not easily digested, like cellulose.

CAROTENE
A substance found in grass. It can be converted in the animal body to make Vitamin A. It must be supplied in food of cattle because they cannot make it themselves.

CELLULOSE
A structural tissue of plants and a carbohydrate. An important source of carbohydrate to cattle and sheep.

COLOSTRUM
The first milk from the mother after birth of the offspring. It is rich in nutrients but the composition changes rapidly to that of normal milk in a few days.

CONSERVATION
The preservation from destructive influences. Thus crop conservation is the preservation of crops in such a condition that nutritive value is not lost, e.g. silage. Also soil conservation which refers to practices which prevent soil being washed away in the rainy season.

CRUDE FIBRE
The "skeleton" of plants. It is composed mainly of cellulose in young plants, largely of hemicellulose in old grass and lignin in trees.

CRUDE PROTEIN
All proteins contain about 16 per cent of the substance nitrogen. This fact is used to make a rapid determination of the approximate amount of protein

in food. Thus the amout of nitrogen found in a food is multiplied by 6.25 (100/16) to give the amount of crude protein. See also digestible protein.

CULL

An animal taken out of a herd as being unsuitable.

DETERGENT

A chemical cleaning agent which is usually dissolved in water before use. Modern detergents are often made for special purposes, e.g. those used to clean dairy utensils are different from those used to clean floors and walls.

DIET

A diet is a food or group of foods given for a certain purpose and usually in specified quantities.

DIGESTION

The process by which food is broken down in the stomach and intestines into substances which can be used by the body for tissue building and repair and other vital processes.

DIGESTIBLE PROTEIN

The part of crude protein which can be digested and used by the animal. That which cannot be used is voided from the body.

D.M. OR DRY MATTER

All foods contain some water. If a food is heated to 100°C. (the temperature at which water turns to water vapour) the water will evaporate. The residue is known as dry matter and contains the nutrients of the food.

ENERGY

In the same way as a motor car needs a source of energy to make it work so the body needs energy to carry out its living processes. Carbohydrates are the main sources of energy in cattle foods. (See section 3.3).

ETHER EXTRACT

The fat and oil content of a food. In the chemical analysis of feeding stuffs the dry matter is treated with a solvent (ethyl ether) which dissolves fats and oils. The solvent is then driven off (vaporised by heat) and the amount of fats and oils present is weighed. (See section 3.7).

GENES

These are chemical substances which control the characteristics of all living things. Each parent provides an offspring with a sample of their own genes by a process of chance assortment. The genes are carried in the sperm of males and the eggs of females. The development of the fertilised egg and the characteristics of the individual which forms from it, are determined by the genes passed on by the parents.

GUT

The digestive tract or alimentary canal of an animal.

HEREDITY

The transfer of characteristics from one generation to another.

INSEMINATE

The injection of semen into a female.

INTESTINE

The lower part of the gut, i.e. from stomach to anus. The main absorption of the nutrient products of digestion takes place in the intestine.

LACTATION

The production of milk by the female. In dairying lactation specifically means the period of time during which a cow produces milk.

LIGNOCELLULOSE

An indigestible carbohydrate formed from cellulose as a plant matures.

MILKSTONE

A deposit of salts from hard water found on dairy equipment. It is difficult to move by normal cleaning methods and can harbour harmful bacteria which spoil milk.

N or NITROGEN

An essential element in the nutrition of plants and animals. Fertiliser requirements may be given as the number of pounds of N to the acre. Thus if 100 lb. N/acre is recommended then 500 lb. of a fertiliser containing 20 per cent N would be required.

N.F.E. NITROGEN-FREE EXTRACTIVES

A term used to describe carbohydrates and similar substances in the chemical analysis of feeding stuffs.

NUTRIENT

A nourishing food.

NUTRITION

The supply of nourishing food.

PELLAGRA

A "deficiency disease" i.e. a disease which arises because a nutrient is absent from the diet.

PRODUCTION

The process by which things are produced. Dairy farming is primarily concerned with the production of milk, of growth in young animals and of crops to enable milk and growth to be produced.

PROTEINS

Substances which form a large part of all living things. Proteins are essential in food; they are broken down into their constituent amino acids during digestion and these are used to form body tissue, e.g. muscle etc. in animals.

RATION

A fixed daily allowance of food.

REPRODUCTION

The process by which one generation gives rise to a succeeding generation.

SEMEN

The generative fluid of males containing sperm which are capable of making the female's egg fertile so permitting the development of a new animal in the womb.

SPECIES

A group of animals or plants which are broadly similar but differ in minor details.

SPORES

A minute living body capable of individual development. Some bacteria are able to change into spores in an adverse environment. In this form they are able to "rest" until a favourable environment arises. Spores are often highly resistant to adverse conditions and therefore difficult to kill.

STARCH

A carbohydrate constituent of all plants which is usually easily digested into simple sugars. It is thus an important source of energy.

STERILENT

A substance which can kill micro-organisms.

STOCKMANSHIP

The skill that a man can acquire with animals which enables him to know how to care for them so that they are productive.

SUGARS

Sweet substances derived from carbohydrate digestion. They dissolve easily and are readily taken through the wall of the intestines and used by the body as a source of energy.

TISSUES

The substances of the living body, e.g. muscle, fat, nerve tissue, etc.

T.D.N. TOTAL DIGESTIBLE NUTRIENTS

A measure of the useful energy an animal received from the food it eats, i.e. the difference between what is eaten and what is voided as dung.

TROCHAR AND CANNULA

A device for puncturing the stomach (rumen) wall which allows dangerous accumulations of gas to escape (e.g. bloat). It consists of a sharply pointed steel rod (trochar) which fits into a tube (cannula). The instrument is plunged through skin and stomach wall, the trochar is removed and the cannula left to allow the excess gas to escape. After this the cannula is removed and the wound heals.

VELD

The natural vegetation of Central and Southern Africa. It is composed of grasses, bushes and trees either singly or together depending on climate.

VITAMINS

Accessory or supplementary food substances which are essential to the health of man and animals. Their absence from the diet is associated with malnutrition and leads to deficiency diseases.

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TABLE 19

Nutritive value of the common feeding stuffs of Central Africa

*Roughages**	D.P. %	T.D.N. %
Cob meal (maize)	neg. +	45
Cowpea hay (*Vigna sinensis*)	12·3	51
Dolichos bean hay (*Dolichos lablab. L.*)	8·5	56
Grass hay —Early flower (good)†	3·5–4·0	50
—Mature (ave.)†	1·0	45
—Very mature (poor)†	·02	40
Ground-nut hay (*Arachis hypogaea L.*) (ave.)	5·0	60
Jack bean hay—Cut early	8·0	49
—Cut late	7·0	57
Legume hays (range)	5–10	45–54
(average)	8·0	50
Lucerne hay—Cut early (good)	12·0	52
—Average quality (ave.)	11·0	50
—Mature (poor)	8·0	46
Maize stover—Stooked	1·0	45
—Late cut	0·2	40
Soyabean-hay (*Glycine max.* L.)	10·0	58
—straw	1·0	40
Sunnhemp hay (*Crotalaria juncea* L.)	8·0	50
Sweet potato vines—dry	8·0	50
Veld hay—Range	0·0–3·0	40–50
—Average	1·5	44
Velvet bean hay (*Stizolobium* spp.)	9·0	47

Succulents	D.M. %	D.P. %	T.D.N. %
Grass silage (ave.)	20–25	4·0	50
Green barley	20–25	3·5–2·0	12·0–16·0
Green oats	20–25	2·3–1·5	12·0–14·0
Green maize	20–27	1·0–1·2	14·0–20·0
Jack bean silage	28	2·3	14·0
Lucerne—young	20	3·5	12·5
—early flower	25	3·5	14·0
—mature	35	2·5	14·5

*The average dry matter content is 90 per cent.
+neg. = negligible quantity.
†good, average and poor refer to feeding quality.

	D.M. %	D.P. %	T.D.N. %
Lucerne silage	25	2·5	15·0
Maize silage —good	30	1·3	20·0
—average	27	1·0	17·0
—poor	25	0·8	15·0
Maize top silage	25	neg.	8·0
Maize and velvet bean silage	30	1·5	20·0
Majorda melons (*C. vulgaris*)	6·0	0·5	4·8
Pumpkins (*Cucurbita peop.* L.)	13·0	1·3	9·0
Sorghum silage	38	0·8	16·0
Sunnhemp silage	27	2·0	13·0
Sweet potatoes (*Ipomoea batatas*)			
—tubers	28	1·2	25·0
—young leaves	15	1·5	6·0

Concentrates

	D.M. %	D.P. %	T.D.N. %
Barley	90·0	7·5	76·0
Bloodmeal	91·8	58·0	61·3
Brewers' grains (wet)	30·0	6·0	20–25
Buckwheat (*F. esculentum*)	90·0	7·4	62·0
Cassava (*Manihot utilissima*)	32·6	0·5	75·0
Cottonseed meal/cake —decorticated	93·5	32–36	73·0
—undecorticated	93·0	18·0	50·0
Cottonseed hulls	90·0	0	43·0
Fishmeal (white)	93·1	55·0	70·0
Groundnut meal/cake—decorticated	93·5	36–42	75·0
—undecorticated	93·0	26·0	67·0
Jack beans (*Canavalia ensiformis*)	89·3	20·0	68·0
Jack bean meal (with pods)	90	13·0	72
Linseed meal/cake	90·5	30·0	75
Maize	90	6·5	80
Maize corn and cob meal	90	5·5	72
Maize bran	90	4·0	63
Maize cobs	90	neg.	45
Meat and bone meal	94	32–40	65
Molasses	75	neg.	60
Munga (*Pennisitum typhoides*)	90	8·0	80
Oats	95	7·5	70
Orange pulp (dried)	87·9	2·0	67
Pollard	90	11·0	72
Rapoko (*Eleusine coracana*)	90	5·5	72
Sorghum or Kaffir Corn (*Sorghum vulgare*)	90	7·5	78
Soyabeans (*Glycine max.*)	91	34–42	88
Soyabean meal or cake	90·9	37·0	78
Sunflower seed (*Helianthus annus* L.)			
—without hulls	95·5	24·0	110
—with hulls	93·6	14·0	75

	D.M. %	D.P. %	T.D.N. %
Sunflower heads	90	11·0	60–65
Sunflower meal/cake—decorticated ..	90·6	35·0	75–80
—undecorticated ..	90·6	17·0	55
Velvet beans (*Stizolobium* spp.)	90	19·0	82
—with pods	90	13·0	74
Wheat (*Triticum sestium* L.)	89·5	8·5–13	80
Wheat bran	90	11·0	66

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