14 · *Management Aspects of the Captive-Bred African Buffalo* (Syncerus caffer) *in South Africa*

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Introduction

The objective of most buffalo production systems is to produce offspring that meet specific requirements. In the case of captive-bred African buffalo in South Africa, the main aim is to produce trophy-quality animals for breeding and hunting. Managing nutrition and feeding is of the utmost importance when working with high-value species such as the African buffalo, as their nutritional status has a direct effect on their (re-)production and the profitability of the enterprise. In natural systems (game reserves, national parks), droughts cause buffalo numbers to decline due to animals not being able to source the necessary nutrients for reproduction in the available dry grazing (Chapter 7), thus reducing the animals' reproductive performance and production. Within intensive systems focusing on individual and herd performance, particularly reproductive performance, there is a need to create management programmes and practices to assuage potential poor performance due to a lack of necessary nutrients at different times of the year. Although numerous factors, such as sexually transmitted diseases, libido, age of first mating, season and nutrition, influence reproduction rate, this section will discuss how nutrition may be used to support reproduction and production in intensively and semi-extensively housed/ranched African buffalo herds. In this chapter, we discuss the feeding preferences under semi-extensive systems together with the estimation of stocking rates for buffalo of differing physiological stages, as well as the nutritional requirements of buffalo, the effects of season on these, and how supplementary feeding may be used to ensure adequate nutrition – most of the knowledge/experience presented in this chapter comes from southern Africa, given their development of the private wildlife sector (see Chapter 13).

Furthermore, fundamental information regarding buffalo reproduction and their utilization for meat production is summarized using real-time ranch experience originating from the disease-free buffalo breeding ranches that flowed out into commercial buffalo ranching in South Africa. It is essential to give credit where it is due; the origin of buffalo ranching started with the cattle industry's husbandry techniques, and as time progressed, more and more scientific data were collected. This scientific knowledge allowed the game industry to not only gain the knowledge of breeding disease-free buffalo, but also to introduce these animals back into the wild.

Nutrition

Buffalo are broadly classified as bulk grazers, spending 40–80 per cent of their time feeding and ruminating depending on the season. Rumination is the process through which selected forage, already in the rumen, is repeatedly regurgitated into the mouth and back to the rumen to decrease particle size and buffer rumen pH via saliva; these fine food particles are degraded in the rumen by microbial action and fermentation. These small particles pass through into the omasum, then the abomasum, and then the small and large intestine for further degradation, digestion and nutrient absorption. The African buffalo consumes a wide variety of grass species, with grass constituting a relatively high proportion of their diet (75–100 per cent), but utilize more browse during the dry season or in different vegetation zones (woodlands or forest) when they are forced to graze less selectively and browse on woody shrubs, increasing the browse proportion of their diet.

African buffalo are relatively unselective grazers, but prefer highly palatable nutrient-rich grass. In extensive systems of southern Africa within granite and basalt landscapes (Macandza et al., 2004), they depend primarily on *Panicum* spp. (mostly *P. maximum*) throughout the year, and as the dry season progresses, *Digitaria eriantha* and *Urochloa mosambicensis* (previously also known as *U. usambarensis*) and *Cynodon dactylon* are the predominant species consumed. Some *Bothriochloa* spp. become important contributors to the buffalo's diet during the transition from wet to dry seasons, but mostly not *B. insculpta*, while *Eragrostis* spp. contribute towards the end of the dry season. On the other hand, important cattle forage species, like *Themeda triandra*, which generally hold more fibrous content during the dry season, are less favoured by African buffalo under low-input management conditions Furthermore, *Cymbopogon plurinodis*, *Bothriochloa* spp., *Pogonarthria squarrosa*, *Aristida* spp. and *Setaria* spp. tend to be rejected by buffalo, regardless of the season.

The quantity (amount) and quality (nutrients) of grazing is influenced by soil type, topography, rainfall, ambient temperature and animal stocking rate/density. In semi-extensive ranching systems, these factors need to be taken cognisance of, as the manager only has control over the number of animals placed in the ranch/camp/paddock (stocking rate/density), keeping in mind factors such as carrying capacity (see below).

Extensive Grazing and Stocking Rates

Safe stocking rate (referred to as 'carrying capacity' by many game and livestock ranchers) can be defined as the number of animals that a specific piece of land can accommodate annually without degrading the quality of the forage, and can be measured in different animal units, generally known as large stock or large animal units (LSU or LAU), grazing and browsing units (GU/BU) in southern Africa. With irregularities existing in stocking rate methodology and the interpretation of the animal units in these methods, researchers developed a model where the different methods could be interpreted on a metabolizable energy basis measured in megajoules (MJ ME), establishing a calculated large stock unit (LSU^C), grazing and browsing unit (GU^C/BU^C) to be used in the model. One LSU is equivalent to a steer (cattle) with a body mass of 450 kg that is growing 500 g per day by feeding on grazing that has a mean digestible energy concentration of 55 per cent, thus supplying 75 MJ ME per day (Meissner, 1982). A grazing unit (GU) is a 180 kg blue wildebeest and a browsing unit (BU) is a 180 kg kudu (Van Rooyen and Bothma, 2016) requiring 29.71 MJ ME per day (Shepstone et al., 2022). These methods are conservative ways to calculate a piece of land's safe stocking rate if its grazing and browsing capacity has been assessed. This prevents overutilization of the available forage and ensures that the quantity and quality of grazing do not deteriorate over time.

When estimating the carrying capacity and stocking rate on semi-extensive systems, the average LSU^C or GU^C/BU^C value for the specific species should be used. Using averages for all production phases mentioned in Table 14.1 will undersupply energy to lactating females,

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Table 14.1 *Calculated large stock unit equivalents and metabolizable energy values for different physiological stages of African buffalo.*

Physiological stage	Mass (kg)	ME (MJ/day)*	$LSU^{C\#}$	$BU^{C}/GU^{C\#}$
Calf, 8 months	145	29.6	0.39	1.00
Heifer, dry, 4 years	460	78.1	1.04	2.63
Cow, dry, 10 years	530	72.6	0.97	2.44
Cow, with calf, 4 years	460	99.1	1.32	3.34
Cow, with calf, 10 years	530	93.2	1.24	3.14
Young bull, 4 years	500	80.2	1.07	2.70
Adult bull, 10 years	640	81.9	1.09	2.76

* Calculated metabolizable energy.
# Calculated large stock, grazing and browsing units.
Adapted from Shepstone et al. (2022).

as well as growing and adult males. Intensive systems should either use the fixed values in Table 14.1, where the number of animals is multiplied by the LSU^C or GU^C/BU^C value for each respective physiological state in a spreadsheet, or use the lactating cow (cow with calf) LSU value of 1.32 as the baseline parameter. For example, using the LSU^C value of 1.32, a herd of 20 breeding buffalo will need 264 ha if the carrying capacity of the property is 10 ha/LSU. On commercial ranches in southern Africa, stocking rates vary and range between 2.6 and 13.3 ha/LSU (Hildebrandt, 2014). The methodology behind calculating the ME requirements, calculated large stock, grazing and browsing unit values and dry matter intake (DMI), is described by Shepstone et al. (2022).

When the stocking rate exceeds the assessed safe stocking rate, the property is overstocked, making it necessary to purchase or supply stored roughage of a suitable quality to reach the desired reproductive goals. In circumstances where the stocking rate equals, or is lower than, the assessed safe stocking rate, and the quality of the available grazing is not suitable for optimal reproductive performance, the specific nutrients that nature cannot supply must be provided so the ranch can reach the desired production goal. The production constraining nutrients normally found in dry grasses are digestible protein, minerals and vitamins. It is important to note that no specific nutrient guidelines currently exist for buffalo, so cattle data are used to extrapolate the nutrient requirements for buffalo and other similar species. When supplying animals with supplemental feed formulated to mitigate a deficiency, it is important to understand that content and

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quantity of a particular nutrient will differ from one production system to another, and from one ranch to another. The nutrient concentration and the amount to be fed are directly influenced by the nutrient requirements of the animals/herds at that specific time, the quantity and quality of the natural grazing (high correlation with rainfall) or supplied roughage, seasonal changes, availability of raw materials, manufacturing equipment and storage of the mixed feed and raw materials. In order to ensure optimal rangeland utilization on a piece of land, and to limit rangeland degradation by overutilization (i.e. too many animals), routine vegetation studies are necessary to calculate its respective annual safe stocking rate and to take measures to ensure a conservative stocking rate using either or both the calculated LSU^C, GU^C and BU^C methods. Similar animal unit methods are used internationally, such as the animal unit (AU) used in North America and the tropical livestock unit (TLU) used in tropical countries. Be aware of the differences before translating values 1 to 1.

Nutrient Requirements

When considering nutrient requirements for wild animals, a similar well-studied species is used as a proxy when formulating feeds; when considering the bulk-grazing African buffalo, other bulk grazing species such as beef cattle and water buffalo (*Bubalis bubalus*) data can be used. In this document, we use nutrient requirements of beef cattle in the United States (National Academies of Sciences Engineering and Medicine, 2016) as the baseline comparative nutrition proxy because rangeland beef cattle in southern Africa select a similar diet, live in similar habitats and have a similar daily water requirement to the African buffalo. On the other hand, water buffalo are animals housed and raised similarly to how the dairy industry houses and raises their dairy cattle, making this species less comparable to the African buffalo from a comparative nutrition point of view. Using cattle nutrient requirement data to estimate the daily nutrient requirements of buffalo is of little value if the buffalo's average weight, physiological state and daily DMI are unknown; thus, these are important factors to account for when formulating a supplement/feed for buffalo. Knowing the physiological state and average weight aids in calculating the animal's nutrient requirements, and nutrient analysis of the grass or roughage supplied to the animals will aid in calculating what shortfalls exist.

In addition to providing sufficient quantities of feed, the quality (nutrients) of feed, which includes the energy, protein, fibre and trace elements (vitamins and minerals) content, is important for ensuring optimal production and reproduction based on the animals' nutrient requirements. The calculated LSU^C, GU^C and BU^C methods discussed above is currently the most accurate method to calculate the energy requirements for game animals (Shepstone et al., 2022), where the energy used by the animal is expressed as ME, measured in megajoules (MJ). When conditions are favourable, ruminants eat to meet their energy requirements rather than to fill their rumens (intake capacity). However, during the dry season, when the available ME in the selected grazing is too low to meet maintenance/lactation requirements, the animals cannot consume more grass or browse to satisfy their requirements, the main reason being that the total amount of feed intake per unit of time is restricted by their thoracic cavity (restricted rumen capacity). Furthermore, a cow in her last trimester of pregnancy has even less space (as the calf is taking up a lot of the abdominal cavity) for food in her rumen. The average voluntary feed intake (VFI) for buffalo is calculated to be approximately 1.8–2.3 per cent of their live body mass (530 kg) for a dry cow and a lactating cow, respectively (Shepstone et al., 2022), which compares well to the published value of 2.5 per cent of live body mass on a dry mass (DM) basis (Prins, 1996).

The supply and intake of protein are the main factors controlling production performance in ruminants like cattle (Köster et al., 1996) and buffalo on dry rangeland. The minimum crude protein requirement of buffalo is 7–8 per cent (Prins, 1996), which may be provided by browse when available. When considering dietary protein supply in ruminants, it can generally be broken down into rumen-degradable protein (RDP) and rumen-undegradable protein (UDP). Ruminants require protein (nitrogen and amino acids) for two important functions. First, specific amino acids are needed for their metabolic processes (UDP). Second, and more importantly, protein from grass and supplemental feed is needed to supply the necessary nitrogen (RDP) to the rumen microbes to multiply, playing a pivotal role in increasing the VFI of dry forage. A ruminant's RDP requirement in general can be calculated using the following equation: $\text{RDP} = \text{live body weight}^{0.75} \times 4$. The VFI of dry grass is directly related to the concentration of RDP in the forage and/or feed.

While buffalo can increase their dietary protein intake by increasing their VFI, they are constrained by the need to ruminate, which competes with grazing time. In addition to selecting more browse during periods when high quantities of mixed quality food are available or under food scarcity/poor quality conditions, buffalo apply bulk grazing, whereby they graze during periods of adequate or high grazing volume availability and spend equal amounts of time grazing and ruminating (Prins, 1996). When the quantity and quality of grazing is poor, buffalo spend more time in search of food, therefore they have less time for rumination and digestion on a daily basis, and are limited by rumen fill (capacity) regardless of passage rate. Feed supplementation should be considered to meet the nutrient requirements of buffalo, especially with regards to RDP during the dry season or during periods of increased productive/reproductive performance.

The most important goal of supplementation, particularly RDP (nitrogen), is to maximize the VFI of dry roughage during the dry season to ensure optimal ruminal microbe proliferation and supply of microbial protein. With a limited supply of RDP (nitrogen), fewer microbes are available to ferment the finer particles of grass that have been masticated into small particles by rumination, thereby reducing the fermentation rate of the ingested food, causing food to stay in the rumen for longer periods. As it takes the animal a longer amount of time to degrade and digest the food, the animal starts losing condition, forcing it to mobilize stored energy (fat) and protein (muscle) to survive. When this problem can be diminished or even prevented by increasing the VFI of dry grass, the animal will have more nutrients to maintain its good body condition. This can be done by ensuring adequate amounts of RDP are available all year round. Green grazing normally has sufficient RDP to maintain the animal's condition, but as the dry season progresses the plants dry out, causing the quality and supply of protein to become limited for the rumen bacteria first, thereby making it necessary to supply additional RDP. Supplements formulated to supply the appropriate amount and ratio of RDP and other nutrients will enable beneficial microbes to proliferate. With a larger microbe population, the animals can degrade and ferment more food, thereby increasing their VFI of dry grass, resulting in improved production, body condition, health, milk, and colostrum quality and strong calves. As buffalo are ruminants, they can utilise nitrogen from non-protein nitrogen (NPN) sources such as urea and convert this into microbial protein (McDonald et al., 2002), making it possible to design supplements that include NPN sources such as urea.

In addition to energy and protein, minerals (macro-minerals > 100 mg/kg feed and micro-/trace minerals < 100 mg/kg feed) and vitamins are nutrients important for herbivorous animals including buffalo. Macro-minerals, micro-minerals and vitamins are important components of supplementary feed if optimal reproductive performance is desired. As grass is the main component of a buffalo's diet, the animal relies on the minerals and vitamins that grass supplies. The mineral content and the availability of grass to the animal are influenced by different factors, including grass species and stage of maturity of the grazing, the type of soil, climate and seasonal conditions, and the condition of the soil, such as pH and mineral content as well as fertilization and liming (McDonald et al., 2002). The (trace) elements that are typically deficient are phosphorous, sodium, chloride, sulphur, iron, iodine, copper, cobalt, manganese, and selenium (Schmidt and Snyman, 2016), although there may be specific minerals that are deficient in specific areas.

Vitamins are needed in small quantities by herbivorous animals, and ruminants require even less as they have microorganisms that synthesize some vitamins in the rumen that can be used in the buffalo's body. Under natural extensive conditions, vitamin levels in green grazing are generally high enough to meet the animals' requirements. The exception is vitamin A, which normally is found in low concentrations in dry mature grass and grains used in formulated feeds. As with most supplementation of shortages, the most effective starting point to control or manage a mineral or vitamin shortage is to accurately predict its extent. A possible way of predicting the mineral shortages of buffalo is to analyse the grass species selected by the animal on the ranch at different stages of growth, and then formulate a mineral supplement that makes up for the shortfalls of the grazing (Schmidt and Snyman, 2016). However, this method might prove impractical and/or costly. Alternatively, basic knowledge of the animal's well-being and behaviour, regular observation and accurate record-keeping combined with basic knowledge of the environment (type of veld, general shortages in the area, weather patterns, parasites, etc.) should suffice to identify most shortages. The buffalo themselves are the best indicators of mineral shortages, and if the animals maintain good health with 13-month intercalving periods, and the calves display optimal growth and health, then any changes made are likely unwarranted. Any unnecessary changes to the 'environment' may have an adverse effect on production and cause monetary losses.

The planting of additional grazing (pastures) is an effective management method in areas that provide low-quality natural grazing (such as sourveld in the dry months; 'sourveld' is the term used in Southern Africa for nutrient-poor, dystrophic savannas and grassland types), especially for overwintering. By irrigating these planted pastures, the feed production of the pasture can be raised substantially, and the expense of feed costs can be lowered. Nonetheless, these planted pastures can be a potential reservoir for parasites, especially in cases where the grazing forms a thick matt at the base, such as kikuyu (*Pennisetum clandestinum*, also known as *Cenchrus clandestinus*) and should be managed accordingly. Additional advantages include the fact that many of these grasses are perennial grasses, and once established, all that is needed for growth is sufficient water and, depending on the soil type, at times fertilizer. The grass not used for grazing can be baled and either stored for drought years or sold as an additional source of income.

Influence of Season on Nutrition and Feeding

Three factors need to be taken into consideration to estimate what nutrient shortfalls exist, if any, namely: (i) a nutrient analysis of the grass or roughage supplied to the animals; (ii) an assessment of the physiological state of the particular class of animals, including body condition, to gauge their nutrient requirements; and (iii) for the same reason, an estimate of the typical weights of the particular class of animals for which one wants to estimate the possible nutrient shortfall. The available grass on reserves and game ranches is normally a combination of annual and perennial grass species. These grasses have a green growing phase and a dry phase (Figure 14.1). During the dry phase, perennial grasses go into dormancy and store most of their nutrients in their roots and seeds, while the annual grass species release their seeds and die. Under free-ranging conditions, many buffalo populations would migrate shorter or longer distances, grazing higher-quality food elsewhere, but within ranches they are stuck in an area (due to fencing) where the grass nearly always deteriorates to a point where the buffalo lose condition. Buffalo in a poor body condition have lower conception rates, fewer calves, less milk and fewer calves that reach adulthood (see Chapter 7); in addition, the general health of the adult and subadult deteriorates over time.

The changes in nutrient quality from a high-/higher-quality green plant to a dry, brownish, poor-quality plant have a direct effect on the buffalo's ability to break down and digest the available grass. Protein, energy, macro-minerals, trace minerals and vitamin concentrations decrease as the plant dries out, while the fibre portion increases. The drastic decrease in nutrient concentration, particularly RDP, results in fewer microbes proliferating, slowing down the degradation and digestion of the ingested fibrous feed, and thus the production of volatile fatty acids (VFA). VFAs produced by these microbes are the main energy source for ruminants and thus buffalo. The small population of microbes present when buffalo feed on poor-quality feed takes longer to degrade

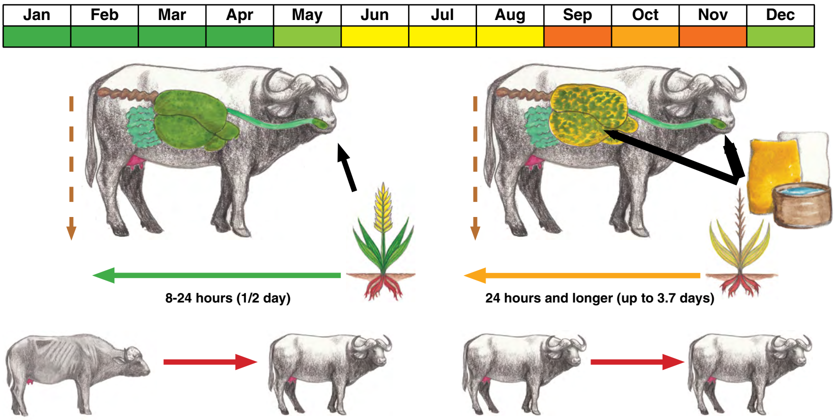

Figure 14.1 How the season affects the quality of the grazing and animals' body condition in southern Africa. Considering the months of January through to December (a full year), each month has a shade of green (rainy season), or yellow to orange (dry season). The green blocks correspond with the rumen and plant (in green) and the green arrow below it, portraying the time of the year when the selected feed gets degraded and digested in less than 24 h. The yellow to orange blocks correspond with the rumen and plant (in yellow/orange) and the orange arrow below it, portraying the time of the year when the selected takes longer than 24 h to be degraded and digested. Source: Craig Shepstone.

the fibrous feed, resulting in the feed remaining in the rumen for a longer period, forcing the animals to mobilize stored nutrients to survive (Figure 14.1) and resulting in the animal losing body condition.

As shown in Figure 14.1, the nutrient-rich green grass available from January to April supplies enough nutrients for increased VFI. Bulk grazing ruminants like buffalo then only need between 8 and 24 h to digest the green grass, resulting in an improved body condition (poor to improved body condition). However, in the dry season (June to November), buffalo can take as long as 3.7 days to digest the nutrient-poor grazing available, resulting in poorer body condition. The lower the RDP concentration in the dry grazing, the longer it takes to be digested in the rumen. Supplying the correct amounts of the necessary nutrients in the dry season will aid in reaching the desired production/reproduction goals, reducing feed digestion time from 3.7 days (worst case scenario) to 24 h.

For optimal production, managers should pre-empt the negative effects of the upcoming dry season and supply supplemental feed in small amounts before the grass deteriorates and the animals start losing condition. As the dry season progresses, it may be necessary to supply more nutrients for optimal body condition; the reason for this is that grass nutritional quality deteriorates further as the dry season progresses, particularly the protein and energy contents. Supplementing ranched/managed animals with the feed nutrients they need during the times when nature cannot supply these nutrients will not only speed up the time taken to digest the ingested food, but will also improve body condition, conception, milk production and general health. Not unimportant, it will assist in raising healthy calves. Furthermore, when considering optimal production in times of drought where the quality and the quantity of the available feed gets poorer, it is imperative that animal numbers are reduced, or additional high-quality roughage be supplied. Droughts have deleterious effects on production, reproduction and growth, with young and weaned animals being the most vulnerable (Chapter 7).

Supplementary Feeding of Ranched Buffalo

High-quality feeds can be used to supplement buffalo during critical periods (without having to decrease the number of animals) and can be found in different forms. These include everything from pellets to home-mixed rations, which are normally supplied in an amount smaller or equal to one-third of total daily intake. Supplementary feed for buffalo on dry grazing focuses on supplying RDP, energy, minerals and vitamins. In situations where grazing is limited or not available (in a 'boma', also known as 'kraal' or 'corral'), feed must be supplied daily with all of the above nutrients together with ample high-quality roughage. In the rainy season, when the quantity and quality of grazing are high, supplying adequate amounts of protein and energy, some minerals may nonetheless remain deficient. For example, phosphorus, copper and zinc are deficient in most parts of southern Africa, making it advisable to supply some minerals to the animals throughout the year. Mineral licks composed of salt, macro-, and trace minerals will supply the nutrients for the animals to reach their owners' production goals.

For any rancher/manager interested in obtaining well-balanced feeds, licks in both meal and block form for supplying buffalo the nutrients nature cannot, feed companies throughout southern Africa (South Africa, Namibia, Zimbabwe, Zambia) can be contacted, who will formulate and supply custom diets for the game ranches' specific need. Purchased or self-mixed feeds usually come in the form of a supplement (concentrated feed) providing $\leq \frac{1}{3}$ of total DMI a semi-ad-libitum

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feed supplying approximately ⅔ of total DMI and full feeds, otherwise known as total mixed rations (TMR). Semi-ad-libitum feeds are usually 50:50 concentrated nutrients: high-quality roughage. Some pellets on the market, known as high-fibre pellets, are designed to be fed as semi-ad-libitum feeds. A TMR for buffalo usually contains roughly one-third (33–40 per cent) of the total daily amount of feed as concentrated nutrients that supply all of the desired trace minerals and vitamins, and most of the protein and energy, with the rest of the roughage making up the difference. To ensure optimal rumination in the bulk-grazing African buffalo, fibre length should be at least 2.5–3.5 cm.

Intakes of concentrated supplemental feed, known in Africa as lick, in a meal (powder) or block form can be controlled by increasing or decreasing the concentration of salt, ammonium sulphate and mono-calcium phosphate and by hardening the licks in block form by adding binders like calcium hydroxide, magnesium oxide and molasses syrup.

When pellets or fine meals are used as ⅔ of the total DMI, the concentrations of the nutrients, particularly protein, energy and copper, should be kept in mind. Do not supply a pellet or fine meal that is designed as a supplement as a semi-ad-libitum feed at approximately two-thirds of DMI or as a full feed at three-thirds. This will result in the overconsumption of some nutrients or minerals, which could cause deleterious effects. Additives like Poly Ethylene Glycol (PEG) can be added to a supplemental diet to aid the buffalo in degrading and digesting tannin-rich browse when they need to consume browse as a food source. Mycotoxin binders should be added to all self-mix recipes. If self-mix recipes are stored for periods longer than 2 or 3 days, the addition of a mould inhibitor is advised. The addition of an active yeast product will aid in the control of rumen pH (reducing the risk of acidosis) and enhance fibre digestion (Chaucheyras-Durand et al., 2016). All dry or semi-dry feed should be stored in a well-ventilated (dehumidified if necessary) storeroom or container (rodent-, insect- and bird-free), preferably on pallets, and never in direct sunlight.

Buffalo should receive good-quality grass hay as the largest portion of their diet. When hays (alfalfa, grass, oat or other cereal hays) are supplied to the animals in the camp (ad-libitum if limited or no grazing is available), place them in or near the feeding area, in a separate bowl or hay rack that keeps the hay off the ground (reducing losses and cost). All hay that falls on the ground should be removed, preventing young animals from eating wet/soiled/mouldy hay. Mouldy or dusty hay can cause pneumonia, colic and/or heaves. All roughage with any visible signs of mould should not be used, as it usually contains high levels of mycotoxins. If poor-quality grass is the only source of grass hay available to the animals, it would be advisable to mix 10–20 per cent legume hay (alfalfa) into the roughage diet to augment the amount of protein. Legume hay roughage, such as soya bean or peanut, can be used as a roughage source if the products are free of mycotoxins, as the pods often house the fungus. When in doubt, use a suitable mycotoxin binder when using any such roughage as feed. Macronutrient analysis of all hay should be done routinely. This will not only help illustrate what the buffalo are eating, but it will also assist in deciding how much legume hay is needed to be mixed into a ration if the grass hay is of poor nutrient quality. Exclusive use of small grain hay and alfalfa hay for the Cape buffalo is discouraged as it may lead to mineral imbalances, laminitis, colic and diarrhoea, and other dietary abnormalities.

When the season changes and the nutrient quality of the grass drops to levels where it is necessary to supplement the animals with a supplemental (concentrated) feed to keep them in good condition, it is critical to remember that the animals need to be slowly adapted to the feed (over 5 weeks) to avoid conditions like acidosis, rumenitis and *Clostridium*-related illnesses, which can be fatal. This is also important when changing concentrated feeds, where the new feed is mixed with the old in increasing increments of $\frac{1}{5}$ over the 5 weeks. Animals should be vaccinated against red gut (frequently caused by sudden feed changes to ruminant diets, thought to be caused by excess growth of *Clostridium perfringens* type A, which causes an enterotoxaemia or torsion of the gut). During the growing season, it is necessary to supply a well-balanced mineral lick, and a well-balanced supplement/semi-ad-libitum feed in the dry season.

When a particular spot in a camp is used continuously as a feeding site, problems could arise in the long term, namely parasite build up (wire and other roundworms and coccidia) and a breeding place for disease due to the high number of flies and mould growing in old food, leading to possible mycotoxicosis. Unfortunately, feeding sites that are used continuously are often associated with accumulated faeces and urine. To prevent the build up of the abovementioned problems, and to encourage the animals to eat grass in a different part of the reserve or game ranch, feeding sites should be moved regularly. Small enclosures are an exception, making dedicated feeding sites necessary. These feeding areas need to be designed so they can be cleaned and disinfected routinely. Feed should not be placed near water troughs, and placing feed bowls a short distance away will limit the amount of collected feed falling out of

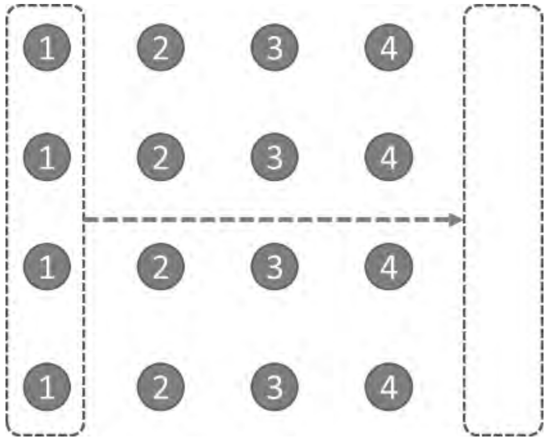

Figure 14.2 Feed bowl placement in a camp and movement suggestions. The circles represent bowls, and the figures refer to a column of bowls that need to be moved together periodically, from left to right as shown in the diagram. Spaces between bowls should be 2.5 the animal's length. Source: Craig Shepstone.

the animal's mouth into the water. Water troughs and feed bowls must be cleaned routinely, and new feed should not be added on top of old remaining feed.

A rule of thumb suggested to ranchers who keep animals where both male and female animals have horns is to place a bowl per animal and an extra bowl for every four animals, but observation of the competition at feeding is necessary, and it may be necessary to increase the number of bowls. Place the bowls 2.5 animal lengths apart in a rectangular chessboard-like fashion and only feed the animals when they are near the feed bowls. Move one line of bowls every second or third day (Figure 14.2). This not only saves time but also gives the keeper the chance to clean all the bowls at least once a month.

Water Provision

The importance of water in ruminant nutrition is often overlooked; water being the basis of rumen fluid creates a suitable environment in which the beneficial anaerobic bacteria can degrade (ferment) and digest the selected food, making it imperative that animals like buffalo need a regular supply of clean water.

The water requirements of buffalo differ according to the different circumstances and environments. Factors affecting water requirements include the gestation, age and physiological condition of the buffalo, the composition of the vegetation fed on and environmental conditions. Watering points are needed at regular intervals to supply adequate water without the buffalo having to travel long distances. Buffalo can utilize most types of water sources but seem to prefer artificial water holes and dams over troughs. In the case of intensive ranching, it is advisable to use water sources that can be controlled. Controlled water points can be tested and analysed for quality and contaminants (which is advised when ranching intensively with high-value species) and filtered if harmful agents are found in the water, as opposed to open and stagnant ground-/rainwater which could contain toxin-producing bacteria or other harmful agents. Open groundwater also doubles as a potential mud hole for wallowing, which is a part of daily activity in warm months, especially by bulls. As buffalo tend to urinate or defecate in these mud holes, it is advised to limit these to only wallowing (and not drinking as well) to prevent any potential diseases emanating from these activities.

Reproduction

The reproduction efficiency of buffalo is influenced by body condition (like cattle), and thus nutrition plays a crucial role in a herd's reproductive performance. It is influenced by the fact that buffalo show some degree of seasonality in their breeding activities under extensive conditions, with most births occurring during seasons when food quality and availability are at their highest (Bertschinger, 1996). However, the degree of breeding seasonality may differ under semi-extensive/intensive conditions where nutrition is optimal and health challenges are minimized. The attainment of sexual maturity is primarily influenced by body condition and thus nutrition; sexual maturity in buffalo is estimated to occur when they attain two-thirds of their genetically determined adult body mass which, depending on their condition, is generally 4–5 years of age for wild free-ranging southern African buffalo heifers. Typically, mature males can weigh 650–850 kg while females can weigh 520–635 kg at maturity. In captive-bred/supplemented herds, buffalo heifers, due to better nutrition and consequently faster growth rates, regularly become sexually mature in the latter stages of their third year. The average lifespan of the buffalo is 11 years under wild conditions (disease and predation being mostly responsible for mortalities) and 16 years in captivity. Females become senescent at 15 years (Prins, 1996). Maximum lifespans are 24 and 20 years on average, for males and females, respectively.

African buffalo are promiscuous, and under extensive, so-called natural conditions, adult buffalo bulls constitute 10–15 per cent of the herd and adult females 55 per cent (Sinclair, 1977), and thus a 1:5 adult sex ratio typically exists. As reported in the survey of Hildebrandt (2014), southern African ranches tend to have a male:female ratio of 1:2 under intensive ranching conditions, with a ratio of active breeding bulls:cows being 1:27, within herds that ranged from 56 to 290 buffalo (mean = 156 animals/enterprise). Hildebrandt concluded that the optimal ratio of breeding bulls:cows would be 1:30, provided that their nutritional requirements are met and body condition is maintained.

The buffalo cow is polyoestrous, and her oestrous cycle is 23 days long, with oestrus lasting 24 h, and the ovulation of two ova is rare (the second is often resolved). The buffalo is a long-day breeder, being sensitive to photoperiod effects. The gestational period of buffalo is ~340 days, with an intercalving period varying from 13 to 29 months, depending on nutritional conditions (Prins, 1996). Hildebrandt (2014) conducted surveys of a number of ranches in southern Africa and reported an average intercalving period of 443 days (14,6 months), with the optimum period being under 400 days. Typically, lactation lasts 10–15 months (Carmichael et al., 1977). Calves are on average 40 kg at birth. When the calf is removed shortly after birth (3 days), oestrus occurs within 5 weeks, but post-partum anoestrus depends on the conditions of the cow and population dynamics. Cows with good body condition at parturition, receiving a high-energy diet, resume oestrus within 90 days post-partum. On the contrary, poor nutrition of the cow may result in low fecundity for up to 2 years thereafter (Ryan et al., 2007). The body condition of the cow during gestation also affects the calf's growth and survival.

Thus, prior to parturition and during lactation, the cow would benefit from improved nutrition and her body condition should be monitored. It is important to remember that as soon as implantation of the embryo takes place during gestation, the feed intake of the cow becomes the feed intake of the calf too. This continues after parturition, as the calf is now dependent on the milk from the cow, although less direct than when in the uterus, but the quality of the milk has a direct effect on the development of the calf and its performance as an adult (McDonald et al., 2002). The energy requirement of lactation is extremely high and can reach between 93 and 99 MJ/day at peak milk production (~5 weeks after parturition; Shepstone et al., 2022). The weaning age of buffalo in southern African ranches ranges from 6, 12 to 18 months (Hildebrandt, 2014). In the wild, it appears to tend more to 18 months than to shorter periods (Prins, 1996).

The feeding of weaned male buffalo bulls is often neglected, as most of them are placed in a bull camp to grow out with as little expense as possible to the rancher. As some of the weaned bulls might prove to be the best sellers, especially when from a good genetic background, it may be worthwhile to also attend to their feed requirements to optimize growth and obtain the maximum expression of their genetic potential.

From a trophy-hunting perspective, the 'solid boss' of a bull is its most desirable characteristic. Wild, free-ranging southern African buffalo, which occur south of the Zambezi River in areas with 450–750 mm of annual rainfall, become sexually mature in their fifth year, but their bosses only become sufficiently hard enough to become a desirable 'trophy' by their ninth year (Pienaar, 1969). This is the same in East Africa (Prins, 1996). Better nutrition enables captive-bred bull buffalo to grow faster and attain their sexual maturity weight at a younger age, which makes their bosses develop sooner; a 6-year-old bull buffalo may have the appearance of a solid-bossed 9-year-old simply by providing better nutrition, which in turn enables them to be hunted as 'trophies' at a much younger age.

Meat Production

Presently, with the exception of Kruger National Park (KNP, South Africa), no other entity in southern Africa has sufficient numbers of buffalo to ensure a constant supply of buffalo carcasses. However, as commercial ranchers reach their safe stocking rates and the supply of trophy bulls surpasses the demand, more inferior animals will become available (and cheaper) for so-called 'biltong' (traditional dried lightly salted/spiced meat product) or meat hunters to hunt, or to start harvesting on a more commercial scale. Nonetheless, there are still some buffalo hunted for trophy purposes whose meat is available to enter the consumption market. In addition, the culling of animals for various management reasons is an essential component of wildlife management, and there is interest in economic opportunities for game ranchers and ecotourism. However, concerns have been raised over the practicality and financial benefits of using culled buffalo as a source of meat in South Africa, where buffalo are not normally utilized for their meat. Cape buffalo have carcass yields similar to those of domestic beef cattle and produce meat with favourable organoleptic properties (Van Zyl and Skead, 1964). Cape buffalo carcasses are typically from subadults (280–430 kg live weight), adult cows (450–680 kg) or adult bulls

(600–850 kg), who yield carcass weights of 140–220 kg, 260–330 kg and 300–440 kg, respectively (Grobler, 1996). Thus, buffalo typically have a dressing percentage of 48–58 per cent depending on their gut fill at point of slaughter – similar to that of *Bos taurus* cattle (Hoffman et al., 2020). Under extensive conditions, the mass gains (kg/year) from up until 42 months can be expected to be for different regions of Africa (Bothma and van Rooyen, 2005):

- Kruger National Park, South Africa: 113 kg/year for bulls and 108 kg/year for cows
- Serengeti, Tanzania: 103 kg/year for bulls and 99 kg/year for cows
- Ruwenzori, Uganda: 103 kg/year for bulls and 92 kg/year for cows
- Northern Uganda: 105 kg/year for bulls and 100 kg/year for cows.

Currently, there is a lack of scientific information regarding expected growth rates for intensively farmed buffalo.

As outlined in Figure 14.3, the culling and processing of African savanna buffalo meat typically involve five stages, namely (1) field operation, (2) slaughter, (3) deboning, (4) production of products, and finally (5) marketing. Moreover, these logistical points (phases) will utilize a set of activities required to process a raw material into a value-added product.

Field Operation and Slaughter

Two of the challenges involved in the large-scale harvesting of buffalo in the field is to shoot a sufficient number of animals rapidly and efficiently ensuring that the procedures comply with animal welfare standards and human safety requirements, and to ensure that the carcasses all fall in an area as small as possible to facilitate the further slaughtering and loading of the carcasses for transport to the abattoir. Due to these challenges, a typical system that has been shown to work efficiently is to shoot a group of buffalo out of a helicopter with darts containing scoline (suxamethonium chloride, also known as suxamethonium or succinylcholine). This is a medication used to cause short-term paralysis; in most countries the use of scoline has to be managed by a veterinarian. The helicopter pilot can herd the darted group of buffalo (four to eight, depending on terrain, herd size and abattoir capacity) into a small compact group until all of the darted animals have dropped (±5 min from the first dart). Before the cull, careful selection of the 'killing zone' needs to be made to ensure that the animals are close to this area and that it is accessible to

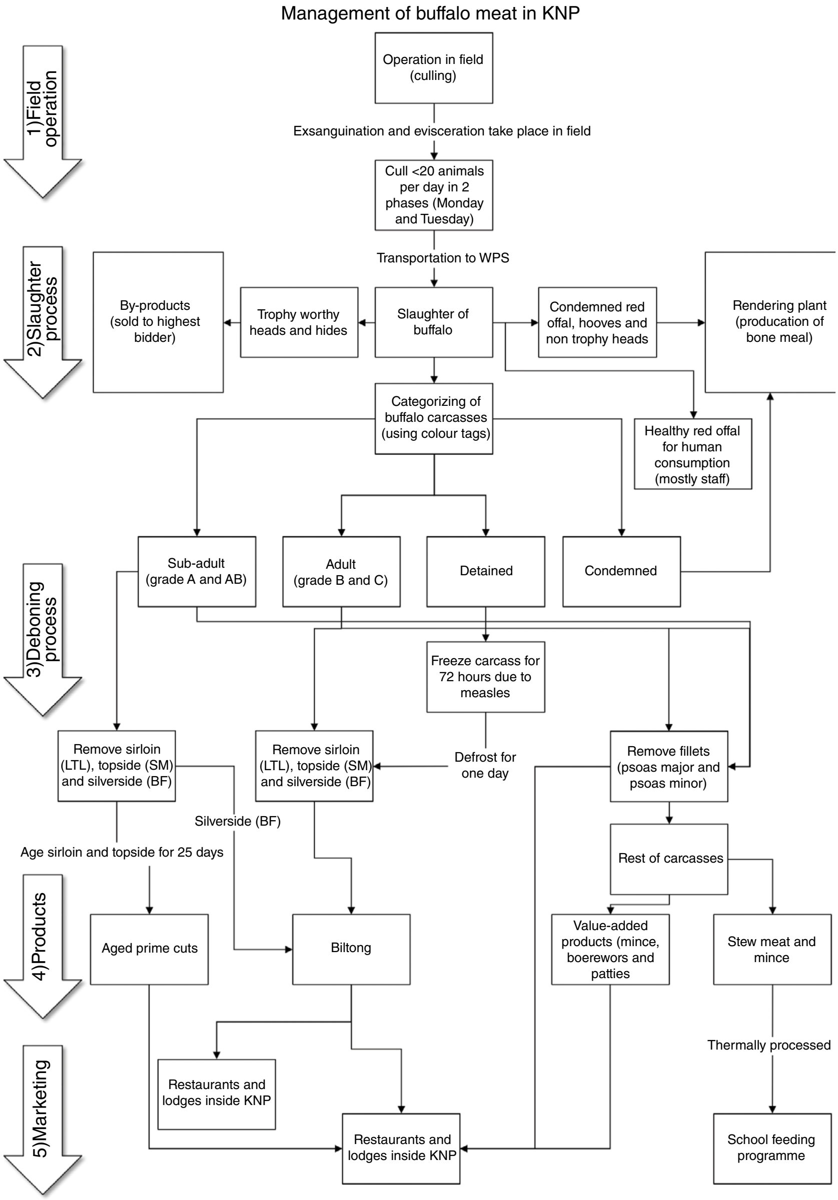

Figure 14.3 Standard operating system for the major logistical operational points to be considered in a typical buffalo culling scheme, as demonstrated in Kruger National Park (KNP, South Africa). LTL = *longissimus thoracis et lumborum*; BF = *biceps femoris*; SM = *semimembranosus* muscles; WPS = Wildlife Processing Structure. Source: Louwrens Hoffman.

the ground team and all vehicles. After dropping, the animals are killed with a free bullet shot in the head with a heavy-calibre rifle.

Although cost-effective, safe for the operators and widely used since the 1980s, the use of scoline is prone to ethical issues. Herding, darting buffalo with scoline and resulting asphyxia was shown to generate high levels of cortisol concentrations compared to animals shot at a standstill (Hattingh et al., 1984). Such response could partly be ascribed to conscious perception of asphyxia in conscious animals with resulting fear (Button and Mülders, 1983). Previous studies suggested that residues of scoline in meat and biltong are apparently considered acceptable by public health authorities (Button et al., 1981). This statement should be re-examined in the light of recent technologies and standards, also taking into consideration that using scoline alters physical meat quality attributes (pale, soft and exudative meat; Hoffman, 2001). In a context of evolving animal welfare standards, the cost–benefits associated with the use of scoline should also be reconsidered.

After shooting, the animals are bled/exsanguinated, preferably on a slope or suspended. Using a terrain vehicle that is equipped with a conveyer belt whereupon the buffalo carcasses are placed helps to speed up the time between exsanguination and the hanging process. Removal of the internal organs from the carcass takes place in the field to ensure that there is no bloating of the carcass (which increases the risk of contamination). Ideally, transportation to the abattoir should not take longer than 2 h. It is important to ensure that knives are sterilized throughout and that hand-cleaning facilities are available. The primary meat inspection is conducted by a state veterinarian in the field and includes inspecting the head, pluck (red offal), feet, abdominal and reproductive organs of a partially dressed game carcass with the pluck and carcass then being sent to a registered game abattoir. Most of the white offal is left in the field for predators or vultures. However, some of the white offal will be cleaned and taken for consumption by the staff, such as the plies (third stomach) and set of tripe (weasand, first, second and fourth stomach and rectum).

Following the field operation, buffalo arrive at the abattoir offloading section (Figure 14.3). The carcasses are hoisted up, suspended from both Achilles tendons, and weighed. The head is removed, and trophy-worthy heads are cleaned and dried in the sun to be sold as trophies to hotels and restaurants as decoration or to individuals, while the smaller heads and the condemned (i.e. rejected) carcasses go to the rendering plant to produce an end product known as bone meal that can be sold as fertilizer. The skin is then removed, and to prevent contamination, removal of the hides should be done carefully, preferably when the carcass is warm, and all of the cuts are made from the inside to the outside to prevent contamination of the meat, using the two knife principles. The hides are normally processed (salted and dried) to be sold at auctions.

Red offal is preferably removed at the abattoir and is hung on a separate line, in the same order as the carcasses, for inspection by the veterinarians so that they may be correlated with the carcass, which is also individually inspected. The carcasses should be split with a saw blade along the spinal column to promote chilling. Lastly, the carcasses are washed with potable water, to remove all blood and bone sawdust, quartered between the ninth and tenth ribs, and weighed before being placed in the cold room (<7°C).

If only the red offal is affected, and the rest of the carcass is normal, only the red offal is condemned (lungs, heart and liver). However, if the intestines are linked to general diseases such as enlargement of the lymph glandes, fever, or hepatitis, etc. the whole carcass is condemned. The condemned carcasses and condemned organs are sent to the rendering plant to create bone meal. Carcasses can be partially or totally condemned. Affected areas are condemned for various reasons, such as infections caused by systematic or generalized lesions.

Older buffalo, depending on where they have been reared and with which other species (generally wild dogs and carnivores) they have interacted, can contain intermediate stages of tapeworm parasites (cysticerci and hydatid cysts) and need to be frozen for a minimum of 72 h with an air temperature of at least –18°C before being deemed fit for human consumption. However, the freezing compromises the quality of the meat and it is no longer suitable for selling as tender prime meat and should thus be processed further.

Deboning and Products

While no official carcass grading system is currently used for buffalo, or any other game species really, Table 14.2 provides a suggested grading system that could be utilized to class buffalo carcasses according to age. The application of a grading system helps to categorize buffalo carcasses, guiding the deboning team to know which carcasses will go for prime steaks, ageing, value-added products and processed meat. Incorporating the grading of buffalo at the abattoir will help speed up the process and prevent adult/old buffalo meat from being sold as prime tender (and expensive) steaks.

Table 14.2 *Suggested grading of African savanna buffalo (*Syncerus caffer caffer*) carcasses.*

Grade	Permanent incisors	Buffalo age	Category
A	0	<2 years	Juvenile
AB	1–2	2.5; 3–3.5 years	Subadult
B	3–6	4; 4.5; 5; 5.5 years	Adult
C	7–8	6; 6–10; >12 years	Old

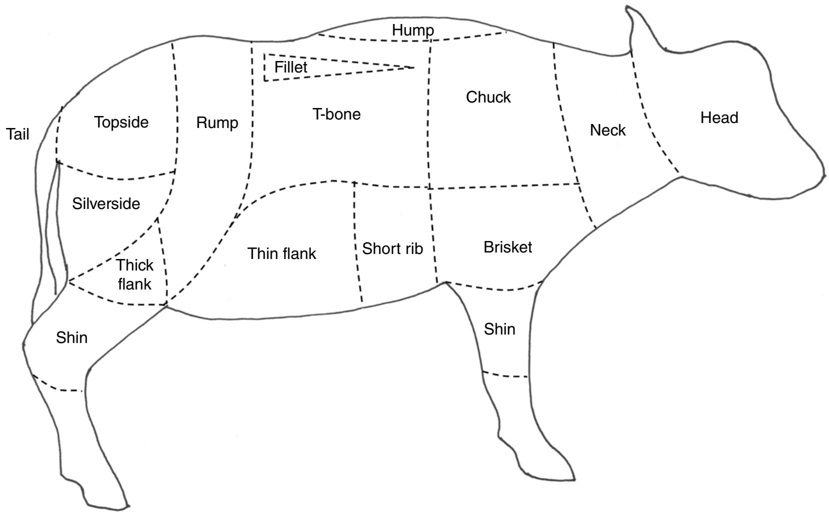

Figure 14.4 Primal cuts of African buffalo carcasses for further processing and marketing. Source: Tersia Needham.

Grades A and AB (subadult) buffalo carcasses should be used for aged primal cuts as well as processing for value-added products. Grades B, C (adult) and detained (frozen) buffalo carcasses can be used for processed meats (mainly biltong, a traditional dried lightly salted/spiced meat product) and value-added products. However, the fillets of all the carcasses can be sold as primal steaks at the highest price.

Deboning is the process whereby the fore and hind quarters of the carcass are taken and processed into various primal cuts (similar to those from beef carcasses, and illustrated in Figure 14.4) at 24–36 h post-mortem. The primal cuts from the hind quarter are silverside (*biceps femoris*), fillet (*psoas major* and *psoas minor*), sirloin (*longissimus thoracis et lumborum*), prime rump (*gluteus medius*), T-bone, topside (*semimembranosus*), knuckle

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(*vastus medialis* and other related muscles) and hind shin (*Peronaeus terius*, *extensor digitorum longus* and *extensor digiti terii proprius*).

Block tests are a measure established for wholesalers and retailers to price a variety of cuts given a certain producer price. By using the block test, the quantity of meat that will be produced can be predicted, and the price per carcass can be calculated. Therefore, block tests (Table 14.3 on a buffalo with a carcass weight of 277 kg) should ideally be conducted regularly to help determine the number of different cuts that will be produced from a buffalo carcass.

Primal cuts should be vacuum-packed and matured for a minimum of 25 days under refrigerated conditions (and labels should clearly indicate the day in and suggested sale date) before being sold, with the sirloin and topside muscles in particular identified as valuable cuts. The fillets of all animals can be sold as soon as they are removed; due to their

Table 14.3 *Block test conducted on an African savanna buffalo (carcass weight of 277 kg).*

Retail cuts	Weight (kg)	% whole carcass
Topside	11.4	4.11
Silverside	15.2	5.49
Rump steak	10.9	3.93
Thin flank	8.5	3.07
Thick flank	8.9	3.21
Short fillet	1.9	0.68
Soft shin	11	3.97
Shin	3.3	1.19
Tail	0.5	0.18
T-bone steak	15.8	5.7
Blade steak	13.7	4.94
Brisket	17.3	6.24
Short rib	6.3	2.27
Chuck/prime	22.7	8.19
Neck	11	3.97
Trimming	21	7.58
Stew	43.6	15.74
Goulash	3.1	1.12
Hump	4.5	1.62
Bones	34	12.27
Sinew and fat	10.7	3.86
Band saw loss	1.7	0.67
Total	**277**	**100**

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inherent nature/composition, they need not be aged. In contrast, the silverside is ideal for biltong production, as toughness will not decrease over a more extended ageing period, and it will thus remain a tough muscle. The offcuts and trimmings could be used for value-added meat products, including biltong, droëwors (traditional dried sausage product made from meat off-cuts, sheep/beef fat and traditional spices), patties, boerewors (traditional fresh sausage) and minced meat. Biltong can be produced from frozen-thawed (detained) carcasses using different drying methods, which creates a larger profit margin because frozen carcasses can only be used for processing biltong, stewing meat and mince.

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