Management and reproduction of the African savanna buffalo (*Syncerus caffer caffer*)

by

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DECLARATION

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SUMMARY

The aim of this study was to evaluate the current managerial practices as used by African Savanna buffalo (*Syncerus caffer caffer*) farmers. Consequently, the best management practices would be combined to formulate a basic management plan to farm captive buffalo. The distribution of buffalo throughout South Africa was also investigated and each province was considered separately for different types of buffalo (Kruger also known as project; Addo and other) and different disease statuses (Foot and Mouth; TB; Corridor disease and disease-free or clean). The basic infrastructure of all farms studied was noted and evaluated to attain the most effective structures and layouts needed for basic captive buffalo farming. The reproductive capabilities of buffalo were assessed on different farms. These farms were divided into winter and summer rainfall areas to ascertain whether season or rainfall would have an effect on calving season. Additionally the reproduction data was analysed to set a benchmark for the reproductive performance of buffalo in herds as well as individually. This assisted in selection in captive breeding of buffalo.

Buffalo are currently distributed throughout South Africa and occur in all nine provinces, with the highest quantity found in Limpopo with 1300 registered buffalo farms. Provinces that contain only disease-free buffalo include Western Cape, Eastern Cape, Freestate, North-West and Gauteng. Corridor infected buffalo are found in the Northern Cape, Mpumalanga and KwaZulu Natal. Foot and Mouth disease is found in Limpopo and Mpumalanga and TB infected buffalo are found in Mpumalanga and KwaZulu Natal.

Factors to consider when managing captive buffalo herds are the herd dynamics and composition, feeding and nutrition and lastly parasite control. Management should be approached adaptively as different areas present different challenges.

Infrastructure is divided into the farm and biomes thereof, feeding and parasite treatment. As with herd management these should be approached adaptively as the composition of each farm differs.

Reproductive maturity of buffalo is reached between the ages of two and six years. Average intercalving period of captive buffalo was to be 443 days with optimal intercalving being below 400 days. Seasonal calving differences between summer and winter rainfall areas were found with calving peaks differing by two months between these areas.

OPSOMMING

Die doel van hierdie studie was om die bestuurstegnieke wat tans deur Afrika Savanna buffel (*Syncerus caffer caffer*) boere gebruik word te evalueer. Gevolglik sal die beste bestuurs-praktyke gekombineer word om 'n basiese bestuursplan the formuleer om omheinde buffels te boer. Die verspreiding van buffels in Suid-Afrika is ook ondersoek en elke provinsie is afsonderlik oorweeg vir die verskillende tipes buffels (Kruger ook bekend as projek; Addo en ander) en verskillende siektestatusse (Bek-en-Klou seer; TB; Corridor siekte en siekte-vrye of skoon). Die basiese infrastruktuur van al die plase in die studie is genoteer en geivalueer op die mees effektiewe strukture en uitlegte vas te stel wat benodig word vir die boer van omheinde buffels. Die reproduktiewe vaardighede van buffels is geassesseer op verskillende plase wat verdeel is in winter en somer reënval streke om vas te stel of seisoen of reënval 'n invloed het op kalf seisoen. Die reproduksie data is ook geanaliseer om 'n riglyn te stel vir die reprodutiewe prestasie van buffels in 'n kudde asook individueel. Dit sal help met die seleksie van teeldiere.

Buffels is tans wyd versprei oor Suid-Afrika and kom in al nege provinsies voor met die hoogste hoeveelheid in Limpopo (1300 geregistreerde buffelplase). Die provinsies wat slegs siekte-vrye buffels bevat is Wes-Kaap; Oos-Kaap; Vrystaat; Noord-Wes en Gauteng. Corridor-besmette buffels kom voor in Noord-Kaap; Mpumalanga en KwaZulu Natal. Bek-en-Klou seer kom voor in Limpopo en Mpumalanga en TB kom voor in Mpumalanga en Kwa-Zulu Natal.

Faktore wat oorweeg moet word met die bestuur van omheinde buffeltroppe is kudde dinamika en samestelling, voeding en laastens parasietbeheer. Buffelbestuur moet aanpasbaar wees aangesien verskillende areas verskillende uitdagings bied.

Infrastruktuur kan opgedeel word in die plaas en sy biome, voeding en parasiet behandelings toediening. Soos met kuddebestuur moet infrastruktuur ook aanpasbaar wees, aangesien die samestelling van elke plaas verskil.

Reproduktiewe volwassenheid van buffels word bereik tussen die ouderdomme van twee en ses jaar. Gemiddelde interkalf periode vir omheinde buffels was 443 dae met optimale interkalwing van minder as 400 dae. Seisoenale kalwingsverskille tussen somer en winter reënvalstreke is opgemerk met kalfpieke wat verskil met twee maande tussen die streke.

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CHAPTER 1

Introduction

The game industry as a whole has increased in size over the last 50 years since the first game auction in 1965 with a drastic peak in game sales in the last 15 years. Of these peaks African Savanna buffalo (*Syncerus caffer caffer*) has shown the greatest increase with record prices for live sales increasing from R250 000 in 2004 to R40 000 000 in 2013 for a single buffalo bull. Apart from the increase in price, the monetary value of buffalo has had a positive influence on the numbers and distribution of buffalo throughout South Africa.

Buffalo numbers and distribution decreased throughout the first half of the century due to a variety of reasons; their association with certain diseases being one of the main factors for this decrease (Furstenburg, 1998; Carruthers, 2008). These diseases include Foot-and-mouth disease (FMD), Corridor disease (CD), Bovine Tuberculosis (BTB) and Bovine Brucellosis. In 1996, a number of disease-free buffalo breeding projects were approved and resulted in the start of the increase in distribution and numbers of buffalo in South Africa. Immediately, the genetic diversity of buffalo sold for private ownership was increased and buffalo became a high value game species. Accordingly, three different disease-free buffalo "types" available for auction emerged namely Addo, Lowveld or Kruger and East African. Each of these types had a different monetary value with Addo being the cheapest and East African the most expensive. Nonetheless, the resulting change in the distribution of buffalo over the last 18 years has not been recorded adequately, especially when considering the different types and origins of the buffalo. This neglect of record keeping has also been noted for the intensive production of buffalo and to date, very little scientific support exists for the management of captive buffalo.

Many opinions exist on the management of buffalo. For intensive buffalo there is little scientific proof that supports the opinions and advice given on management practises. Much of the current advice given as factual is either derived from wild buffalo studies or is a modified version of cattle farm management. Neither of these two methods in isolation will be effective for buffalo and thus a combination of the two is required for the intensive management of buffalo. Additionally, the value of experience should not be under estimated and management practices as implemented by successful buffalo farmers should be used to further modify the optimal management of buffalo.

The efficiency of management can be evaluated by the reproduction of the breeding herd seeing as this is the functional unit of a buffalo farm. Little data exists to evaluate the reproduction performance of a buffalo herd or an individual in a herd. This is due to a lack in record keeping of reproductive parameters. Most of the current data on buffalo reproduction consists of observational studies on wild buffalo. Whether this is due to a lack of recorded data or the unavailability of the recorded data, little knowledge is being shared regarding actual production parameters for buffalo. What is currently known of buffalo is that their gestation period is approximately 340 days (Ryan *et al*., 2007), that the inter-calving period of buffalo can range between 13 to 29 months depending on the availability of high quality feed and grazing (Sinclair, 1977; Prins, 1996), that sexual maturity is reached between 4 to 6 years of age and is greatly influenced by the weight of the cow (Carmichael *et al*., 1977; Jolles, 2007) and that buffalo are a-seasonal breeders and that their breeding and calving times are mainly influenced by the available vegetation to maintain the body condition score of the cow (Skinner *et al*., 2006). Furthermore the calving weights of buffalo are similar to those of domestic cattle and water buffalo of similar frame size and the oestrous cycle of the buffalo cow is 23 days with oestrus lasting 24 hours (Pienaar, 1969; Knechtel, 1993). All this information is available for wild buffalo, but none is available for intensively reared/produced buffalo that have received optimal nutrition year round and have little or no predation and disease stress.

To assist with effective management and facilitate easy record keeping, the correct infrastructure is needed for captive buffalo ranching/farming. However, different infrastructure systems are effective for buffalo farming and thus each farm should be treated as a unique situation. Behaviour of wild buffalo should be used as one of the core determinants for designing the optimal infrastructure. Buffalo are seemingly docile, but are highly unpredictable and have a strong hierarchy among both males and females resulting in them rarely being handled successfully in the same manner as cattle (Mloszewski, 1983; Prins, 1996). Thus special handling/treatment facilities are needed to keep the handler safe and place as little stress as possible on the buffalo. Buffalo are also associated with diseases and thus quarantine facilities are needed for long term lairage (up to four weeks), whilst mandatory tests are being run to ensure the disease-free status of a herd (Laubscher & Hoffman, 2012). Infrastructure for buffalo breeding can be divided into four elements namely: area/topography of location, enclosure, feeding and drinking facilities and treatment/handling facilities.

This study therefore attempted to scientifically quantify some of the knowledge that exists in the industry as pertaining to the management of farmed buffalo with a special emphasis being placed on the reproductive management of these animals.

CHAPTER 2

Background and history of African Savanna buffalo (*Syncerus caffer caffer*)

1. Buffalo in Africa

Records of the African buffalo can be traced as far back as 1553 when a French physician-naturalist, Pierre Belon, made note of an animal which he described as a "little ox" (Mloszewski, 1983). Although his description of buffalo matched that of the smaller northern buffalo (*Syncerus caffer aequinoctialis*), interest was raised in this unfamiliar creature. Over the next two centuries, very little was mentioned about the African buffalo (Mloszewski, 1983). During the mid- and late- 1800s, the number of accounts and descriptions of the African buffalo increased due to the fact that more hunters and explorers travelled the African continent at this time (Mloszewski, 1983; Prins, 1996). Early mammalogists identified 43 sub-species after the African buffalo was renamed from *Bos caffer* to *Syncerus* in 1847, making *Syncerus caffer* the African mammal with the largest morphological variation (Du Toit, 2005). More recently, the sub-species have been narrowed down to two, three or four depending on the classification used.

The most robust classification was set by Smithers (1983), whereby two sub-species were identified, namely the Savanna buffalo (*Syncerus caffer caffer*) and the forest (dwarf) buffalo (*Syncerus caffer nananus*). According to the Rowland Ward Records of Big Game (Smith, 1986), three sub-species are classified and are divided according to their geographic distribution. These are (1) the southern buffalo (*Syncerus caffer caffer*) found in South Africa, Botswana, Angola, Zimbabwe, Mozambique, Tanzania, the Democratic Republic of the Congo (DRC), Uganda, Kenya and Malawi, (2) the northern buffalo (*Syncerus caffer aequinoctialis*) found in Chad, Central African Republic, Sudan, Ethiopia, Somalia, Nigeria, Mali, Niger, Burkina Faso, Senegal and Benin, and (3) the dwarf buffalo (*Syncerus caffer nananus*) occurring in the DRC, Gabon, Cameroon, the forest belt in the Gulf of Guinea, Nigeria, Togo, Liberia, Ghana and Guinea. The difference between the northern and southern buffalo as described in the Rowland Ward Records is that the horns of the former never curve below the level of the scull, whereas the curves of the horns of the latter often drop to below the level of the scull. The dwarf buffalo is much smaller and slighter built with a reddish coat colour and no boss (area on the top of the head where the horns join) and smaller horns (Smith, 1986).

A further classification system set by Ansell (1972) combines both the morphological differences and the geographic distribution to divide the African buffalo into four groups.

Firstly, *S. c. caffer* is found in southern Africa, Angola, central and eastern Africa and as far north as the southern borders of Sudan and Ethiopia. Morphologically, *S. c. caffer* has a shoulder height of up to 1.6 m, males weigh approximately 700 kg and have large horns with a span reaching up to 130 cm (51 inches), making it the largest of the sub-species. *Syncerus caffer nananus* occurs in forests from the Ivory Coast and westwards into Liberia. Measuring in at 1.05 m shoulder height, the aforementioned sub-species is much smaller than *S. c. caffer* and has small horns and a reddish coat colour. *Syncerus caffer brachyceros* is found from the Ivory Coast through Nigeria to Lake Chad, south-east through southern Cameroon, Central African Republic, Congo and the north-western DRC. The latter are described as the intermediate sub-species when comparing size to the previous two sub-species. Lastly, *Syncerus caffer aequinoctialis* is found in the forests of eastern DRC, Lake Tanganyika, Lake Kivu, Lake Chad, southern Sudan, Ethiopia and the upper parts of the Nile (Ansell, 1972). These descriptions and classifications do, however, have exceptions and do overlap at times, which adds to the complexity in classifying the sub-species of *Syncerus caffer*.

Regardless of the classification system, the Savanna buffalo (*S. c. caffer*) is known to be found in a belt through central Africa and south towards South Africa where the distribution is patchy and mostly restricted to fenced wildlife ranches and parks/reserves. African Savanna buffalo's body weight ranges between 650 kg and 850 kg mean mature mass in bulls and 520 kg and 750 kg in cows (Bengis, 1996). Savanna buffalo have a mean shoulder height of 1.5 m and the males have large horns that vary greatly in spread, as well as in thickness. The horns join on the head in a boss which also differs in size. They have a dark or black coat colour and are described as aggressive or unpredictable by hunters, adding to their value as a trophy (Sinclair, 1977; Du Toit, 2005).

2. The Captive Game Industry

2.1. History

Prior to 1961, there was a general mind-set among Africans and Europeans alike that game animals such as antelope had to make way for more modern livestock farming that was on the increase. This was due to the perception that game species were of little economic value and competed with domestic livestock for resources. In addition to using the same resources, it was believed that game animals carried certain diseases that could infect livestock (Carruthers, 2008). This view began to change after it was proposed in the research conducted on a farm in southern Rhodesia (current day Zimbabwe) by Dasmann and Mossman (1960; 1961) that game species and livestock could co-exist and that such mixed farming could increase the income of the farmer. The latter research also suggested that game species could be considered as alternative sources of protein to domestic livestock, as they are well-suited to survive in harsh, extensive conditions (Dasmann, 1964). The ecotourism element offered by keeping game species can also be utilised as a financial incentive, with tourists and hunters both paying for the different sectors of the wildlife industry (Van der Merwe & Saayman, 2007a). An additional advantage of game farming is the improved conservation of endemic game species, with an estimated 80% of conservation initiatives that take place in South Africa occurring on privately-owned land (Van der Merwe & Saayman, 2007b). The dynamics of game farming and utilisation of game species has thus changed considerably in the last five decades and two broad classifications have arisen, namely intensive and extensive game ranching (Carruthers, 2008).

The first records of game ranching in South Africa, which was done by fencing camps for keeping in wildlife, was in the late 1800s and as many as 300 game farms, then commonly called game camps, were reportedly fenced by 1881 (Carruthers, 1995a; Brown, 2002). These farms were 'protected' by farmers publicising that the particular farms were off-limits to trespassers, hunters and unauthorised grazing in the Transvaal Government Gazette (originally called the *Staatscourant*) (Carruthers, 1995a). A number of national parks were established in South Africa between 1910 and 1940, such as the Kruger National Park (1926), Bontebok National Park (1931), Addo Elephant National Park (1931) and Mountain Zebra National Park (1937) (Carruthers, 1989). Nonetheless, these parks were ineffectively managed, with untrained personnel (usually military officials) being put in charge of the parks (Carruthers, 2001). During this time, the development of agriculture was favoured and since game had almost no monetary value, game reserves and national parks were regarded as wasted space and pressure was placed on authorities to convert this land into productive agricultural land (Carruthers, 1995b). Additionally, livestock were favoured above wildlife with regards to research at the time (Bigalke & Verwoerd, 2008). The value of game animals was further diminished when the selling of biltong (the only financial incentive for keeping game at the time) was outlawed around 1910 to conserve game for leisure hunting. Game meat regained some value in 1933 when a home economist, Miss E.M. Ferguson, supplied a number of venison recipes and treatment methods for venison in *Farming in South Africa* (a local magazine) (Carruthers, 1995a).

A change in attitude towards game animals occurred in the 1950s and advances were made towards setting up wildlife research centres in national parks. Game meat was becoming a positive alternative protein source and studies were increasingly conducted on cross-breeding of different game animals with each other as well as with domestic livestock. Among these were experiments involving hybridising cattle and buffalo or Asian buffalo and African buffalo, but these attempts failed as the experiments usually ended in the death of the animals (Carruthers, 2008). After the work of Dasmann and Mossman (1961) demonstrated that game could have an additive value when farmed together with livestock, a market was created for the controlled harvesting of game for venison (game meat), which was then marketed as an expensive or upper-class niche market meat product. Thus began the era of game farming primarily for economic purposes, but also for conservation efforts (Carruthers, 2008). At this time, the buffalo was considered as a ranching species due to its good weight-gaining potential and meat yield, producing meat that tasted like beef and being free from ‘wild’ odours. In effect, buffalo became a viable option for game ranching and meat production in the late 1960s. In addition, the banning of hunting in Kenya in 1977 boosted the hunting market in South Africa. By the 1980s, the hunting of game for trophies rather than for meat was the main income for South African game farmers (Kettlitz, 1983).

2.2. Captive buffalo industry

Despite the positive research on the utilisation of game and buffalo in particular, the distribution of buffalo has decreased drastically throughout Africa since the late 1800s (Ebedes, 1996). The African Savanna buffalo was once one of the most widely occurring mammals in southern Africa (Heller *et al.*, 2008). Nonetheless, the initial decrease in this widespread distribution occurred due to the rinderpest epidemic of 1896 (Wenink *et al.*, 1998; Winterbach, 1998). Thus, from the early- to mid-1900s, buffalo populations were under tremendous pressure. This pressure did not only come from disease, but was worsened by the restriction of buffalo into certain areas (Foggin & Taylor, 1996). The extermination of buffalo by humans for safety reasons was due to their association with the tsetse fly and sleeping sickness, as well as their susceptibility to other diseases that could be detrimental to the cattle and/or beef industry (Furstenburg, 1998; Winterbach, 1998). The discovery that buffalo are carriers of all three types of foot-and-mouth disease (FMD) and Corridor disease (CD) led to the redline-fence being erected in 1964. The redline-fence is a game fence that runs from Zululand (currently KwaZulu Natal), through Limpopo, along the border line between Zimbabwe and South Africa and through eastern Botswana. This fence greatly restricted the movements of many animals such as gnu (*Connochaetes taurinus*), which died in their masses due to constrained migrations (Furstenburg, 1998). Another factor that added to the demise of the buffalo was the use of dichlorodiphenyltrichloroethane (DDT) in marshes for the control of tsetse flies. This directly affected buffalo as they are dependent on water for survival and DDT can be poisonous when ingested.

The aforementioned factors all manifested in an increased scarcity of an animal that plays a pivotal role in both hunting and eco-tourism in Africa, and in particular South Africa, as part of the ‘big five’ (Ebedes, 1996). The only available buffalo for private ‘farming’ or ranching prior to 1990 were Addo buffalo that had been tested and shown to be disease-free, and thus did not pose any direct threats to the beef industry (Neethling, 1996). This meant that the majority of privately-owned buffalo originated from such a small genetic pool that in-breeding posed serious restrictions on the genetic diversity and survival of the species (Van Hooft *et al.*, 2000).

In contrast with the decreasing number of buffalo in Africa, the number of privately-owned game farms has increased over the last 50 years after the first game auction took place on the farm of Peter Knott in 1965. The idea of a game auction was seen by many as idealistic and impractical, but was supported by Willie Roux, a big name in game auctions countrywide, who conducted his first successful game auction as auctioneer in 1974 (2012, A. Marais, Pers. Comm., Stellenbosch). The Directorate Committee for Game Farming was established in South Africa in 1974. In their 1980 report, this Committee recommended that intensive wildlife ranching should be officially recognised as a branch of 'farming', making the sector eligible for equivalent research funding, tax relief and subsidies from government as other branches of agriculture. A short while after, it was decided that extensive wildlife ranching would be afforded similar benefits (research funding, tax relief, subsidies), provided that farmers could obtain a 'Certificate of Adequate Enclosure' for their wildlife from provincial government, a resolution that boosted the game farming industry immensely. Certified game farms in the Transvaal province increased from 528 to 1763 between 1983 and 1993, respectively (Carruthers, 2008). Thus, the demand for certain game species and antelope increased and with this came an increased demand for privately-owned buffalo (Smith & Wilson, 2002). The shallow genetic diversity of the available disease-free buffalo was, however, reason for concern. In addition, the smaller body and trophy size of the Addo buffalo created a demand for disease-free Kruger buffalo, or more specifically 'trophy' quality buffalo. Consequently research was initiated and in 1989 a protocol (Project Buffalo) was written for the breeding of disease-free calves from diseased parent stock (2011, Dr. J. Kriek, Pers. Comm., Matanu Game Farm, Kimberley). The protocol was at first denied by the South African Veterinary Board, but later accepted and in 1996 the first pilot trials were initiated by South African National Parks (SAN Parks). This was to be the start of the intensive breeding of African Savanna buffalo, which made trophy-breeding a viable goal and widened the genetic diversity to such an extent that in-breeding is no longer a serious threat (Laubscher & Hoffman, 2012).

2.3. Diseases affecting buffalo

There are four main diseases that are known to commonly infect buffalo, namely foot-and-mouth disease (FMD), Corridor disease (CD), bovine tuberculosis (BTB) and bovine brucellosis (Bartels et al., 1996). These are the diseases that caused the movement and eradication of buffalo in certain areas and the animals have to test negative for all four diseases to be considered 'disease-free'.

2.3.1. Foot-and-mouth disease (FMD)

Foot-and-mouth disease is caused by the *Picorna* virus and is contagious in cloven-hoofed animals. The name of the disease was derived from the symptoms it induces, which include the formation of vesicles and lesions of the mucosa in the mouth and interdigital skin (Du Toit, 2003). The three strains of FMD that are closely associated with buffalo are the South African Territories (SAT) 1, 2 and 3 (Vosloo *et al.*, 2002). Buffalo almost never show clinical symptoms and act as a long-term carrier of FMD (Meltzer, 1993). The means by which cattle are infected from buffalo is unknown, but direct or indirect close contact is thought to be sufficient to spread the disease since it can be transmitted in saliva which contains the highest concentration of the virus (Vosloo *et al*., 2002; Du Toit, 2003). FMD rarely causes mortalities, but has a high morbidity rate, meaning that it infects a large number of animals in a short time (Thomson, 1996). Infection with FMD lowers the productive capacity of animals and has a drastic decreasing effect on meat exports (Grubman & Baxt, 2004). Thus, areas have to be declared FMD-free to qualify for agricultural exports. The veterinary red-line was set up as part of the measures for the control of FMD and divides the country into FMD-free and FMD-infected areas, with buffer zones in-between (Thomson, 1996). All animals moved from a FMD area are required by law to be tested for FMD during quarantine before being moved. The incubation period of the disease varies from 2 to 8 days and the clinical symptoms include dullness, loss of appetite, a decrease in production and ceasing of rumination (Meltzer, 1996). Thereafter, follows lameness, salivation and 'smacking of the lip' and finally lesions of the tongue and foot at the interdigital skin and the bulbs of the heel (Grubman & Baxt, 2004).

2.3.2. Corridor disease (CD)

The name Corridor disease was derived from its discovery in the corridor of the Hluhluwe and iMfolozi Parks in Zululand during 1955. The disease is caused by a protozoan parasite known as *Theileria parva lawerencei*, which is transmitted from buffalo to cattle by the brown-ear tick (*Ripicephalus appendiculatus*) (Perry & Young, 1995; Boomker *et al.*, 1996; Stoltsz, 1996). The brown-ear tick occurs mainly in the eastern part of South Africa where the climate is wetter (Smith & Parker, 2010). *Ripicephalus appendiculatus* is known as a three-host tick due to the fact that it has to feed on three different hosts during its three different life cycles (Berry, 1996). The parasite can only be contracted during the larval stage if larvae feed on an infected buffalo and can only be transmitted during the adult stage (Meltzer, 1996). The parasite dies along with the tick and cannot be transmitted to the eggs of the tick (Berry, 1996; Smith & Parker, 2010). It is thus speculated that if a veld is free from infected buffalo for 2 years, then the veld will also be free of CD (Du Toit, 2003). The symptoms of CD appear about 9 – 20 days after infection, which is the duration of the incubation period. The symptoms include fever, swollen lymph nodes, listlessness, swollen eye lids, diarrhoea, nasal discharge and emaciation (Stoltsz, 1996).

2.3.3. Bovine tuberculosis (BTB)

Bovine tuberculosis is a lethal disease in buffalo caused by the bacterium *Mycobacterium bovis*, the same bacterium that causes tuberculosis in cattle (Kriek, 1996; Tschopp *et al*., 2010). The disease is believed to have originally infected buffalo in the 1950s when it reportedly spread from imported European cattle to buffalo in the southern part of the Kruger National Park (KNP), but has been diagnosed in kudu (*Tragelaphus strepsiceros*) as early as 1929 (Meltzer, 1996; Grobler *et al*., 2002; Michel *et al*., 2009; Oberem & Oberem, 2011). Once buffalo are infected, they can survive for several years before showing signs of BTB infection. In addition, buffalo are known as maintenance hosts, meaning that once infected, they remain infected and continue spreading the disease until they die (Cross *et al*., 2004; Etter *et al*., 2006). The infection spreads through cough droplets in the atmosphere between animals in a herd or where close contact between herds occurs, but can, although less likely, also be spread by contaminated feed or water (Michel *et al*. 2007; Rossouw, 2010). This disease can also be spread to different carnivores and omnivores that feed on the buffalo or any of their infected tissue (Kriek, 1996; Caron *et al*., 2003). Herbivores such as kudu and black rhino (*Diceros bicornis*), amongst others, have also been known to be infected by buffalo (Oberem & Oberem, 2011). *Mycobacterium bovis* can survive in the external environment for up to six months and thus it is very difficult to remove BTB from an area after it has been infected. The accurate diagnosis of BTB is difficult since clinical symptoms (coughing, swollen lymph nodes, emaciation and a rough hair coat) do not appear until the final stages of the disease, just before the animal dies (Du Toit, 2003; Jolles *et al*., 2005).

2.3.4. Bovine brucellosis

Bovine brucellosis, caused by *Brucella abortus,* is a bacterial infection that is believed to have originated in domestic cattle and then infected buffalo (Meltzer, 1996). The infection is maintained in buffalo and is believed to cause abortion of the first calf after infection. Thereafter the cows develop antibodies towards infection and generally do not show clinical signs or symptoms (Madsen & Anderson, 1995). The cows do, however, become a source of infection due to shedding of the bacteria on the foetal membrane and in the foetal fluids after every normal birth. Further transmission takes place when direct or indirect contact with an infected or aborted foetus occurs or at times through milk from cow to calf. Infected bulls can also transmit the bacteria via semen (Du Toit 2003; Oberem & Oberem, 2011) Once the infection becomes chronic, symptoms are easier to identify with bulls showing testicular inflammation (orchitis) and swelling of the knee or other joints of some of the buffalo, known as hygroma and bursitis, respectively (Oberem & Oberem, 2011).

2.4. Project Buffalo

The concept and protocol of the Project Buffalo breeding scheme (where diseased parent stock was used to produce 'disease-free' offspring) was written in 1989 by Dr. Johan Kriek, a veterinarian originally from Zimbabwe. The rationale behind disease-free breeding was not only to increase the genetic depth of *S. c. caffer* and breed larger trophy buffalo (with financial benefit most probably being the main driving force), but also to increase the distribution of buffalo by supplying both government and the private sector with disease-free buffalo. After writing the protocol, Dr. Kriek applied for permission to continue with a pilot study on his farm in Kimberley in the Northern Cape, but was denied this right due to the presence of disease and infection risks (2011, Dr. J. Kriek, Pers. Comm., Matanu Game Farm, Kimberley). The then Natal Parks Board (NPB) applied the protocol written by Dr. Kriek and in 1991, the first disease-free buffalo breeding scheme began in Kimberley from CD-infected parent stock (Berry, 1996). In 1996, SAN Parks began the first pilot study with the project buffalo breeding scheme from parent stock with FMD (Laubscher & Hoffman, 2012). For the latter trials, two different pilot studies were run simultaneously. The one involved the calf being left with the biological mother until 5 – 7 months of age when the maternally-derived immunity diminished, while the other study involved the calf being removed shortly after birth and being placed with a foster mother (usually a Jersey cow) or hand-reared. With the success of the pilot studies, other projects were approved and the Buffalo Advisory Committee was formed in 1998. The duties of this committee included tracking and monitoring all movement of project animals and disease outbreaks. It was this committee that decided that the project initiative should be phased out by 31 December 2011 as there would be sufficient disease-free breeding stock in South Africa by this time.

The initial parent stock of the breeding project was captured in the KNP as to take advantage of the wide genetic diversity of these buffalo (Van Hooft *et al.*, 2002). The buffalo were then tested in the field for Brucellosis and all the animals that tested positive were released. The remaining buffalo were then placed in a boma and tested for BTB using the intradermal skin test. If any of the animals tested positive, the whole group was rejected (Hofmeyr, 2003). The actual breeding scheme then commenced in one of three ways as illustrated in Figure 2.1. All three methods require intensive management of the cows in sheds built according to specifications for quarantine and easy removal of calves at any time. Two of the three systems utilise the method where calves are removed shortly after birth from the biological mother and either hand-reared or placed with a surrogate mother. The other method involves leaving the calf with the biological mother until an age where the maternally-derived immunity decreases and becomes ineffective.

The first of the three systems requires immediate extraction of the calf after birth. The calf is then fed cattle colostrum and hand-reared thereafter. This system is highly labour intensive and could cause habituation of the animal to humans which would be dangerous to humans later in its life. It does, however, decrease the risk of infection by the parent stock dramatically. In addition, the cow does not experience any lactation anoestrus and this decreases the inter-calving time.

The second system allows the calf to drink from the biological mother and acquires the maternally-derived immunity which promotes the survival of the calf. The calf is then removed from the mother 48 hours after birth and placed in groups of two or three with a BTB- and brucellosis-free foster cow, which is usually a Jersey dairy cow due to their high quality milk and good mothering abilities. Drinking from the biological mother does cause FMD antibody titers which prolongs the completion of the first stage and removal from the infected area.

The final system is where calves are left with the biological mother for the first seven months and are then removed. In so doing, the calf attains the natural immunity from the mother and becomes accustomed to the natural herd structure of buffalo. This system is the least favoured method, as it presents risks, such as infection with CD. Since the calves remain with their CD-infected mothers, if ticks are present, the CD could be transmitted. FMD could also be transmitted to the calves via the milk if the cow is infected during mating by a bull whose semen contains the FMD virus.

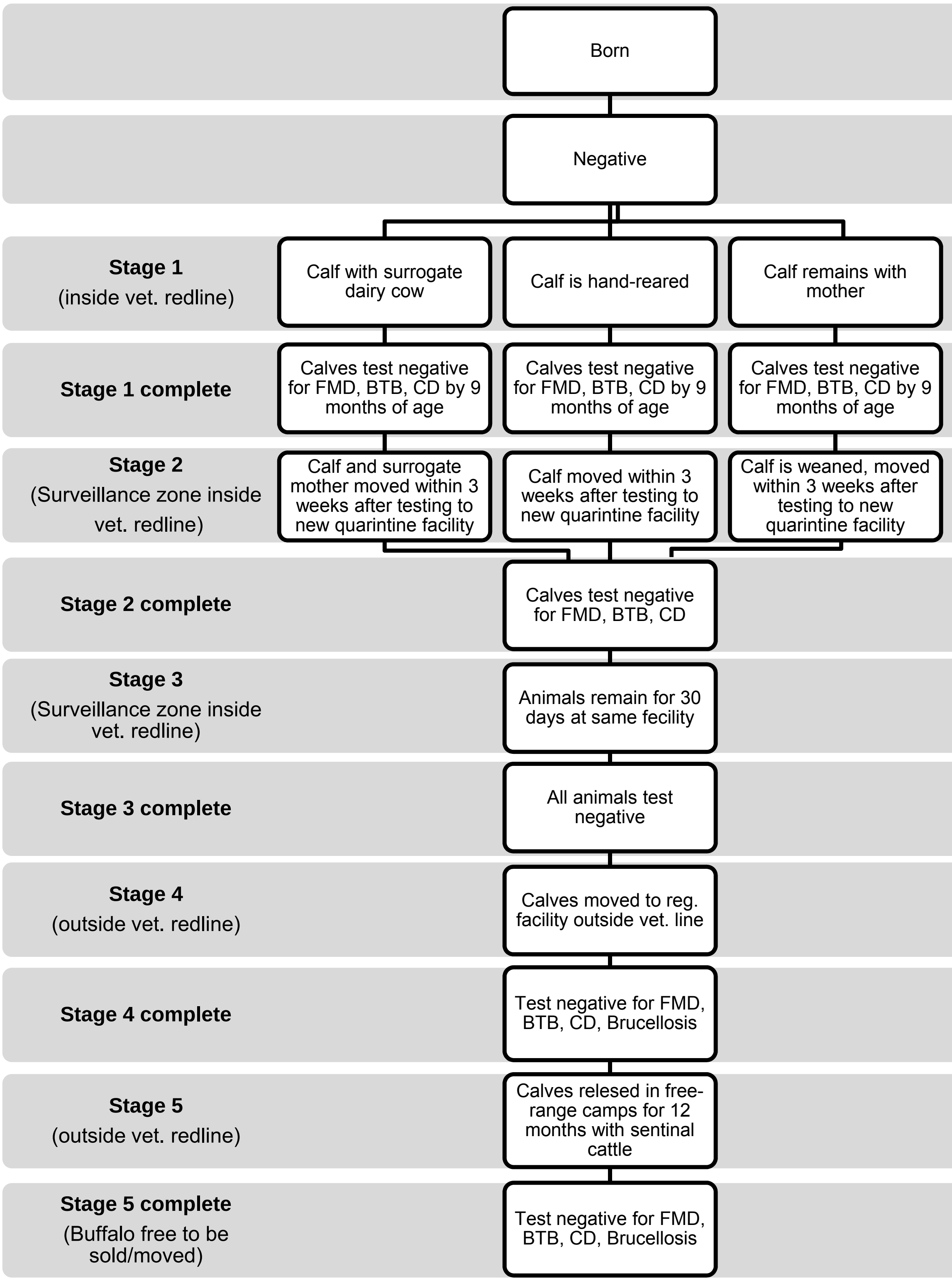

Figure 2.1 Systems for breeding disease-free calves from diseased parent stock (adapted from Laubscher & Hoffman, 2012).

2.5. Buffalo prices

For most of the 20th century disease-free buffalo were of the Addo origin. Addo-buffalo, however, lacked body and trophy size compared to buffalo from the KNP. Demand for the latter attributes created a market for disease-free Kruger buffalo (Edwards, 1999). After the Project Buffalo proved to be a success in rehabilitating Kruger buffalo, breeders began to recognise the potential for intensive and selective breeding. Buffalo became an entity, rather than a wild animal, proving to be worth much more than ever conceived by farmers (Neethling, 1996). Apart from the Project buffalo, also referred to as Kruger or low-veld buffalo, there are two other distinctions of buffalo that are marketed and auctioned, namely east-African buffalo and Addo buffalo. East-African buffalo originated from buffalo that were imported from zoos and other entities from around the world, usually European countries. These buffalo are believed to have been exported to Europe from the eastern part of Africa, where they were bred in captivity for mainly display purposes and private collections. Addo buffalo were for long periods of time the only buffalo on sale for private ownership due to their continued disease-free status and are thus referred to "normal" buffalo in auction directories. The Addo buffalo are buffalo that originated from the Addo Elephant National Park and are phenotypically known to be smaller in size than Kruger and east-African buffalo.

The monetary value of buffalo has increased markedly since 1990, with a dramatic influx over the last 8 years (Fig. 2). Buffalo are part of the eco-tourism 'big seven', along with lion, leopard, elephant, rhino, southern right whale and great white shark and the hunting 'big five', together with lion, leopard, elephant and rhino (Winterbach, 1998), Buffalo have been a sought-after game animal since 1998, with trophy prices ranging from R 44 750 to R 70 000 for a buffalo hunt, a 69% increase compared to 1995 (Winterbach, 1998). Hunting prices for buffalo have not risen remarkably over the past 15 years, at least not at the rate that these prices increased between 1995 and 1998. Breeding buffalo prices have, however, escalated since 1998. With the Project Buffalo initiative in full swing, the possibility of breeding Rowland Ward trophy buffalo with a spread of over 50 inches increased, opening up a market for buffalo breeding as an intensive business.

Average auction prices stabilised between 1991 and 1994 at about R 21 550 per buffalo. After 1994, the prices increased but stabilised again for the period between 1995 and 2003, with the average auction price for these years at R 88 360 per buffalo (Du Toit, 2005). As illustrated in Figure 2.2, this would be the final stabilising of buffalo prices, with average prices increasing to R 150 393 for 2004, and from 2005 the averages of cows and bulls were displayed separately in the annual auction prices of Vleissentraal (South Africa's largest game auctioneers). The average auction price for a cow increased to R 200 000, but for a breeding group decreased to R 136 000 per buffalo. The following prices are according to Vleissentraal's average auction prices per year: 2006 was the same as 2005, in 2007 the price for a cow increased to R 231 000 and for a breeding group to R 178 000 per buffalo. In 2008, the distinction between buffalo, low-veld and east-African buffalo began to appear, with average auction prices for cows at R 245 000, R 253 000 and R 371 600, respectively. In 2009, the average price for a cow increased to R 408 600 and for a breeding group to R 584 400. The year 2010 saw average auction prices for buffalo and low-veld buffalo cows drop to R 330 000, but east-African cow prices increased to R 1 026 000. These prices again increased in 2011, with buffalo and low-veld buffalo cow prices at R 432 000 and east-African cows and bulls both at R 1 095 000. The record prices paid for a live buffalo since 2004 also increased from R 250 000 to R 40 000 000 in 2013. Predicting where and when the prices will stabilise is difficult and it has been postulated by Mr. Lindsey Hunt (Hunt Africa) that buffalo have not yet reached their peak and that there is a long and prosperous future for disease-free buffalo breeding and increasing the numbers and distribution of buffalo in South Africa and possibly Africa further down the line (2011, L. Hunt, Pers. Comm., Elandsberg Buffalo Ranch, Wellington).

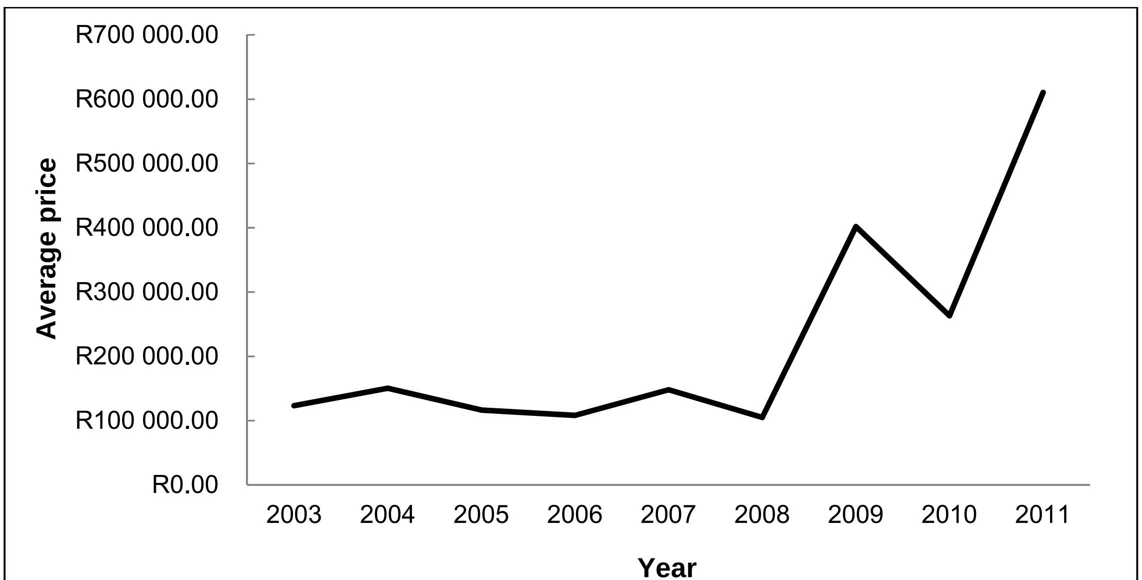

Figure 2.2 Average auction prices for breeding buffalo from 2003 to 2011 according to Vleissentraal's annual prices.

CHAPTER 3

Distribution of African Savanna buffalo (*Syncerus caffer caffer*) in South Africa

1. Introduction

Buffalo can be divided into two broad groups of "true" buffalo, namely the Asian and African buffalo. The African buffalo (*Syncerus caffer*) is then subdivided into three or four subspecies depending on the method of classification. The subdivision or subspecies are as follows, *Syncerus caffer caffer*, *Syncerus caffer nananus*, *Syncerus caffer aequinoctialis* and *Syncerus caffer brachyceros* according to the distribution classification method (Ansell, 1972). The latter two classifications do not, however, differ substantially and are often placed into one group by mammalogists as they are seen as the intermediate subspecies between *S. c. caffer* and *S. c. nananus* (Du Toit, 2005).

Distribution has been one of the main assisting tools used for classification of animals. This is especially applicable to African buffalo due to their differences rather than their similarity regarding morphology within the subspecies. Figure 3.1 gives a clear indication of the distribution of the African buffalo throughout Africa, both in early years (Past/Natural Distribution – before 1900) and more recently (Present distribution - 2008).

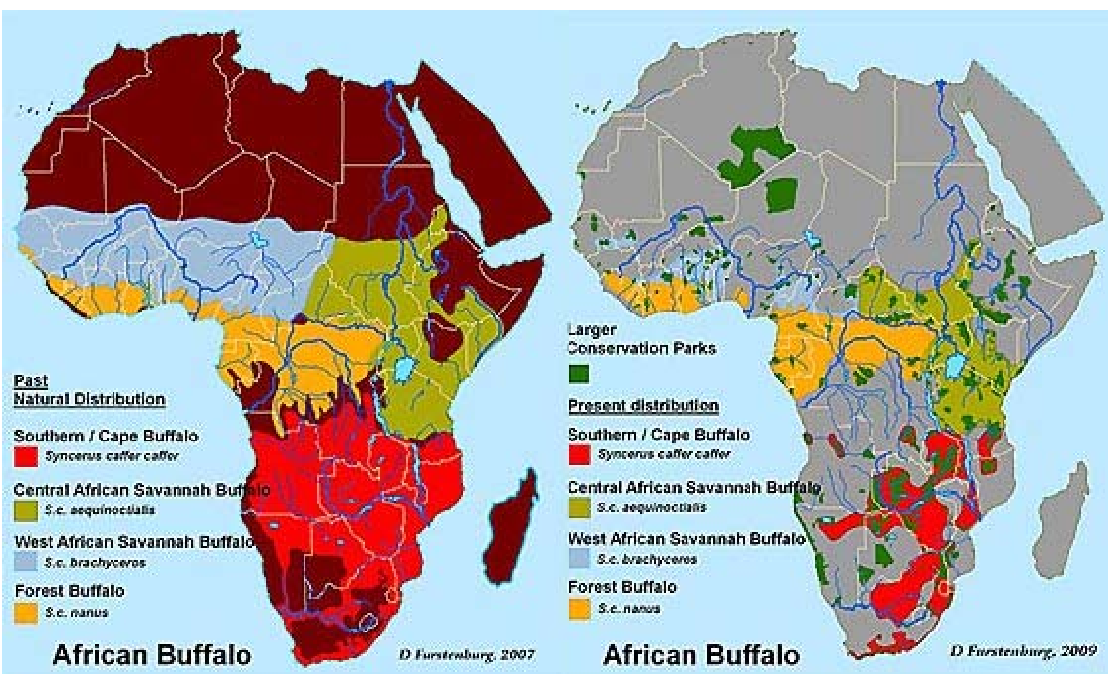

Figure 3.1 Distribution of African buffalo Syncerus caffer in Africa (Furstenburg, 2007).

Syncerus caffer caffer (African Savanna or Cape buffalo, also referred to as buffalo for this chapter) was once one of the African mammals with the largest distribution. This subspecies occurred from southern Africa, Angola, central and eastern Africa and as far north as the southern borders of Sudan and Ethiopia (Ansell, 1972; Smith, 1986). The distribution is roughly the same in present day Africa, with the exception being that the distribution has become much more sparse and patchy with isolated populations occurring in protected game areas and national parks.

The distribution trend as seen for Africa above is reflected in southern Africa, with the distribution of buffalo decreasing over the last two centuries as the human inhabitants and their need for agricultural land increased. Throughout southern Africa the numbers of buffalo decreased drastically for the period 1980 – 1996. In Botswana the buffalo decreased from 73 000 in 1989 to 29 367 in 1996. For Zimbabwe during these same years the numbers decreased from 80 000 to about 48 210. Namibia, however, saw an increase over the period from 1985 to 1996 with numbers increasing from 600 to 2840 during this time. South Africa has had a more or less stable population for a while with numbers ranging around the 30 000 mark during 1996. Mozambique saw the largest decrease in buffalo from 56 000 animals to about 2500 for the time period 1979 to 1994 (Winterbach, 1998). A total of buffalo in southern Africa has thus decreased from 239 600 to 112 917 over the period 1979 to 1996.

African Savanna buffalo were widely distributed throughout South Africa with the exception of the Karoo and arid areas where food and water were insufficient (Brown, 2002). This changed during the 19th and 20th century because of settlers inhabiting the land and utilising it for crop or livestock production (Carruthers, 2008). In addition to the large scale extermination by humans, buffalo also succumbed to different, mostly foreign diseases that caused epidemics and a decrease of the buffalo population in South Africa (Furstenburg, 1998).

One such epidemic was the Rinderpest epidemic of 1896, which wiped out entire herds of buffalo in the Transvaal and most of South Africa (Meltzer, 1993). Rinderpest caused livestock and game mortalities of up to 95%, with buffalo being a major contributor to these numbers (Winterbach, 1998). In addition, buffalo were also widely exterminated for their association with certain diseases and the risk of livestock or human infection by buffalo. These diseases include Foot-and-mouth Disease (FMD), Corridor Disease (CD), Bovine Tuberculosis (BTB), Bovine Brucellosis and Sleeping Sickness, which was carried by Tsetse flies and transmitted to humans and cattle (Furstenburg, 1998).

For the control of these diseases buffalo have been restricted to National parks and game farms behind the Red-line, which is an area originally fenced for the control of FMD and runs from KwaZulu Natal, through Limpopo, along the border line between Zimbabwe and South Africa and through eastern Botswana. The only buffalo that are allowed to move around outside the Red-line are buffalo that have been tested and proved to be clean from all four the major diseases that cattle are also susceptible to. These diseases are FMD, CD, BTB and Bovine Brucellosis. Thus, by 1996 buffalo in South Africa were greatly restricted in their distribution with the overpowering majority occurring in the far-east part of South Africa in the Kruger and Hluhluwe-iMfolozi national parks with isolated populations occurring over South Africa as illustrated in Figure 3.2.

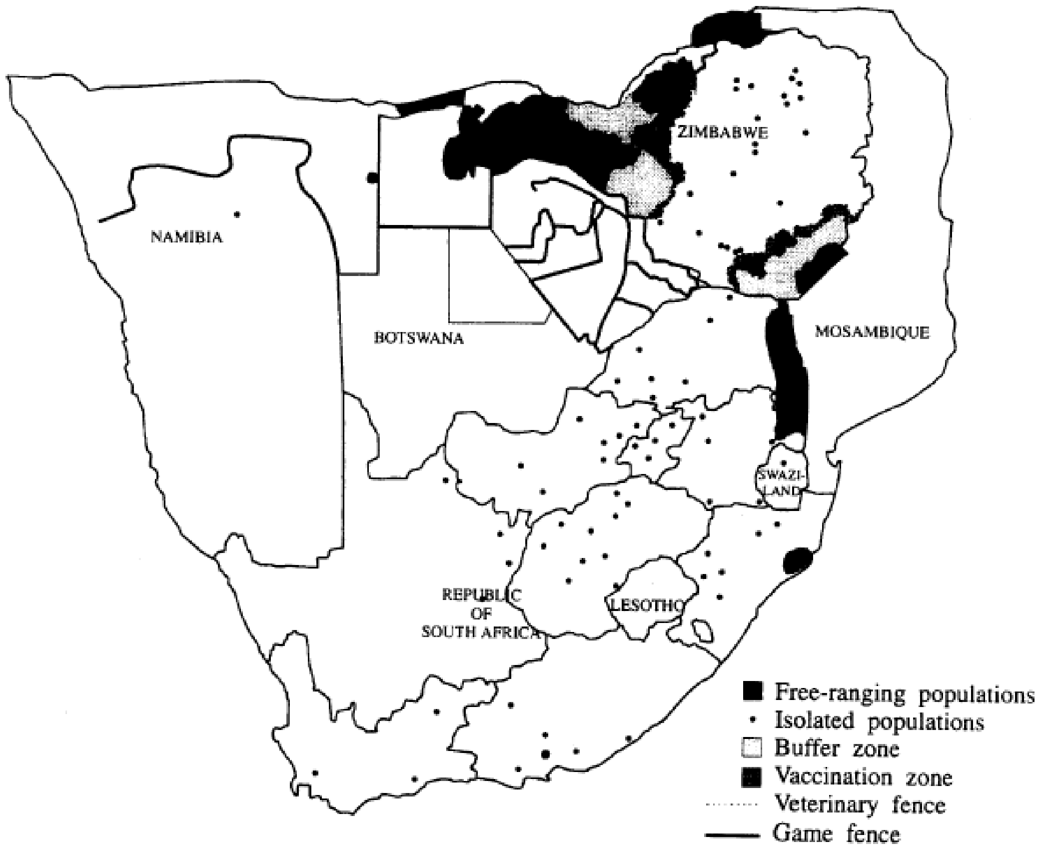

Figure 3.2 Distribution of Cape buffalo *Syncerus caffer caffer* in southern Africa between 1994 and 1996 (Winterbach, 1998).

Of the total estimated 31 500 buffalo in South Africa in 1996, only 7.7% were disease-free (Winterbach, 1998). In addition to FMD and CD, BTB had become a serious threat for buffalo in the Kruger National Park (KNP), not only due to the effect that it had on the buffalo, but also because of the buffalo's ability to transmit this disease to other larger ungulates and carnivores. Of the 31 500 buffalo in RSA in 1996, approximately 23 000 were in the KNP and Hluhluwe-iMfolozi National (HiP) parks, whereas a total of 6195 buffalo were in private ownership with a mere 1310 of these being disease-free (Winterbach, 1998).

Since 1996, many disease-free buffalo breading projects have been established and produce many disease-free Kruger buffalo annually. This has had to effect that many buffalo have been acquired for private game reserves and farms and the distribution has evolved since 1996. According to Robertson (2007), the buffalo numbers in South Africa have increased to about 40 000 with the hunting market developing as the numbers increase. The change in distribution has not been mapped or followed accurately as of yet, in particular for South Africa. Even less so on a province or district scale to accurately indicate where the registered buffalo farms in South Africa are and what the concentration of these are for different areas. The aim of the study was to indicate the distribution of the registered buffalo farms in South Africa on a province and district level, considering diseased and disease-free buffalo.

2. Materials and Methods

The farms, reserves and national parks registered for keeping and breeding buffalo at the Department of Agriculture, Forestry and Fisheries (DAFF) as displayed on their website was extracted and placed into excel format. The farms were grouped into provinces and compared to information obtained from the Surveyor general's database as well as the 2001 census data from StatsSA. The spatial data in shape file format on the cadastral boundaries of all farms in South Africa was obtained from the Surveyor general's database (http://csg.dla.gov.za/data.htm). From the 2001 census data the main place and sub-place data was obtained which was used to group the farms into districts (www.statssa.gov.za/census01/html/Geography_Metadata.htm). The buffalo data obtained from DAFF was then summated per district and the district name coupled with the main place and sub-place records of the 2001 census data. From this coupling a dataset was set up of main places and sub-places that coincided with the district names. The sub-places with no "hits" or district name NONE were extracted and later reviewed as protected areas and then added again if applicable. This then decreased the dataset from 21243 to 16039 sub-places which was then coupled with the buffalo data obtained from DAFF.

The dataset obtained was used to draw up maps on both provincial and district scale using geographic information system (GIS). The maps are given on "farms per province" and "farms per district" basis to illustrate the concentration of buffalo farms throughout South Africa. These were then divided into five separate maps of origin per province, diseases per province, diseased buffalo farms per district, project buffalo farms per district and Addo buffalo farms per district.

3. Results and Discussion

There are currently 2809 registered buffalo farms, reserves and national parks in South Africa. The majority of these (1300; >46%) are located in the Limpopo province and the least in Gauteng (33; <1.2%). This difference between the two neighbouring provinces could be attributed to agricultural or open land availability, where Limpopo has substantially more land available for farming, and game farming in particular, than Gauteng. In addition, the Limpopo province, formerly known as the Northern Transvaal, has been the epicentre of game farming since the first game farms were fenced off in 1881 (Carruthers, 1995; Brown, 2002).

In contrast, the Northern Cape in size is much larger than Limpopo and has large sections of available land, but has only one eighth of the number of buffalo farms. This is due to the unsuitability of the Northern Cape vegetation to sustain large ungulates such as buffalo. Large parts of the Northern Cape are dry arid (marginal) land, mainly used for sheep, goats and smaller or hardier game species such as Oryx (*Oryx gazelle*) and Springbuck (*Antidorcas marsupialis*). The rest of the provinces are suitable for buffalo breeding in regards to vegetation, but in some of the remaining six provinces the cultivated agricultural sector, livestock and crop, is well established and not likely to be transformed into game farms or buffalo breeding farms.

The numbers of buffalo farms per province as well as the division of project vs. Addo buffalo are illustrated in Table 3.1. Addo buffalo are buffalo that are from the Addo bloodline and have been classified and confirmed disease-free. These are from a small population of buffalo that were preserved in the Addo Elephant National Park and are known for their shallow genetic diversity as well as smaller body and horn size (Van Hooft *et al*., 2000; Heller *et al*., 2008). For three of the five decades that buffalo have been sold and moved between game farms and nature reserves, Addo buffalo were the only available disease-free buffalo allowed for resale outside of the veterinary Red-line. Their distribution throughout South Africa is much greater than the other classifications with 2418 (86%) of the registered buffalo farms keeping Addo buffalo.

Project buffalo farms are farms where disease-free buffalo are being bred from diseased Kruger parent stock, or where buffalo have been established that originated from diseased Kruger stock or project buffalo (Edwards, 1999). Kruger buffalo are buffalo that originated primarily from KNP or other reserves along the eastern strip of the country within the Red-line area. “Other” represents farms that do not fall into either of the project or Addo categories and thus are either diseased buffalo or buffalo imported from alternative sources such as zoos and are usually of “East African” origin. East-African buffalo is a term used for buffalo that originated from eastern Africa, where buffalo are believed to be larger in both body and trophy (horn) size. East-African buffalo are, however, genetically similar to Kruger buffalo in such a way that no certain test exists to genetically divide these two buffalo classifications (Van Hooft *et al*, 2000). The only buffalo that can be differentiated on a genetic basis are Kruger buffalo and Addo buffalo which might be ascribed to the isolation of the Addo buffalo population for more than 50 years as well as to natural selection for better adaptation to the high density bushy vegetation of the Addo Elephant National Park.

Table 3.1 Distribution of African Savanna buffalo (*Syncerus caffer caffer*) farms throughout South Africa

Province	Total	Project	Addo	Other
Western Cape	72	12	60	0
Eastern Cape	302	9	293	0
Northern Cape	178	1	168	9
Kwazulu Natal	232	0	61	171
Free state	283	2	274	7
North West	286	3	283	0
Gauteng	33	3	30	0
Mpumalanga	123	3	75	45
Limpopo	1300	33	1174	93
Total	2809	66	2418	325

The distribution of Table 3.1 is represented in map form in Figure 3.3 and gives a visual representation of the general distribution of buffalo in the three classifications as mentioned above throughout South Africa on province scale. From Figure 3.3 it is clear that Addo buffalo farms are the majority in seven of the nine provinces with the exception of KwaZulu-Natal and Mpumalanga. The majority of these two provinces are of “other” origin and when referring to Figure 3.4 it is clear that the “other” refers to diseased buffalo farms. Figure 3.5 indicates that the distribution of these aforementioned diseased buffalo farms is in the far east of the provinces with the exception of one farm that lies to the central and western part of KwaZulu-Natal. Thus, these districts represent farms, reserves or national parks that are all on or behind the veterinary Red-line. In addition, these are situated near or as part of two of the main national parks, KNP and HiP, that have the largest buffalo herds in South Africa (Carruthers, 1995b; Winterbach, 1998).

Figure 3.4 indicates the registered buffalo farms or reserves per province that contain diseased buffalo. In addition to Figure 3.3, Figure 3.4 breaks down the diseases into portions per disease for each province. The Western Cape, Eastern Cape, Free State, North West and Gauteng are completely free from any diseased buffalo farms. The Northern Cape contains a small number (8; <5%) of Corridor Disease infected buffalo farms which can be attributed to the project buffalo found here. These were of the first farms in South Africa where project buffalo were bred. Even though project buffalo have attained disease-free status in South Africa, the parents that they originated from are not disease-free, which explains the disease status of the aforementioned farms (Berry, 1996). Five of these eight farms belong to South African National Parks (SAN parks), two belong to De Beers and one to Dr. Kriek, the writer of the original disease-free buffalo breeding project protocol. These farms should, however, be disease-free as of 31 December 2011 due to the extermination of the disease-free breeding project at this time, but have not yet been recorded as such due to the database not being updated before the publication of this thesis.

In Limpopo, the prevalence of both BTB and FMD is evident, but again if referring to the district scale map it is clear that these farms or reserves are mainly in the far eastern part of the province, either bordering or part of the KNP. Thus the animals are behind the veterinary red-line or in the buffer zone. As the buffalo of the KNP are known carriers of both FMD and BTB, these results were expected (Cross *et al.*, 2004; Oberem, 2011). The remainder of the farms not belonging to SAN parks are buffalo farms and reserves that are in private ownership and either have buffalo for hunting or eco-tourism purposes or for breeding project buffalo.

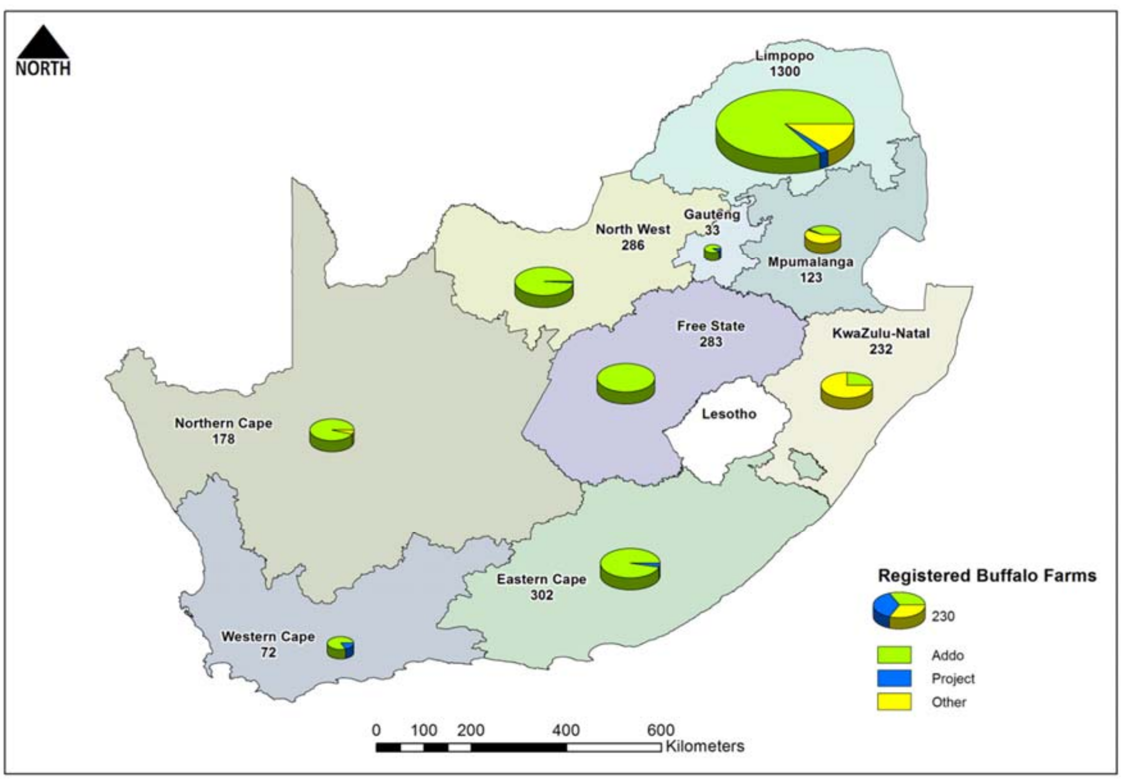

Figure 3.3 Distribution of African Savanna buffalo (*Syncerus caffer caffer*) according to number of farms per province throughout South Africa. Numbers below province name indicate total number of buffalo farms.

KwaZulu-Natal harbours buffalo that carry both CD and BTB, with CD being the more prevalent disease found on the farms. These are buffalo found in and around HiP which also accounts for the higher portion of CD infected buffalo when compared to other provinces in South Africa. CD was first discovered in this area and also derived its name from the corridor between Hluhluwe and iMfolozi before these parks were united (Perry & Young, 1995). The BTB fragment is buffalo found in reserves only and not buffalo in private possession.

Mpumalanga is the province between Limpopo and KwaZulu-Natal and this is evident from the diseases as all three namely FMD, BTB and CD occur here. The farms or reserves registered as having buffalo infected by all three diseases are those from Sabi Sands game reserve and Mala Mala game reserve and account for 23 (51.1%) of the "other" registered buffalo farms in Mpumalanga which is 18.7% of the total registered buffalo farms in Mpumalanga. The remainder of the diseased farms are also found in the eastern part of Mpumalanga, around the Sabi Sands and Mala Mala game reserves as illustrated in Figure 3.5 and are located behind the veterinary red-line.

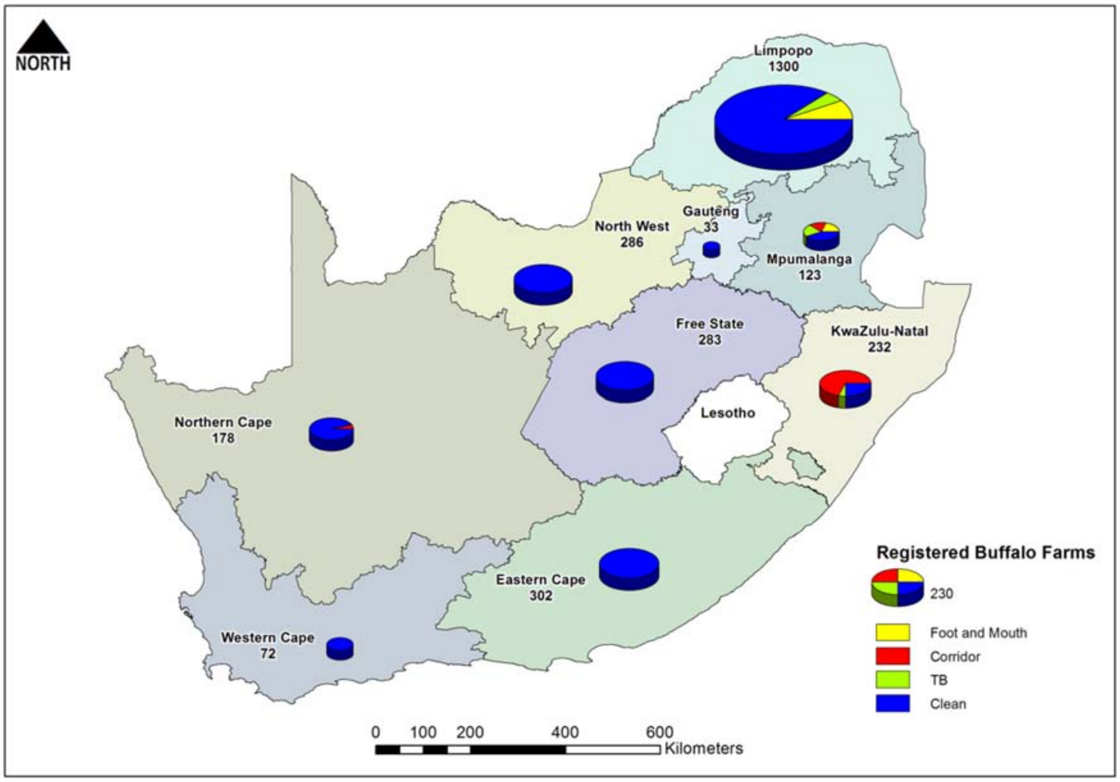

Figure 3.4 Portion of farms carrying diseased buffalo in South Africa per province.

From Figure 3.5 it can be deducted that the diseases occur in an isolated strip along the far eastern part of South Africa with the exception of the 8 farms (2.5% of the total "other" farms in SA) in the Northern Cape. This is due to two main contributing factors. Firstly the strict control and regulation of the buffalo in South Africa and their movements, assisted by the relentless testing for the major diseases in buffalo (FMD, BTB, CD and Brucellosis), by both the government and the farmers themselves (Ebedes, 1996). Secondly, the virulence and persistence of these diseases in and between buffalo and cattle have kept the diseases "alive" regardless of the strict control measures. In addition to this fact is the hardiness of buffalo and their ability to be long term carriers and maintenance hosts or reservoirs for these diseases (Du Toit, 2003; Grubman & Baxt, 2004; Du Toit, 2005; Oberem, 2011; Laubscher & Hoffman, 2012).

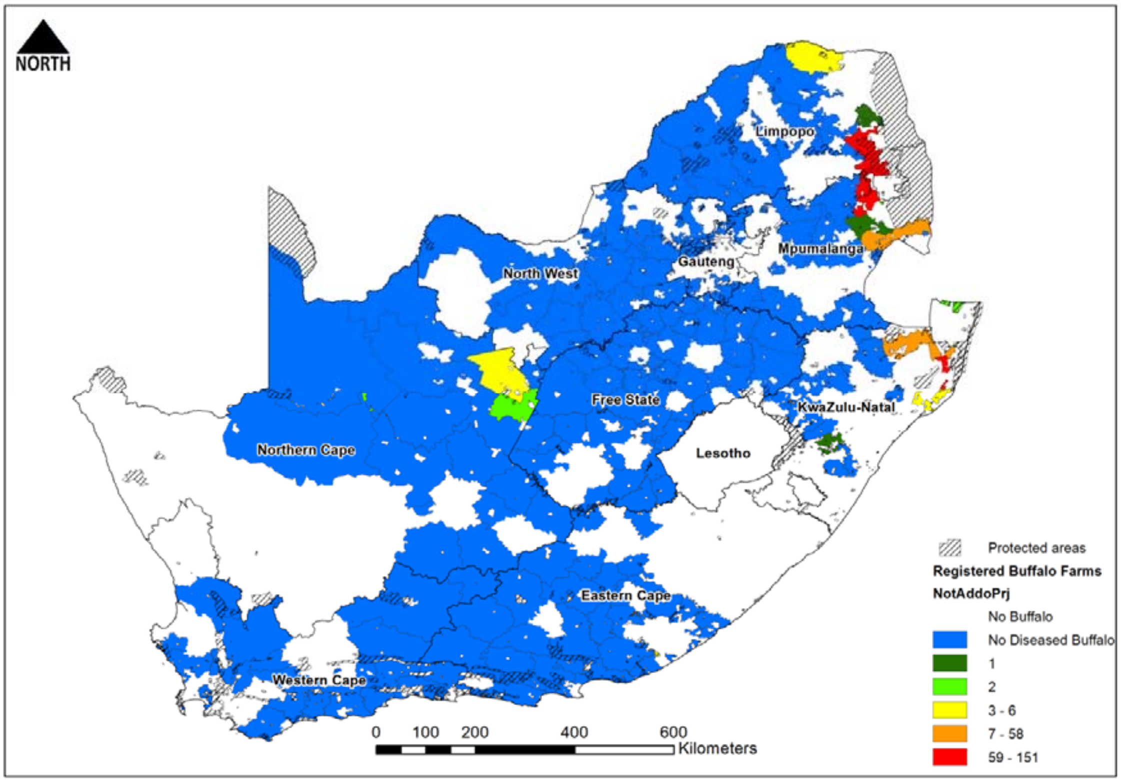

Figure 3.5 Distribution of "other" or diseased buffalo in South Africa per district.

The occurrence of project buffalo farms throughout South Africa is more uniform than the diseased or “other” buffalo farms, but less evenly distributed than the Addo buffalo farms. Figure 3.6 indicates the highest concentration of project buffalo being in Limpopo with the specific district being the one closest to the KNP. The reason for this is that there are buffalo kept in and near the buffer zone for testing purposes as well as for breeding of disease-free stock to provide for the need of the other farms and reserves throughout South Africa. Additionally this area is highly suited for buffalo in terms of climate and high quality grazing and has a high concentration of sweet veld grass species. The supply of disease-free buffalo is high and translocation procedures of buffalo for this area is easy as the largest majority of project buffalo were attained from KNP which is in Limpopo and Mpumalanga. Moving buffalo within a province, especially Limpopo, is easier with regards to legislation and permits compared to moving buffalo between or within other provinces.

The second highest concentration of project buffalo farms occur in the central and southern part of the Western Cape. Due to the fact that buffalo have not been located in this province for many years, it is relatively risk free with regards to FMD, CD, BTB and Brucellosis. The natural disease vectors also do not occur here and if found are not infected due to the absence of buffalo acting as maintenance hosts. Nonetheless, there are other diseases that do prevail in the Western Cape due to livestock, such as South African Malignant Catarrhal Fever (SA-MCF), also known as “snotsiekte”, which is caused by the Ovine herpesvirus2 (OvHV2) that is carried by sheep and causes high mortality in buffalo, but low or no morbidity as the disease is not transmitted between buffalo (Reid & Van Vuuren, 1984).

In contrast, KwaZulu-Natal has no project buffalo farms. This might be due to the high prevalence of the CD vector *Ripicephalus appendiculatus* which is readily found here, as well as the high occurrence of local stockman that have herds of unfenced cattle covering large areas that could infect disease-free buffalo (Boomker *et al*., 1996). Thus, KwaZulu-Natal would be seen as a high risk area to breed project buffalo.

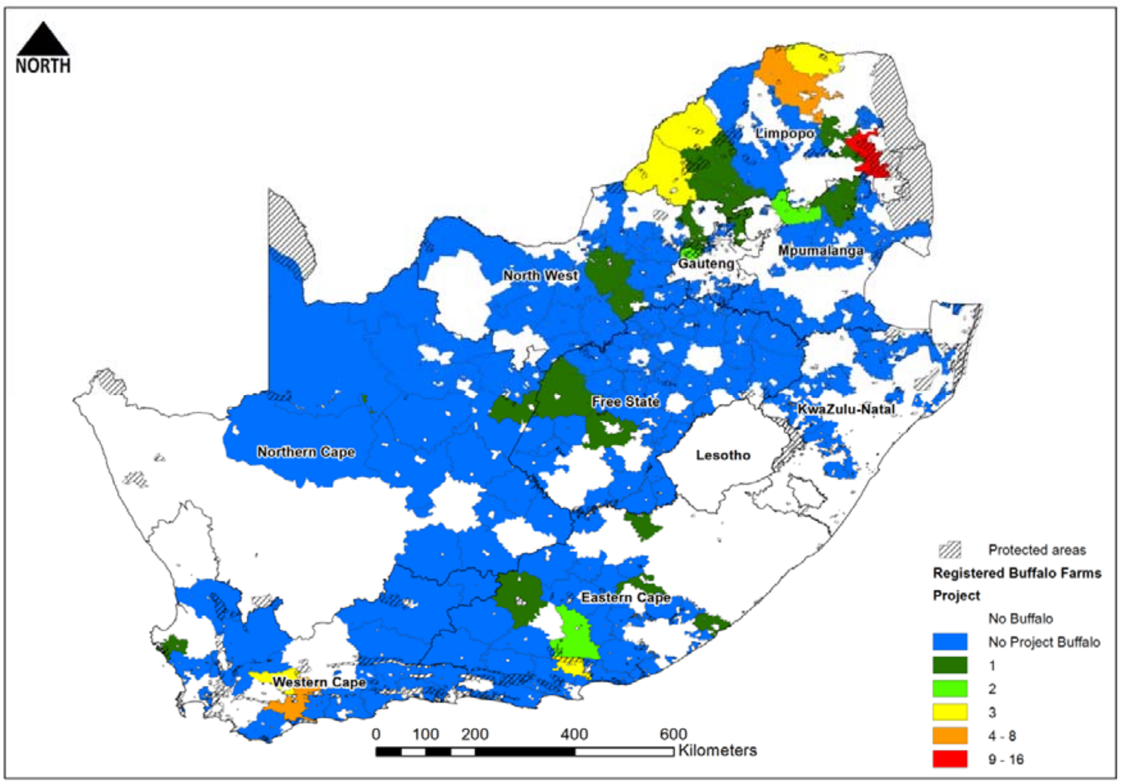

Figure 3.6 Distribution of project buffalo in South Africa per district.

Addo buffalo farms represent the largest portion of registered buffalo farms in South Africa (2418; >86%). These buffalo farms are found in all nine provinces and distributed almost evenly throughout South Africa with the exception of Limpopo, as illustrated in Figure 3.7, once again showing the highest concentration of Addo buffalo farms (1174; 48.6% of the total Addo buffalo farms in South Africa). This is attributed to the high concentration of game farms in this province, which has remained so since the first game farms were fenced.

In addition, the fact that the largest part of trophy hunting in South Africa also occurs in Limpopo forced these farmers to buy Addo stock for international hunters as it was the only disease-free buffalo available for private ownership and breeding outside the Red-line prior to 1996.

Some Addo buffalo farms seem to be located within the buffer zone of the protected areas of the KNP, an area traditionally known for its Kruger or project buffalo. The reason for the Addo buffalo farms in KNP territory is unclear as the risk of infection in this area is very high, but might be private sections or reserves that were fenced off or that bought in buffalo as to improve the genetic diversity of their own buffalo and experiment with hybrid vigour.

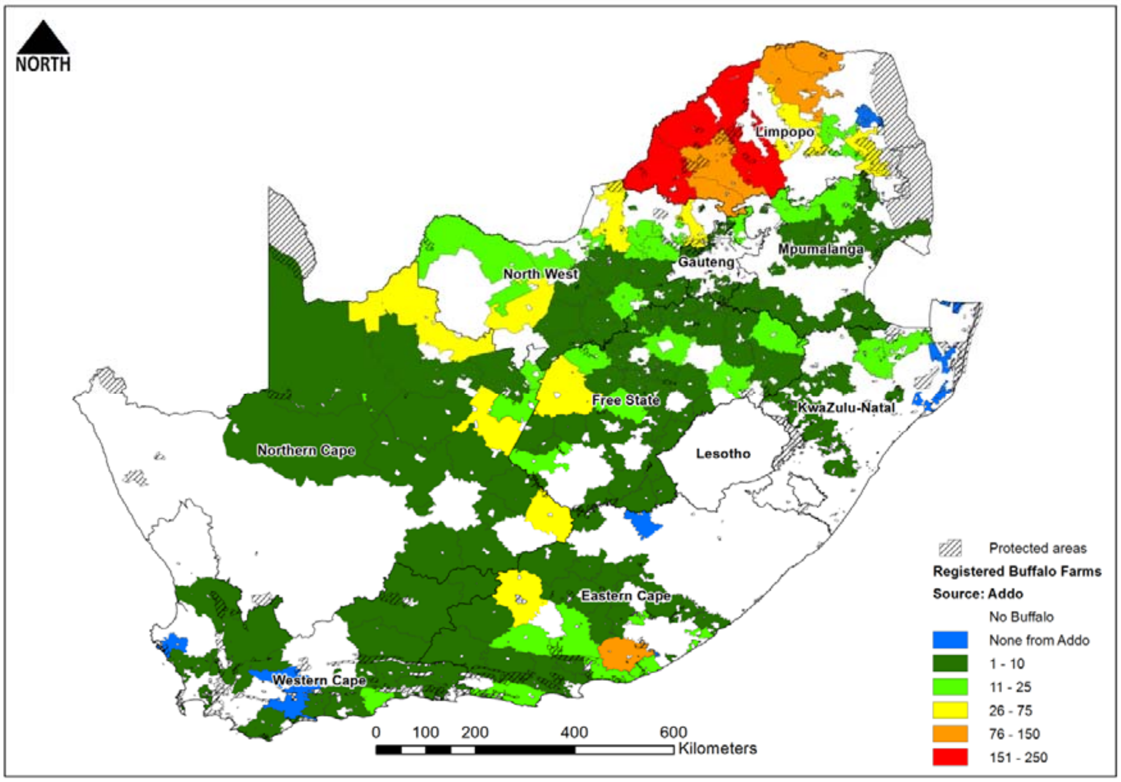

Figure 3.7 Distribution of Addo buffalo in South Africa per district

The figures clearly indicate a strong bias for keeping buffalo in Limpopo, as most registered buffalo farms are located in this province (1300; >46%). This area is known for its Savanna type bush and average to high quality grazing for buffalo with mixed, sweet and sour veld occurring here as well as good quality sweet veld that provides a high protein feed for the buffalo (Tainton, 2000; Van Oudtshoorn, 2006). In contrast, there seem to be large parts of the Northern Cape that do not contain any buffalo. This is due to the very low quality natural feed available in these areas combined with the arid and almost desert like environment with high summer temperatures and low annual rainfall (Van Oudtshoorn, 2006). The Eastern Cape also has a large area where no buffalo are found to the east of the province. This, however, is due to the incompatibility and unreliability of the data obtained on the whereabouts of these farms and the fragmentation caused on the maps due to these factors. The district names were also inconsistent and fragmented, which might be due to this area being part of the old “homeland” Transkei. This same fact seemingly also affects the southern part of KwaZulu-Natal regarding the consistency of data for mapping.

4. Conclusion

The distribution of African Savanna buffalo (*S. c. caffer*) has evidently increased throughout South Africa in all areas where the environment is suitable in terms of feed quantity and quality and water availability. The greatest concentration of buffalo are still located in Limpopo, but this province now accounts for less than 50% of the buffalo farms which was not the case in the past and indicates a healthy increase in the other eight provinces. This increase is in part due to a growing demand for buffalo and an increasing breeding and hunting market stimulated by the different role players (farmers, business men and government) working together. In addition, the supply of trophy quality Kruger buffalo that are disease-free (FMD, BTB, CD and Brucellosis) from the disease-free buffalo breeding project also contributed to both the economic value as well as the genetic depth of the species. The disease-free buffalo progress of KwaZulu-Natal is, however, less positive as 73.7% of the total registered buffalo farms in KwaZulu-Natal are not disease-free and are carriers of CD and/or BTB. This might be due to the high concentration of the brown-ear tick (*R. appendiculatus*) in this province, which is the main vector for CD.

Nonetheless, from this study the future seems positive for the Cape buffalo in South Africa and the distribution increase is evident. The dearth of this study lies in the distribution on farm scale and to truly make an accurate deduction and prediction, the number of buffalo per farm or per district is needed. Accordingly, the exact origin of the buffalo would give an accurate indication of the genetic diversity of buffalo in South Africa and the true state and survivability of these animals. This then would also add to the information and assist in making more accurate predictions on the present state and future of the buffalo market in South Africa.

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CHAPTER 4

The African Savanna buffalo (*Syncerus caffer caffer*) industry

1. Future of the industry

Compared to livestock farming, the game industry as a whole has seen a large increase over the past five decades as displayed in Figure 4.1 and discussed in chapter 2 and 3. The industry can be divided into four sections namely breeding of animals (including scarce species), hunting, meat products and eco-tourism.

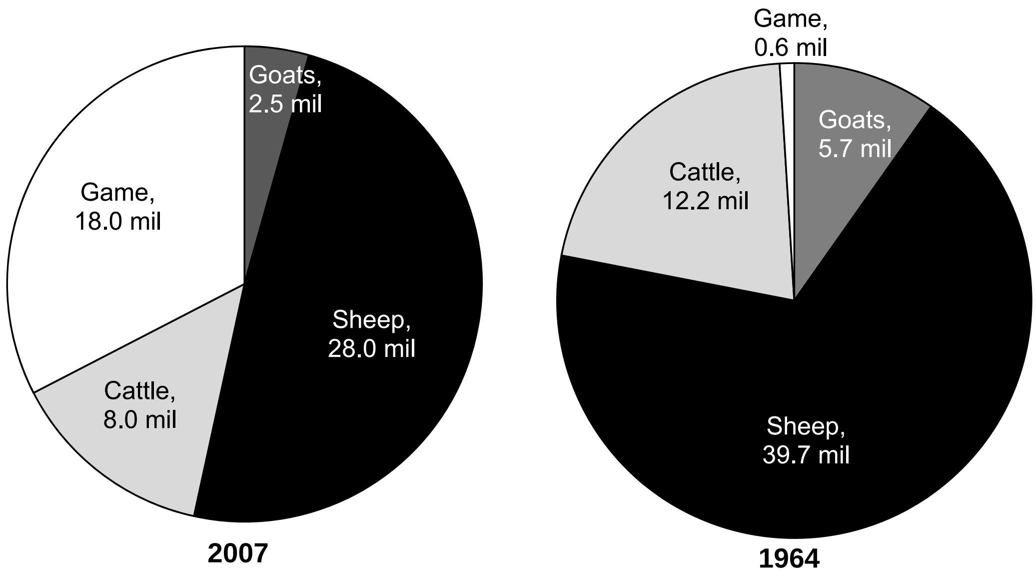

Figure 4.1 Change in numbers of domestic animals to game animals in South Africa between 1964 and 2007 (adapted from Carruthers, 2008).

1.1.Breeding of game animals

The breeding of game animals for live sale is not considered to be an attractive industry since the costs related to capture and the risks involved when selling 'general' or plains game are high in comparison to the income generated (Whyte, 1996). In contrast, the breeding of high-value scarce game species such as buffalo, sable, roan, as well as colour variants is a considerably more profitable and worthwhile endeavour (Bengis, 1996; Ebedes, 1996).

The annual income generated from auction sales for 2010 was R 315 million, which is three times more than in 2006. Auction sales account for approximately one-third of the total live game sales, which amounted to over R 900 million for 2010 (Anonymous, 2012). Of the

R 315 million income generated from auctions, R 93 286 500 was made from buffalo (Vleissentraal Bosveld average game auction prices, 2010). Assuming that auction sales remained at one third of the total live game sales, then the total income generated by buffalo sales alone for 2010 is calculated as R 279 million. The total number of buffalo sold on auction in 2010 was 220, amounting to an average price of R 424 029 per buffalo sold. Buffalo prices increased drastically (*ca.* 44%) in 2011, with the average price paid per buffalo being R 610 526. These prices are expected to increase even further, in light of the fact that record prices of R 20 million and R 40 million were paid for a cow and a bull, respectively, in 2012/13.

1.2. Hunting

For the greater parts of the 1800s and first half of the 1900s, hunting was seen as either extermination or recreation, but was rarely seen as a means of generating income. This was emphasised by the 'outlawing' of biltong sales in 1910, which was the greatest income for game at the time (Carruthers, 1995b). Between 1929 and 1931, the South African Division of Veterinary Services declared the extermination of game so as to eliminate the disease risk the game posed and 35 000 game animals were killed during that time in Zululand alone (Bigalke & Skinner, 2002). This extermination was followed by large-scale criticism from external parties relating to the justification and agenda behind the decision. Consequently, there was an increasing need for scientific research to be conducted in order to provide assistance in the taking of informed decisions relating to such widespread exterminations.

In 1966, it was suggested that certain areas of South Africa should be opened up for keeping game species and using these for sport hunting as an additional income source to that derived from the meat (Steyn, 1966). The hunting industry progressively developed and was given an immense boost by the banning of hunting in Kenya in 1977 and by the perception that South Africa was an easier and safer location to hunt (Carruthers, 2008). By the 1980s, the main reason for game ranching had become hunting rather than meat production or husbandry (Carruthers, 2008).

Hunting can be divided into foreign hunters (trophy hunting) and local hunters (biltong hunting). Recreational (biltong) hunting remains the largest portion of income generated by the local game industry overall, with 300 000 local hunters in 2008 spending R 3.1 billion on direct hunting costs, accounting for 66% of the income of the entire industry (Anonymous, 2012). These figures are high when compared to the R 510 million brought in by foreign or trophy hunters (Cloete *et al*., 2007) or the R 1.2 billion (estimated by the South African Wildlife Management Association (SAWMA)) that is paid by foreign hunters on direct hunting costs (Anonymous, 2012). For many of the international hunters, buffalo are considered to be the main attraction and foreigners return annually to hunt them (Foggin & Taylor, 1996; Grobler, 1996).

A good indication of the state of the buffalo hunting in South Africa is the average hunting prices for buffalo, which range between US$ 10 000 (R 88 000) and US$ 25 000 (R 220 000) in 2012 depending on the trophy size and outfitter. Further, a record price of R 1.7 million was paid for a ‘50 inch’ bull at the 2012 Thaba Tholo auction and as the bull was said to be infertile, it could only be used for hunting purposes, which confirms the well-being of the buffalo hunting industry in South Africa. Thus, it is clear that the hunting industry in South Africa is a lucrative business that appears to still be in its growth stages.

From an economic perspective, the rationale for breeding buffalo is mainly directed towards trophy hunting. Stud buffalo are bred by elite stud breeders and are thereafter sold to other stud breeders. The latter then supply buffalo to commercial breeders, who in turn mostly supply to the trophy hunting market. This ‘pyramid top-down’ system is similar to livestock stud breeding and production today (Viljoen, 1991). Nonetheless, the buffalo industry is not currently running according to this system, due to the fact that elite stud breeders are mostly selling to other elite stud breeders. These elite stud breeders are also supplying the market with high quality hunting buffalo and thus there is little space for the average commercial breeder at the moment. Theoretically this should change as the industry develops.

Two measurements of trophy horns exist for hunters. These are the Rowland Ward (RW) measurements and Safari Club International (SCI) measurements. Rowland Ward is the distance between the widest two outside points of the horns also known as the spread of the horns (distance XY in figure 4.2) (Rowland Ward, 2014). The minimum RW measurement required to qualify for a record book entry is 42 inches and the current world record is 64 inches. Safari Club International measures the outside line length along the curl, also known as the tip to tip measurement and adds the straight-line width measurement of both bosses (GH in figure 4.2). The minimum requirement for a SCI record book entry is 101 inches with a world record of 141 inches (Safari Club International, 2014).

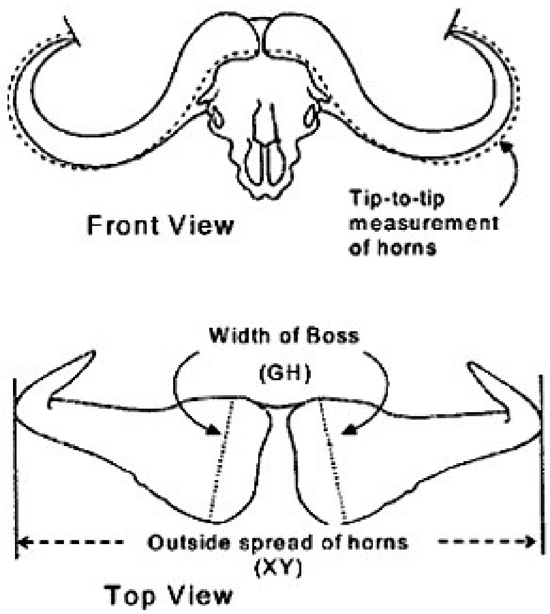

Figure 4.2 Horn measurements of African Savanna buffalo

1.3. Meat production

Meat production supplies the smallest portion of all the game income divisions, especially for buffalo which are seldom hunted for their meat. The value of the game meat market in South Africa is estimated to be between R 300 million and R 400 million annually, of which Springbok accounts for the largest part (*ca.* R 70 million) (Anonymous, 2012). In earlier years, buffalo were investigated as potential meat animals due to their good production parameters and hardiness, as well as the pleasant taste of the meat. However, attempts to produce buffalo for meat did not succeed as they are difficult to farm and their meat production was inferior when compared to that of domestic cattle. Thus, at present, the only buffalo meat that enters the market is that which is derived from trophy animals when the hunter does not wish to retain the meat, and as such this adds little value to the game meat industry (Grobler, 1996; Hornsveld, 1996). There is, however, very little research done on buffalo meat and thus a chapter on the chemical composition of buffalo meat is added in Addendum A.

1.4. Eco-tourism

The eco-tourism element of the game industry generates about R 1 billion in revenue annually (Anonymous, 2012). In the global context, this contribution seems substantial, but when considering this on a per lodge profitability scale, the contribution decreases rapidly. It has been speculated that only 5% of South African game lodges focusing on eco-tourism alone generate a profit, with an average lodge occupancy rate of 20% annually (2012, J. van Heteren, Pers. Comm., Madikwe Game Reserve). Additionally, the prices of marketing and travel agent commissions have increased over the past 5 years, with the weakening economic situation in Europe worsening the problem. Thus, without the income generated from hunting or live game sales, game farming solely for eco-tourism appears to be mostly non-profitable in South Africa at present, with other African countries presenting better opportunities (Anonymous, 2012).

CHAPTER 5

Wild African Savanna buffalo (*Syncerus caffer caffer*)

A wide variety of data are available on African Savanna buffalo in the wild, some of which is contradictory. Although a large majority of this data are observational and subject to personal opinions, it remains the most scientific form of data relating to buffalo research at present and is thus frequently used for setting up buffalo management practices.

1. Population and family structure

The basic family structure of a buffalo herd consists of adult males and females and then infants, juveniles and sub-adults (Mloszewski, 1983). This is, however, a very simplistic classification and different authors use more complex classifications according to age, status and grouping. With regards to grouping, gender only has an effect on adults and thus the other three categories are not defined according to gender since this has no effect on their place in the hierarchy (Mloszewski, 1983). Hierarchy and rank have mostly been found to be applicable within a herd or group and any buffalo entering the herd that already has a place in another group or herd is not challenged or dominated, but also does not have rights associated with status or rank in the entered herd (Sinclair, 1977; Mloszewski, 1983; Prins, 1996). Thus, the main groups found in a herd can be narrowed down to the bulls (adult and sub-adult), cows (adult and sub-adult) and calves and juveniles (Winnie *et al*., 2008).

1.1. Bulls

Adult bulls are the largest and seemingly highest in the hierarchy with the other buffalo in the herd displaying submissive behaviour towards them (Sinclair, 1977). Adult bulls can be defined as those over the age of 4 – 5 years, as bulls reach puberty by 3 years of age and are then considered sub-adults (Sinclair, 1977). Mloszewski (1983) describes an adult male to adult female ratio of 0.4 – 0.9 to 1.0, with an adult female being at the head of the hierarchy. Sinclair (1977) narrows this ratio down to dominant adult bulls constituting 10% – 15% of the herd size. The rank of these bulls is greatly influenced by both size and age. Less dominant younger bulls are tolerated in the herd, but tend to form bachelor groups and are either located around the edges of the breeding herd or move away from the herd completely during the dry season (Sinclair, 1977; Mloszewski, 1983). The reasons for these bulls leaving the herd seems to be due to the better mobility to increase feed intake and the decreased number of cows in oestrus (fewer mating opportunities) during the dry season

(Hay *et al*., 2008). The herd also tends to fragment into smaller groups during the dry season (Sinclair, 1977).

The bachelor groups also contain older bulls (>10 years) that were once dominant, but have become too old and infertile to stay in the main herd. Nonetheless, the ageing of the older bulls is greatly influenced by not only genetics and time, but also alimentary and parasitological factors (Mloszewski, 1983). Sinclair (1977) suggests that older bulls do not return to the herd and when in close proximity to the herd they remain on the outskirts. However, Mloszewski (1983) observed that older and once dominant bulls remain in the herd as long as they maintain the physical capacity to keep up with the herd. The reason for the findings of the former author appear to be two-fold in nature, as previously dominant bulls are regularly harassed by the younger and currently dominant bulls and as they are mostly infertile, have little motivation to re-join the herd. The infertility is brought on not only by age, but also by brucellosis, which over time reduces the fertility of the bulls (Krüger, 1996). These older bulls, which can reach ages of over 19 years, are also lighter and thinner than the dominant bulls, so they have little chance of returning to the herd. The younger adult bulls that reside in the bachelor groups during the dry season do return to the herd for rutting (male dominance displays during the breeding season) in the rainy season.

The younger adult bulls are only tolerated in the herd as long as they keep to their ranks and display submissive behaviour towards the more dominant bulls. These structures are, however, much better established and controlled in smaller herds (<200 head) than in the larger herds such as those in the Serengeti (average herd size of 350 buffalo, potentially reaching over 1000 animals) (Sinclair, 1977). The herds always contain one or more bulls with very high status. These bulls form their own 'bachelor' groups inside or just outside of the main herd. On the other hand, when females are in oestrus, the bulls can be found inside the herd attending to these females (Mloszewski, 1983). Less dominant males also get opportunities to tend to females when there are many in oestrus at a single time, However, the less dominant males are usually displaced by more dominant ones at the peak of oestrus during ovulation and thus effectively serve as identifiers of ready females for the more dominant bulls (Mloszewski, 1983).

In herds of 1000 animals or more there can be as many as 150 adult bulls present, which makes the control of rank difficult. Thus, the ratio of adult bulls to adult cows in this case is 0.15:1.0 which is very low considering the ratio at birth is approximately equal and remains so up to at least one year of age (Sinclair, 1974a; Skinner *et al.*, 2006). Even when considering the ratio of 0.4 - 0.9 to 1.0 as suggested by Mloszewski (1983), the number of males remains lower than the females. This ratio change, from one year of age to adulthood, is a strong indication of external and environmental influences on the buffalo's survival. These external factors include hunters that prefer bulls over cows, both for hunting and for meat. The smaller size of bachelor herds adds to the susceptibility of males to predators. Older bachelor bulls are more likely to be taken by predators (mainly lions) than those buffalo residing in larger herds. Predation accounts for up to 30% of buffalo mortalities in the wild, of which as high as 25% are bulls (Sinclair, 1974b). It has been suggested that the combat for dominance between bulls also has a marked effect on their numbers. Nevertheless, Mloszewski (1983) suggests that the frequency at which such combats end in fatalities is low and is probably a negligible cause of mortality. Fighting for dominance could, however, add to the susceptibility of males to predators, since the losers may be injured or expelled from the herd and may be less capable of defending themselves against attacks. The observation that buffalo bulls are more susceptible to the aforementioned detrimental factors has been used as a rationale to suggest that an adult cow is the dominant animal in the hierarchy (Mloszewski, 1983).

1.2. Cows

In instances where it has been observed that female buffalo were dominant over some of the lower-ranked bulls in the herd, it was also noted that these females had secondary male characteristics and were mostly infertile (Mloszewski, 1983). These 'dominant' females are additionally reported to be more aggressive than other females and initiate up to 75% of agonistic encounters with other herd members. As many as 24% of the agonistic encounters with adult males are reportedly won by these 'dominant' females with secondary male characteristics (Mloszewski, 1983). These females, however, only constitute about 0.25% of a herd and thus overall dominance of females over adult males is seldom observed.

Female to female dominance is noticeable and although both Sinclair (1977) and Mloszewski (1983) indicate that it is not as defined as the hierarchy in adult males, Prins (1996) suggests that females are highly structured in their hierarchy and remain in that order for the greatest part of their reproductive life span. The only obvious circumstances in which adult cows were observed to change rank was when their breeding status changed, such as during calf suckling or when their calf had recently died (Prins, 1996). The hierarchy has been proposed to be based on the positioning of the cow within the herd during movement, which is supported by studies on cattle (Beilharz & Zeeb, 1982). The average wild herd excluding adult bulls as reported by Prins (1996) consists of 65% adult cows, 7% sub-adult cows, 7% sub-adult bulls, 7% juveniles and 14% calves. The cows are very seldom located outside the herd and the only potential reason that this would occur would be during parturition or when the cow is isolated by a tending bull. The permanency of a herd is much greater than one generation and herds that have existed in the same area for over 50 years have been identified, in which most of the cows remained for their total life span (average 12 years) (Prins, 1996).

Apart from the permanent structure of the herds over the years, buffalo display a fusion-fission society. A fusion-fission society is defined as a population that splits and then regroups for different periods of time. The size of the herd, as well as the season, has a large effect on the time span of the splitting of the groups in a herd. The groups that split off are usually those located at the rear of the herd, which in the dry season would have access to very low-quality food. The dry season is associated with more splitting within the herd than the rainy season and although the herd splits, the buffalo present in a group form a smaller herd unit which imitates the structures and tendencies of the larger herd (Sinclair, 1977; Mloszewski, 1983; Prins, 1996). Mloszewski (1983) suggests that the hierarchy of the females in a herd are set within the groups and not in the herd as a whole. Rank is in turn strongly influenced by family associations, with the dominant cow providing 'borrowed' dominance for her daughters and their offspring as a sort of 'triad'. This borrowed dominance is lost when the dominant cow dies or is no longer dominant (Mloszewski, 1983). The dominance interactions between members within a group are also much higher than between members of different groups (Sinclair, 1977; Mloszewski, 1983).

The positioning of buffalo in the herd is strongly correlated with the quantity and quality of food available and the more dominant animals have access to better and more food, with body condition scores of the buffalo supporting this (Prins, 1996). The quality of the ingested food has a direct effect on inter-calving period and the ability of a cow to provide for her calf, which in turn has a lifelong influence on the calf's reproductive ability. Thus, in terms of bulls, the motivation for higher rank within a herd is for the purposes of spreading their genes and mating rights. However, in terms of cows, the rationale for dominance is closely related to access to food of higher quality and quantity, which promotes the survival of themselves and their offspring.

1.3. Juveniles and calves

Juveniles and calves are associated with their mothers in almost all cases and enjoy the rank that the dam holds during feeding up to the age of sub-adult, irrespective of their gender. From the age of 2 years, the female heifers usually form family units with their mothers and attain a 'borrowed' dominance from them. The sub-adult bulls, however, form bachelor groups from 2 years of age and are less bound to their dam than the females (Sinclair, 1977; Mloszewski, 1983). These sub-adult bulls then fall into the hierarchy at the bottom and remain there until after puberty, from which time they can commence challenging for status among the other bulls.

2. Behaviour

Buffalo have long been renowned for their unpredictable and aggressive demeanour and displays of serious agonistic behaviour. Nonetheless, African Savanna buffalo seem to be well organised and structured herd animals. These structural behaviours are not only seen in the hierarchy, but are also observed during feeding, migration (movement), sexual (reproductive) encounters, as well as when threatened.

2.1. Agonistic behaviour

Agonistic behaviour is defined as any social behaviour related to fighting, very similar to aggression, but encompassing a wider scope. The basic structure of agonistic behaviour can be condensed into categories, namely threat, aggression and submission. These are usually limited to displays of dominance rather than actual fighting in most species, but can range and escalate to fights, at times even ending in death (Sinclair, 1977).

The intra-specific encounters can range from low-intensity ‘show-case’ type combats to more serious high-intensity fights. The intensity level is often subject to willingness of either party to submit purely based on physical attributes. The conflicts between bulls are much more frequent than in cows and have a tendency to escalate more often. This phenomenon is ascribed to the limited positions available for bulls in the herd and also the linearity of the male hierarchy, which is seen in bachelor herds where no females are present (Mloszewski, 1983). Although less frequent in cows, this display has been observed within a herd between two closely-ranked cows. The conflict often rapidly escalates and then de-escalates as the losing member retreats, with the victor attaining the higher rank that was in contention. Agonistic behaviour by a cow towards her calf has also been observed on isolated occasions; however, this normally occurs when the cow does not want the calf to suckle either temporarily or permanently. Other agonistic behaviours are defined as low- or medium-intensity encounters and have been described more as sparring to test or establish rank (Mloszewski, 1983).

The high-intensity combat that occurs between two similarly ranked males has a relatively set sequence of events and is the most likely a type of conflict that could lead to injury. These encounters generally begin with the males observing and sizing each other up from a distance, which then indicates the unwillingness to give ground. These bulls then circle as if to outflank the other, which rarely happens, or possibly to have a prolonged display of size with intent to intimidate and give the opponent time to retreat after realising his inferiority. During this time, there is also a display of aggression by means of head tossing and horning, usually involving soil and plants. Thereafter, a head on charge follows if neither decides to retreat. Such charges do not occur at full speed, as this impact would be extremely severe due to the fact that these bulls can weigh up to 900 kg and move at speeds of 40 km per hour or more. The pushing match then commences until the weaker loses balance and has to move to the side, thereby exposing his flank to injury. In order to avoid injury, the loser normally flees at this stage with the victor in pursuit for a few meters (Sinclair, 1977; Mloszewski, 1983).

The less intense forms of agonistic interactions are usually referred to as sparring, usually taking place between younger or sub-adult animals and resembling play. The sparring is mostly the pushing between two animals without the circling and may happen up to eight times before either of the animals back away (Sinclair, 1977). The functionality of sparring is often strongly related to growth and development, especially in males, when developing strength needs to be tested regularly. Sparring may also take place between a sub-adult and an adult male, during which time the adult bull usually completely over-powers the sub-adult by pushing him forward with ease (Mloszewski, 1983). This is contrary to the observations of Sinclair (1977), who suggested that dominant adult males never engage in sparring. Sparring between calves and their mothers has also been noted and is largely playful in nature (Mloszewski, 1983).

Different methods of surrender or de-escalation exist, although the two main ways involve the loser surrendering or assuming the ‘clasp’ position. The ‘clasp’ position is when the surrendering or submissive bull places his muzzle below the belly of the victor at which time they turn in circles at rapid pace seemingly chasing each other’s rumps (Sinclair, 1977; Mloszewski, 1983). This manoeuvre is never followed by combat. In the case of a sub-ordinate animal moving in front of a dominant animal, especially during stressful times (e.g. times of feed shortage), the dominant animal often displays aggression by charging with its head low and swiping with the horns. In such cases, if the sub-ordinate animal does not flee, it gets butted in the rump (Mloszewski, 1983). This display of dominance occurs in both males and females and the dominant animals are readily recognised by all herd members. The submissive behaviour towards the dominant buffalo is thus associated with the sub-ordinate animal lowering its head and placing it under some part of the dominant animal. Alternatively, when the display comes from the dominant animal, the dominant animal places its head on top of the lower-ranked animal at different sites depending on the situation (Sinclair, 1977; Mloszewski, 1983).

2.2. Threatened behaviour

Due to their impressive size, dangerous weapons (horns) and demeanour buffalo are seldom threatened by other animals and predators. When considering predators, the two main threats to buffalo are humans and lions. In relation to feeding, buffalo are in competition with African elephants (*Loxodonta africana*), not zebra (*Equus quagga*) and wildebeest (*Connochaetes taurinus*) as might be expected (Prins, 1996).

Aggression or agonistic behaviour towards humans is often observed, but is mostly followed by flight (Mloszewski, 1983). This is contrary to the accounts of numerous hunters who have reportedly experienced the attacking nature of buffalo. Threat displays by buffalo are characterised, but not restricted to, head tossing whilst in an alert posture (Mloszewski, 1983). The head tossing is usually observed in the front-ranking animals. However, animals within the group have also been observed to display this behaviour, whilst lifting their bodies to either have a better view of the threat or to make themselves seem larger or more conspicuous (Mloszewski, 1983). Head tossing is marked in both males and females, adults and sub-adults, and is not restricted to rank in a herd or solitary animals.

Buffalo react on sound, smell and sight associated with humans well over 100 meters away. Even in the absence of both smell and sound, buffalo displayed threat behaviour on sight of humans as far as 100 meters away. These are very seldom associated with aggressive attacks and even less so in areas where hunters are absent. It has been suggested that buffalo form an association with humans and are able to assess whether they are a threat (Mloszewski, 1983). The aforementioned author also speculated that buffalo are able to assess whether a gun shot or certain noise from a human is aggressively intended or not, with buffalo not even reacting to gun shots in areas where hunters have been absent for long periods of time. Noise could, however, provoke pre-emptive attacks in circumstances where vision is impaired, even though the smell is evident. In the case of wounded animals, the attack is evidently made purely on sight and at a specific target. The buffalo attacks and even if the target changes position, the buffalo will alter its course as to compensate for the change in position. This is then followed by a horning and goring action when reaching the target with clear intent to kill. Wounded buffalo are seldom distracted from the target and usually continue until either the attacker or the victim are dead (Mloszewski, 1983). According to Mloszewski (1983), cows with calves are not particularly aggressive towards humans. This is contrary to the observations of Sinclair (1977), who observed cows with calves to be much more easily provoked to charge, yet never leaving the calf for more than a few seconds. The first response of buffalo in general, however, is to flee and if that possibility is eliminated, attack is imminent as seen in circumstances where young rejected calves have been found. In circumstances where motor vehicles have been used during observation, mature bulls have been reported to attack these vehicles. These animals were usually solitary and the behaviour is seldom seen when in a herd, which could suggest that the animal felt exposed and threatened or was wounded (Mloszewski, 1983).

The only other true buffalo predators known are lions (*Panthera leo*) and to a lesser extent also hyenas (*Crocuta crocuta*) (Sinclair, 1977; Mloszewski, 1983). Whether or not buffalo constitute a choice prey item for lions is debatable. On the one hand, buffalo are strong animals that defend themselves well when compared to other prey animals. On the other hand, a buffalo kill is advantageous in terms of the amount of meat present on the carcass and is facilitated by the fact that the buffalo follow similar routines when moving around in their home range, making it simple for lions to plan a co-ordinated attack with minimal energy expenditure. The buffalo react by marking places where lion attacks are most probable, protecting the most important or vulnerable animals in the herd in these areas, and leaving the 'outcast' animals for the lions – an almost mutualistic situation (Mloszewski, 1983). Also of interest is that the main proportion of kills is on adult bulls (which should be able to adequately defend themselves) that are on the sides or the back of the herd. Even when attacks are planned and executed successfully, more adult bulls are killed than other herd members. The reason for this is speculated to be the strong anti-predator response of the buffalo that makes the less-dominant adult males or 'outcasts' more vulnerable to attack, while cows and younger animals within the herd are kept safe by repeated attacks on the lions by the larger and dominant bulls (Mloszewski, 1983). In the cases where non-adult buffalo were taken by lions, the anti-predator behaviour was likely restricted due to stampeding by the herd and by single or a pair of lions (Mloszewski, 1983).

There are six common reactions of buffalo to predator threat as summed up by Mloszewski (1983) as increased caution, selective scrutiny, auditory-olfactory probing, flight, preventative aggression and reciprocal aggression. The reactions usually occur in succession of one another depending on the severity of the threat and also the immediate environmental factors that could increase or decrease the chance of survival.

2.3. Feeding and movement

Buffalo are bulk grazing ruminants and devote between 40% – 80% of their time to feeding (including both grazing and ruminating), depending on the season and availability of food (Bartels *et al*., 1996; Prins, 1996). The time spent ingesting food makes up 30% – 60% hereof and ruminating about 10% – 45%. These proportions of time are very similar for both day and night times for buffalo, with the main differences observed between the wet and dry seasons (Sinclair, 1977; Mloszewski, 1983; Prins, 1996). The times grazed during the wet season are more or less evenly distributed, with slight grazing lows during sunrise, midday and sunset. During the dry season, the peaks are much more marked, with grazing highs taking place just before sunset. There is also a higher percentage of high intensity grazing (58%) during the dry season than during the wet season (43%) (Mloszewski, 1983). In times of severe drought and grass shortages, buffalo have been observed to resort to browsing as a means of selective feeding in order to obtain their required nutrients (Mloszewski, 1983).

Grazing and ruminating are negatively correlated, as the less time spent in grazing, the more time is spent during ruminating. A potential reason for this could be that the higher the quality of the feed, the less feed is needed, and the greater amounts of nutrients that can be taken out of the ingested feed (Prins, 1996). The time spent grazing is also influenced by bite size. During the dry season buffalo tend to reject certain patches as being inadequate and also change their manner of grazing from plucking grass with their tongue to cutting with their incisors. Consequently, the bite size is reduced and thus the time needed to acquire adequate quantities of feed is increased (Prins, 1996). This then raises the question on whether buffalo are time-limited or resource-limited in terms of feed intake? Even though buffalo seem to be resource-limited (as discussed in section 4.3), time and selection of grazing grounds (patch selection) are of utmost importance.

Buffalo are not seasonal migratory animals as many other wild African ungulates that utilise grazing, but have been known to make migratory trips on occasions where no other options were left for survival (Winnie *et al.*, 2008). Instead, buffalo herds generally move and live within a home range, the size of which is influenced by the abundance of edible food and water and can be as large as 105 kilometres in circumference (McNaughton & Georgiadis, 1986; Ryan *et al.*, 1996). In areas where multiple herds are found, their home ranges often overlap and the boundaries shift depending on herd size and composition, which changes from time to time (Sinclair, 1977; Mloszewski, 1983). According to Mloszewski (1983), the size and density of these home ranges are between 26 and 588 ha per buffalo.

Within the home range, a route is identified based on the abundance of grazing availability and the herd follows this route repeatedly. The strip grazed can vary between 1 – 5 kilometres in width depending on the size of the herd and the availability of food. The factors that cause buffalo to deviate from the route, even for a short while, include watering spots, exceptional grazing, resting areas, licks in the form of termite mounds and salt in mud near springs and places that offer particularly good protection from predation due to the physiographic features (Mloszewski, 1983; Ogutu & Owen-Smith, 2005). This said, buffalo apparently are not influenced by regular and moderate predation when selecting preferred grazing sites and areas and thus the route is not altered due to increased predation by lions (Sinclair, 1977; Mloszewski, 1983; Prins, 1996; Winnie *et al.*, 2008). Irregular and excessive predation, especially by humans has, however, been noted to bring about changes in the movement of buffalo, especially where the predation has been excessive to the point that it threatened to eradicate a herd (Marks, 1977; Mloszewski, 1983).

Other than when fleeing, the average speed of motion of wild buffalo is 0.3 kilometres per hour, but this differs greatly between 0.1 – 9.0 kilometres per hour when walking rapidly or as high as 44.0 kilometres per hour when running at full speed (Mloszewski, 1983). It also appears that buffalo prefer to move up wind, probably as to enable them to detect danger out of sight, however, they do not deviate from the route to remain walking into the wind (Mloszewski, 1983). Nonetheless, the herd is led by a main pathfinder that is ‘assisted’ by other pathfinders in times of low visibility. The herd moves in columns of single or multiple animals in width, with the pathfinder walking ahead almost detached from the herd. The latter observation supports the theory that the route followed is not marked by landmarks, but rather cognitively decided upon by the pathfinder (Mloszewski, 1983; Prins, 1996). This column formation is exchanged for a ‘wide-front’ formation during very slow movement and grazing. At such times, although the animals might appear randomly scattered over a plain, they are actually moving forward very slowly in ranked formation as predicted by hierarchy, with the pathfinder either in front or on the up-wind flank (Mloszewski, 1983).

Re-grazing is another determining factor for the movement of buffalo, as they seem to re-graze specific patches regularly as to maintain optimal growth of the grasses (Krüger, 1996; Prins, 1996). This re-grazing is beneficial for many other herbivores, excluding elephants, due to the preferred state of the vegetation and the ability of buffalo to have a marked effect thereon. Thus buffalo select and maintain grazing areas that will provide them with the optimal amount of green leaf material to provide their daily protein requirements as far as the environmental factors (such as rain) allow. The selection by the buffalo appears to be cognitive and buffalo have been observed to ‘assess’ a certain patch and then move on without grazing that area. It is speculated that in these areas the amount of time expended compared to the amount of nutrients (especially protein) acquired are not optimal and they therefore prefer to move on to another superior patch (Prins, 1996).

Buffalo need to drink at least once a day with little exception and their drinking behaviour differs between the wet and dry season (Mloszewski, 1983). Since surface water is considerably more abundant during the wet season, buffalo herds seem to frequently graze, rest and drink simultaneously at surrounding water holes and streams at such times. However, in the dry season, the division between these activities is much more marked and the buffalo usually graze as a group and then move towards water as a group. They drink for an average of 43 minutes and then move away from the water to rest or graze when drinking once daily, or for 2-3 minutes at a time when drinking more frequently. The peak times of drinking are also more pronounced during the dry season, with a definite peak during the late afternoon and early evening. These peaks and the stress during drinking are influenced by the familiarity of the area around the water and the prevalence of predators, especially humans (Mloszewski, 1983). Taking this into consideration, buffalo generally display higher levels of stress and alertness during drinking in comparison to during grazing.

Resting and rumination often occur in unison. Buffalo prefer to rest more during the middle of the day than during the transition times from night to day or day to night and prefer more daylight resting time in the wet season as opposed to the more evenly-spaced resting during day and night times in the dry season (Sinclair, 1977; Mloszewski, 1983). Buffalo prefer moist ground as opposed to soggy ground when lying down and thus move to higher areas or woodlands during the wet season for resting times. Woodlands are often utilised more for cover from predators than for shade, except during extreme heat, as buffalo seem to prefer open grassland for resting. Ruminating usually takes place when lying down, apart from cases where the ground is soggy. Under the aforementioned circumstances, the buffalo ruminate whilst standing or walking (Mloszewski, 1983). Chewing of the bolus usually takes place at about 40 chews per bolus, but this differs depending on the type and quality of food ingested, as well as the age of the buffalo (Sinclair, 1977; Mloszewski, 1983). It is speculated that older males form bachelor groups so as to enable them to increase their ruminating durations and to allow more time for selective feeding to fulfil their daily requirements (Sinclair 1977).

3. Nutrition

As with most mammals, the main limiting nutrients for buffalo are energy and protein. According to Prins (1996) the most important of these is nitrogen, which can be used directly to synthesize protein in the case of ruminants such as buffalo. The buffalo’s minimum requirement for protein is between 7% to 8% of the diet (Prins, 1996). An adaptation of buffalo for the ingestion of the required amount of protein in the diet is to turn to browsing. Browsing supplies a higher protein concentration than grazing, but is only effective in buffalo when they select for species that have a low content of acid detergent fibre (ADF) and when they avoid increasing their crude fibre intake. Hoffman (1989) suggested that buffalo have developed a means of increasing the passage rate of feed through the rumen by allowing larger particles to pass through the reticulo-omasal orifice, meaning that lower food quality does not affect them as drastically as other bulk grazers. However, the plausibility of this theory has been questioned by others, as has the method of data collection used in the aforementioned study (Van Soest, 1994).

As ruminants, buffalo are restricted by protein (nitrogen) intake for effective fermentation in the rumen by rumen micro-organisms (Van Soest, 1994; McDonald *et al*., 2002). Consequently, food quality is of utmost importance, more so than quantity (Winnie *et al*., 2008). Adding to the complexities of ingesting sufficient protein (nitrogen) is the fact that buffalo have to ruminate, the time for which competes with grazing. In addition to browsing, buffalo have developed two means of dealing with constraints in grazing quality and quantity. The first is bulk grazing, which is known as the default method of feeding for larger ruminants such as buffalo. Buffalo opt for bulk grazing during times when an adequate volume of grazing is available, with almost equal grazing versus ruminating time (Prins, 1996). Alternatively, buffalo can focus on selective grazing, which is preferred at times of high quantity food availability of mixed quality, or at times where food is scarce and of poor quality (Prins, 1996). The latter increases grazing time and drastically decreases time spent on ruminating, which implies that the fibre content of the ingested feed is higher and that buffalo are restricted by rumen fill, regardless of passage rate (Prins, 1996). Both Sinclair (1977) and Prins (1996) proposed that in terms of nutrition, buffalo are resource limited, with the former study being based on bone marrow analyses.

Other than energy and protein, minerals and vitamins are equally important for optimal nutrition and performance. Minerals can be grouped into macro minerals (concentrations > 1g/kg feed) and micro or trace minerals (concentrations < 100mg/kg feed) (McDonald *et al*., 2002). The most commonly required minerals, their sources and shortage symptoms are set out in Table 5.1 (macro minerals) and Table 5.2 (micro minerals). Other trace elements not mentioned in Table 5.2 that are found in the animal's body are Silicon, Chromium, Vanadium, Nickel, Tin and Arsenic (McDonald *et al*., 2002). These only occur in minute quantities in the body and seem to almost never be in shortage in South Africa (Schmidt & Snyman, 2005). South Africa has P poor soil and thus a P deficiency is almost always found in the diets of grazing animals. Along with P, the other minerals that are known to be deficient in different areas of South Africa are Na, Cl, S, Fe, I, Cu, Co, Mn, Se (Schmidt & Snyman, 2005). The remaining minerals are not often deficient, but isolated cases have been found throughout South Africa. In Table 5.1 only deficiency symptoms are listed as opposed to Table 5.2 which has both deficiency and toxicity symptoms listed. This is because toxicity of macro minerals seldom occurs and the animals have better coping mechanisms for these, whereas the micro or trace minerals have a higher tendency to be toxic as minute amounts of these minerals are required and utilised by the animal's body. Calcium shortages are rarely found in South Africa and an excess is more likely. This excess Ca causes complications with the Ca:P ratio which should be 2:1 for optimal performance in ruminants (McDonald *et al*., 2002; Schmidt & Snyman, 2005). A skew Ca:P ratio could be as bad as a deficiency of either or both Ca and P, with similar deficiency symptoms. Ruminants have been known to tolerate higher ratios of Ca:P than 2:1 in circumstances where the P requirement of the ruminant has been met, but this is not ideal (McDonald *et al*., 2002). Effectively minerals should be managed to avoid any deficiency or toxicity as either could be to the detriment of the animal.

Table 5.1 Macro minerals for ruminants, deficiency symptoms and sources of each (adapted from McDonald et al., 2002; Oberem et al., 2006; Oberem & Oberem, 2011)

Mineral	Deficiency symptoms	Source
Phosphorous (P)	Rickets, osteomalacia, depraved appetite, stiff joints, muscular weakness, poor fertility, oestrus irregularity, subnormal growth, low weight gains	Milk, cereal grains, fishmeal, limestone, monocalcium phosphate
Calcium (Ca)	Milk fever, rickets, osteomalacia	Milk, legumes, fishmeal, limestone, dicalcium phosphate
Salt (Na + Cl)	Lowered appetite, weight loss, lowered milk production, alkalosis	Common salt
Potassium (K)	Retarded growth, weakness, tetany	Potassium chloride, potassium bicarbonate, potassium sulphate, potassium carbonate, most green grazing
Magnesium (Mg)	hypomagnesaemic tetany (grass staggers), anorexia, increased blood flow, convulsions, frothing at the mouth, prolific salivation	Wheat bran, dried yeast, cottonseed cake, magnesium acetate
Sulphur (S)	Nervous and respiratory distress, prussic acid poisoning, lowered feed intake, anorexia, weakness	Sodium sulphate, ammonium sulphate, calcium sulphate, potassium sulphate, magnesium sulphate, elemental sulphur

Vitamins are needed in very small quantities by animals and even less in the case of ruminants as they have micro-organisms that synthesise needed vitamins in the rumen (B vitamins and Vitamin K) that can be utilised by the body. Under natural extensive conditions, the vitamin levels are usually high enough to supply the requirement of the animals. The only exception to this might be vitamin A, which is high in green feeds and could thus be low towards the end of the plant growth season (Oberem *et al*., 2006). Hypervitaminosis is the oversupply and intake of vitamins by animals. This is highly unlikely in most systems, except where animals are fed complete rations and feed mixing has not been properly done (McDonald *et al*., 2002). The symptoms of vitamin toxicity include loss of appetite, poor growth, diarrhoea, encrustation around the mouth, reddening of the eye and deposition of Ca in the arteries. These are, however, very unlikely to occur in game species. Vitamins can be included into supplementary feeds or blocks, but are often affected by external conditions that either reduces their affectivity or they are destroyed. There are 14 vitamins that are known and of importance for animals. These are divided into fat- and water-soluble vitamins. The fat-soluble vitamins are A, D, E and K and the water-soluble vitamins are the B complex vitamins and vitamin C. The sources and deficiency symptoms of each are listed in Table 3.

Table 5.2 Micro minerals for ruminants, deficiency and toxicity symptoms and sources of each (adapted from McDonald et al., 2002; Oberem et al., 2006; Oberem & Oberem, 2011)

Mineral	Deficiency symptoms	Toxicity symptoms	Source
Zinc (Zn)	Inflammation of nose/mouth, stiff joint, parakeratosis, swollen feet, hair loss, slow healing wounds, listlessness, lowered reproductive performance	Depressed appetite, induced copper deficiency, reduced weight gain and feed efficiency	yeast, cereal grains, legumes, fishmeal
Iron (Fe)	Anaemia, sway-back, lethargy, lowered feed intake, reduced weight gain	Reduced growth, P deficiency, diarrhoea, acidosis, hypothermia	Forage, cereal grains, oilseed meals, water, ferrous sulphate, ferrous carbonate
Iodine (I)	Goitre, weak/dead young, suppressed oestrus, reduced fertility	lowered weight gain, lowered feed intake, coughing, undue nasal discharge	calcium iodate, EDDI, seaweed, fishmeal
Copper (Cu)	Poor-growth, anaemia, bone disorders, scouring, infertility, depigmentation of hair, GIT disturbances	Necrosis of liver cells, jaundice, lowered appetite, hepatic coma	legumes, oilseed meals, copper sulphate, copper carbonate
Cobalt (Co)	Lowered appetite, anaemia, muscular wasting, pica	Decreased feed intake, emaciation, weakness	Legumes, cobalt sulphate, cobalt carbonate
Manganese (Mn)	Retarded growth, skeletal abnormalities, ataxia of new born calves, reproductive difficulty, irregular oestrus	Reduced growth, lowered feed intake	Forages, manganese sulphate, manganese methionine, manganese oxide, rice bran
Selenium (Se)	White muscle disease, reduced growth, lowered fertility	Lameness, anorexia, emaciation, cracked and deformed hooves, kidney inflammation, tail hair loss, respiratory failure	sodium selenite/selenate, selenium yeast
Molybdenum (Mo)	Lowered cellulose digestion, impaired growth	Diarrhoea, anorexia, weight loss, stiffness, discolored hair, increased puberty age of heifers, reduced conception rate	Forage, cereal grains, protein sources
Fluorine (Fl)	Reduced bone and tooth formation	Dental pitting and wear, decreased appetite, lameness, reduced production, bone/joint abnormalities	Processed phosphates

Table 5.3 Vitamins required for animals and the deficiency symptoms and sources of each (adapted from McDonald et al., 2002)

Vitamin	**Deficiency symptom**	**Source**
A (retinol)	Blindness, epithelial infection, low semen quality	Green leafy forages, corn
D (cholecalciferol)	Rickets, stiff joints, digestive problems	Fish-liver oil, sundried roughage
E (α-tocopherol)	Muscle degeneration, liver damage	Green forages, cereals
K (menadione)	Anaemia, delayed blood clotting	Green forages
B1 (thiamine)	Poor growth, polyneuritis	Seeds
B2 (riboflavin)	Poor growth, curled toe paralysis	Green forages, milk
Nicotinamide	Poor growth, dermatitis	Yeast, tryptophan
B6 (pyridoxine)	Poor growth, convulsions	Cereals, yeast
Pantothenic acid	Poor growth, scaly skin, goose stepping	Yeast, cereals
Folic acid	Poor growth, anaemia	Green forages, cereals, oilseed meals
Biotin	Foot lesions, hair loss, fatty liver and kidney syndrome	Vegetables
Choline	Poor growth, fatty liver, perosis	Green forages, cereals, methionine
B12 (cyanocobalamin)	Poor growth, anaemia, poor coat quality	Micro-organisms
C (ascorbic acid)	Reduced resistance to infection	Citrus, leafy vegetables

4. Reproduction

Buffalo seem to be seasonal breeders, with the largest proportion of births taking place during the seasons when the highest quality food is available (Bertschinger, 1996; Skinner *et al.*, 2006). Thus, reproduction efficiency in buffalo is strongly influenced by body condition, a tendency similar to that seen in cattle. Nonetheless, the births of calves at Lake Manyara Park in Tanzania is evenly distributed throughout the year, except for during the end of the dry season and the start of the wet season, which shows a drastic decrease in calf births as well as body condition of cows (Prins, 1996). This correlates well with the mating season described by Jolles (2007) during the wet season, with the only exception being that the observations by the latter author narrows the calf births down to the start of the wet season. The wet season also sees a marked increase in the proportion of bulls within the main herd, which is presumably due to the onset of the mating season, with one male for every twenty females in the dry season, as opposed to one male for every four females in the wet season (Turner *et al*., 2005).

The cow requires a high level of nutrition just before and after the birth of the calf in order to meet its high energy requirements for late gestation (during which time the growth of the foetus is substantial) and for early- and mid-lactation (Schmidt *et al.*, 2006). The energy requirement for lactation is reported to be as high as 50 MJ/day at peak milk production (*ca.* five weeks after birth) and can only be supplied during the middle of the wet season when the feed is of the highest nutritional value (Sinclair, 1977). Although high rainfall is a strong indicator of increased food availability, it is speculated that the synchronisation of conception could also be affected by the lunar cycle or a similar external stimulus, as in wildebeest (Sinclair, 1977; Berger, 1992; Owen-Smith *et al*., 2005).

Mating behaviour of *S. c. caffer* can be grouped into pre-copulatory and copulatory behaviour. Pre-copulatory behaviour is simply the general behaviour leading up to copulation. As discussed in the section on agonistic behaviour (section 4.2.1), there is a simple hierarchy between bulls which provides a structure for bulls to mate. Thus, if a female in oestrus is being tended to and another higher ranking male arrives on the scene, the lower ranking male simply gives way to the higher ranking male. The higher ranking male then either tends to the female up to copulation or loses interest and moves away, during which time the lower ranking male will resume his position of tending to the female in oestrus (Mloszewski, 1983; Bertschinger, 1996). The female in oestrus or approaching oestrus is often observed to display a higher level of tension than normal and regularly assumes the alert stance. The time of oestrus is difficult to pinpoint, but the bulls do, however, display the flehman response (lifting of upper lip with the head tilted slightly upwards), which is triggered by the hormones secreted by females coming into oestrus. After signs of a female on heat have been identified by the males, they energetically move from female to female until the female in oestrus has been positively identified. However, ambient temperature, rather than the presence of females in oestrus, reportedly has a more marked effect in mature male activity during the day (Turner *et al*., 2005). The flehman response is not restricted to sexual behaviour and is speculated to be used during times when heightened olfactory probing is required (Mloszewski, 1983).

Chin resting is the next phase of tending to females in oestrus and involves the male resting his chin on the rump of the female. If the female moves away or just remains standing, she is not yet ready for mounting. If she leans into the male she indicates a readiness for copulation. This then indicates full oestrus during which the female is tumescent and attracts males around her. The highest ranking unengaged bull then dislodge the current tending bull and 'chin rests' the female (Sinclair, 1977; Mloszewski, 1983). The female then stands wide and leans into the bull, who then mounts her in the same manner as a domestic bull does a cow. Copulation lasts for 10 - 30 seconds after which the bull keeps tending the cow and mounts her again after some time. The frequency and number of mountings differs between bulls and the duration of the whole process is terminated by the sexual depletion of the bull, after which other males will tend to the cow, or the termination of oestrus in the cow. Copulation is often watched by other males that display alert or a threatening posture (Mloszewski, 1983).

The oestrous cycle in African buffalo lasts 23 days with oestrus lasting for 24 hours (Pienaar, 1969; Knechtel, 1993; Bertschinger, 1996). There is a definite bias toward implantation into the right horn of the uterus as opposed to the left side with a combined percentage of observations in the Serengeti, Ruwenzori Park and northern Uganda of 64% implantation in the right horn and 36% in the left (Sinclair, 1977). Ovulation of two eggs is extremely rare and only one case was recorded by Pienaar (1969) and in this case the second embryo was degenerating. The average gestation period of *S. c. caffer* is 340 days and the calf birth weight is *ca.* 35 – 50 kg (Vidler *et al*., 1963; Sinclair, 1977; Schmidt *et al.*, 2006). This constitutes the longest gestation period of the Bovini tribe (Sinclair, 1977).

Sexual maturation can be placed into two broad classes, puberty and sexual maturity. Puberty is the age at which reproduction becomes possible, thus when ovulation starts. Nonetheless, during puberty the females are still maturing physically and thus sexual maturity is the age at which the females reach their full reproductive capacity (Sinclair, 1977). It has been shown that puberty was reached by 50% of wild east African female buffalo at the age of about 3.5 years, and by 4.5 years all the females had started ovulating (Carmichael *et al*., 1977; Sinclair, 1977). This difference in age of puberty is, however, attributed more to the size and weight of the animals, rather than the age. Sexual maturity is the age at which the first conception takes place. In the same buffalo populations as mentioned above (Sinclair 1977), 28% of the females conceived at four years of age and 91% at five and a half years of age. During the age span of 5 – 9 years, 83% of the females were pregnant, but this decreased to 66% when females were older than 15 years (Sinclair, 1977; Jolles, 2007). The males of these buffalo populations reached puberty between the ages of two and three years and 50% of the males reached sexual maturity by four and a half years, with all males reaching sexual maturity by six years of age (Sinclair, 1977; Neethling, 1996).

Calving interval is the average time elapsed between successive calves in a specific cow. Averages of different wild populations were found to range between 15 to 24 months, with the lowest being 13.3 months in the Serengeti buffalo (Carmichael *et al*., 1977; Sinclair, 1977). On the other hand, Prins (1996) found that the Manyara buffalo had an average calving interval of 29 months and gave birth at the age of six years for the first time. Factors causing this large variation between populations include not only age, size and weight of the dams, but also the availability of high quality feed and postpartum anoestrus. Postpartum anoestrus can range between 2 - 23 months depending on the available feed and the population dynamics, but when the calf is removed within 3 days after birth, the cow is in oestrus within 5 weeks. Thus, it has been proposed that lactation prolongs anoestrus and in effect extends the calving interval (Sinclair, 1977). In contrast, it was found that cows receiving a high energy diet before calving and having a good body condition at birth came into oestrus much earlier (within 90 days after birth) than cows that had a lower body condition score at birth. It therefore appears that the body condition of the cow has the largest effect on inter-calving periods, as opposed to the anoestrus caused by lactation (Sinclair, 1977; Ryan *et al.*, 2007). In support of the latter, the research conducted by Carmichael *et al*. (1977) showed that lactation lasts for 10 – 15 months and thus has either no or little effect on the postpartum anoestrus. In addition to the anoestrus duration, body condition of the dam during the entire gestation period has a marked effect on the postpartum growth and survival of the calf (Sinclair, 1977). Ryan *et al*. (2007) adds that low nutritional availability might cause low fecundity in the two years following the feed shortage. Thus it is concluded that parturition is not photosensitive, but rather in synchronization with the nutritional value of available feed, especially protein (Carmichael *et al*., 1977).

5. Conclusion

Game ranching, and in particular scarce species breeding is a constantly growing and evolving industry in South Africa, with the African Savanna buffalo being at the pinnacle of the scarce and highly-valued game species. The management and marketing of buffalo that have an average auction price-tag of over R 500 000 per animal opens up the market to potential corruption or discrepancies. In addition, the economic aspect has been greatly developed and emphasised, but requires a scientific foundation for sustainability to be ensured. The scientific foundation for the production benchmarking and management is, however, lacking or inadequate for intensive production systems, being mainly based on wild buffalo or domestic livestock management. Nonetheless, the research done on wild buffalo sets the basis from which a captive buffalo management plan can be formulated and is thus imperative to this study.

Buffalo breeding seems to be moving in the same direction as cattle breeding a century ago, with the exception that while the technology and knowledge are available to accelerate the development of the buffalo industry, these are not currently being utilised to their full potential. Without proper scientifically-based managerial practices and record keeping, the price for certain animals could exceed their true value and create a synthetic market, which inevitably will cause a collapse in the buffalo industry in South Africa.

CHAPTER 6

Case studies (materials and methods)

Collection of data was done on a case study basis where eleven buffalo farms were visited throughout South Africa. The farms are situated in Limpopo, Western Cape, Northern Cape, Eastern Cape, Mpumalanga, North-West province and Free State (Figure 6.1), excluding KwaZulu Natal and Gauteng due to a lack in contacts and unavailability of farms for the study. An attempt was made to get farms from different provinces and veld types. Most of these farms were livestock farms that were transformed into buffalo farms with the rise in value of buffalo. The farms were selected on an availability basis in that farmers (that had established buffalo breeding operations) who were prepared to answer the majority of the questions and/or provide data were interviewed. The summer and winter rainfall areas were covered as well as at least three different veld types (sweet, sour and mixed) and feeding regimes. Farms with different scale of operations ranging from an intensive 20 buffalo breeding operation to large scale extensive breeding of over 200 buffalo were questioned. Nine of the farms housed their buffalo herds in secluded camps without other species. The remaining two farms combined buffalo with mainly browsers and seeing as this had little effect on the grazing, the other game species were not taken into consideration. It should, however, be mentioned that if buffalo are bred or kept in the same camps as other game or livestock species that less grazing will be available for buffalo and the stocking rates of the camps should be calculated by an environmental analyst to ascertain whether the camps are stocked above their carrying capacity. Nonetheless, for this trial the effect of other game species in the camps of the buffalo were taken as insignificant.

Figure 6.1 Location of the 11 farms used for the case studies.

1. Management practices

Eight of the 11 farms were used for the managerial section of the case study (excluding those in the Western Cape and the Eastern Cape)

A standardised questionnaire (Addendum B) was compiled to acquire the general management practices implemented by each farmer. This questionnaire was completed by the researcher at a one-to-one personal interview. Additionally, at least two full days were spent on each farm to make a personal evaluation of the farm and add any management practices used that were not covered by the questionnaire. Each management practice was noted and qualitatively analysed as to highlight any tendencies that might arise within and between different farms. The management efficiency of each farm was then evaluated for use in a management plan.

2. Infrastructure implemented

All 11 farms were used for the infrastructure case study. The infrastructure of each of these farms was noted during a 2 day personal visit by the researcher. Reasons for and practicality of infrastructure implemented was evaluated using the principles of livestock farming infrastructure and adapting these to compensate for the buffalo demeanour. Detailed notes were made of each of the infrastructural components. The efficacy of each component was scrutinized on the basis of the farmer's experience/opinion and where possible by observing their actual use in practice. The infrastructural components could then be divided into farm specifications, restraining and containing infrastructure, feeding and watering infrastructure and parasite treatment infrastructure. Frequency of the different methods was noted and is discussed.

3. Reproduction

Six of the farms were used for the reproduction case study. The data used was obtained from records kept by the farmers themselves. Two farms were located in the Western Cape (winter rainfall area) and four in Limpopo and Mpumalanga (summer rainfall area). All six ensured a steady supply of nutrients throughout the year and supplied feed whenever a grazing shortage occurred. Thus, the buffalo never or seldom had a shortage of nutrients and were fed for optimum production. Reproduction for this trial was divided into reproduction parameters and seasonality of births.

3.1. Reproduction parameters

The birth date of the dams and all the birth dates of their calves were used to calculate the different reproduction parameters. The reproduction parameters calculated were: age at first calving and inter-calving period (ICP). These parameters were then used to set up scatter plots and graphs in Microsoft Office Excel 2010 using the stats function of Excel. Graphs depicting the correlation between age and ICP as well as between number of calvings and ICP were constructed. For the age/ICP correlation all six farms' data was used as the exact age of the cow could be calculated. Only three farms could supply definite dates of first time calvings and thus the number of calvings/ICP correlation could only be done using the data of three farms. Other than visual representation of the data, the graphs also supply a regression equation to calculate the effect of age and number of calving on ICP. The dates of calving of 219 cows were used from the six different farms.

3.2. Seasonality of births

Dates of births was recorded for all six farms and divided into summer rainfall areas and winter rainfall areas. This was done to ascertain whether there were other environmental factors, apart from feeding, that influenced season of birth or season of conception. Two farms were located in the winter rainfall area and four farms in the summer rainfall area. The farms had different quantities of breeding animals and accordingly a correction factor was used to compensate for the differences. The total number of births per year was transposed to 100 and the births per month were then expressed as a fraction thereof or in other words as a percentage of the total number of births. This corrected number of births was then used to compare the difference in breeding season between summer and winter rainfall areas using standard descriptive statistics by plotting the data on a bar graph. Due to a lack of degrees of freedom no further statistical analyses were done.

3.3. Herd growth

Population growth for intensively produced buffalo can be expressed as a percentage of the time needed for the current herd to double itself. For an intensive herd we have calculated population growth as a fraction of the breeding cows, seeing as the proportion of breeding cows to breeding bulls is very high. Thus the equation is as follows:

$$G = \frac{((C \div BC) \div t)}{4}$$

G is the population growth, C the number of calves born in time t, BC is the number of breeding cows used during time t. The divider 4 is used due to the age of sexual maturity of buffalo which is at approximately 4 years.

CHAPTER 7

Results

1. Management practices

The management of buffalo herds can be classified in the following categories as concluded from the questionnaires: herd structure, feeding and parasite control.

1.1. Herd structure

The mean size of the farms used in the questionnaire was 1697.3 ha, with an average of 156.3 buffalo per farm as indicated in Table 7.1. This represents an average stocking density of 10.9 ha per buffalo, or when considering the medians of each parameter, an average stocking density of 7.7 ha per buffalo. The ratio of males to females is approximately 1:2 when all adult bulls are taken into account (Table 7.1). The ratio of active or breeding bulls to breeding cows average around 1:27 as calculated from Table 7.2, with the other bulls either being sub-adults or placed/aggregated in bachelor herds outside of the breeding herd.

Table 7.1 Basic farm and buffalo herd information of eight buffalo farms interviewed

Farm number*	Size (ha)	Tot number of buffalo	Bulls	Cows	Juvenile	ha/buffalo
1	5500	290	95	118	77	19.0
2	1410	156	62	70	24	9.0
3	370	56	11	30	15	6.6
4	960	87	17	35	35	11.0
5	1658	150	20	57	73	11.1
6	890	260	43	139	78	3.4
7	710	163	46	88	29	4.4
8	2080	88	15	69	0	23.6
Total	13578	1250	309	606	331	
Mean	1697.3	156.3	38.6	75.8	41.4	11.0
Median	1185	153	31.5	69.5	32	10.0

*Due to the confidential nature of the information, the farms were not identified by their name but rather by a random number that is retained throughout this study.

Table 7.2 indicates that only three of the farms (1, 2 and 7) had a planned bull rotation system in place. Forced or artificial weaning of the calves took place at four of the eight farms (1, 3, 5 and 6) and the ages at weaning ranged from 6 to 18 months. Three of these farms only weaned bulls and allowed the heifers to stay in the herd. Herd dominance, as observed by the farmer, was more frequent between cows than bulls. Four farms (2, 3, 4 and 5) were only observing dominance displays by cows and three farms (1, 6 and 8) observed dominance by both bulls and cows. Farm 7 only noted dominance displays by the bulls. The three farms (1, 6 and 8) with both gender dominance utilised a 2-bull per herd breeding system, as opposed to farms 1, 3, 5 and 6 that only had one adult bull per breeding herd. The incidence of male dominance displays decreased as the number of breeding females increased. Evidently cows were responsible for the structure of the herd with the adult bulls enjoying top rank in all cases except for one farm that had an infertile female displaying secondary male characteristics. Selection/culling consisted of bulls being placed in a bull camp to be sold, during or after puberty, as either breeding material or for hunting purposes. Only at two of the eight farms (2 and 8) was there hunting camps and these were rarely used as such. Heifers and cows that were not kept in the herd for further breeding were sold to other breeding operations, preferably as a group due to the difficulty involved with introducing single female animals into a new herd. Only three of the eight farms (1, 4 and 5) were open to do fertility testing on bulls sold for breeding. The remaining five farms claimed fertility testing on bulls to have too high a risk factor and would rather include a disclaimer in the sale agreement that if the bull proved to be infertile they would refund the buyer for the purchase value of the bull. No data and no comment in Table 7.2 indicate data that is unavailable for this study.

To ensure correct recording of data, correct identification of each animal was required. Identification was not discussed with each farmer individually, but a short summation of the methods used is given here. All registered disease-free buffalo must have a microchip tag that is implanted below the skin at the base of the tail (on the top part of the pelvis) or the side of the neck. Although this is an adequate method of identification, the microchip can sometimes not be found by the scanner and thus complicates identification. Additionally most farmers use ear tags with only a large number on that can be read from a distance. These occasionally tear out or fall out, but using both microchips and ear tags reduces the chances of confusion. Some farmers are also able to identify each animal by facial characteristics. This method requires that much time should be spent with the buffalo to "get to know" them and also limits correct identification of each buffalo to one or two people on the farm. It is however plausible as buffalo show large morphological differences and individuality regarding visible physical characteristics.

1.2. Feeding

Supplementary feed was given on all eight farms. Supplementary feed for this trial (and for most buffalo breeding operations) refers to a protein and energy feed (production feed) that is produced by most feed companies in pellet form with 12-18% protein concentration. Mineral licks refer to basic mineral feeds that include the deficient minerals of the area as they might be needed by the buffalo and has a high salt concentration to inhibit excessive intake.

Table 7.4 indicates the stocking density in hectares per buffalo when considering only the breeding herds for nutritional purposes. Farm 4 was excluded as no data was available on individual paddock sizes and farm 8 was excluded due to the absence of data on the number of juveniles in the breeding herds. Considering the available grazing or carrying capacity of each farm, three of the six farms (3, 6 and 7) over-stocked the farms, especially during the drier months and thus required supplementary feeding throughout the year. Farm 6 utilised planted/irrigated pastures of Eragrostis varieties as well as Digit grass (*Digitaria eriantha*), which increased the carrying capacity of the paddocks considerably throughout the year. Farm 2 is situated in a sweet veld area, having a relatively high nutrient value for most part of the year, nonetheless, supplementary feed was included in the diet at a low inclusion level to ensure optimal levels of nutrients and a mineral lick supplied *ad lib*. Farm 5 was below the carrying capacity for buffalo, but other grazers such as wildebeest (*Connochaetes taurinus/gnou*) were present in the same paddocks as the buffalo. This increased the pressure on the grazing and thus feed is supplied throughout the year to ensure animals are in an optimal condition. Farm 1 was located in a sourveld region, but due to the large areas available the paddocks were stocked conservatively, although feed was supplied at low inclusion rates of 1kg of pellets per buffalo per day on sight of the buffalo.

Three of the eight farms (2, 3 and 6) had separate bull camps that received no additional feed apart from the available grazing and an *ad lib* mineral supplementation (Table 7.3). Mineral licks were supplied at seven of the farms (1, 2, 3, 5, 6, 7 and 8) throughout the year on an *ad lib* basis. The farm not supplying mineral licks (4) made use of high quality feeds that supplied all the needed minerals and nutrients not supplied by the grazing (Table 7.3). Six of the farms (2, 3, 5, 6, 7 and 8) utilised stationary feeding troughs, farm 1 fed on sight of buffalo (feed the buffalo when they see them) and farm 4 moved the feeding trough monthly as a parasite control measure.

Water supply in all the paddocks at all the questioned farms was sufficient by either natural or artificial watering points. These consisted of dams, troughs and waterholes. These were at times utilised as mud holes for wallowing by the buffalo in dry and warm periods.

Table 7.2 Herd management as applied and noted by the eight buffalo breeders questioned for management

Farm number	Cows/ Bull	Bull change	Weaning age	1st calf	ICP (months)[#]	Calving %*	Fertility test	Dominance in herd observed
1	25	2.5 - 3 yrs	6 months (mother sold)	3 - 4 yrs	12.5	99	On request	Bull/Cows
2	35	3 yrs	No data	No data	No data	99	No	Cows
3	30	None	11 months (Bulls)	No data	No data	No data	No	Cows
4	23	None	No data	No data	No data	97	Yes	Cows
5	35	None	12 months (Bulls)	No data	No data	99	Yes	Cows
6	25	None	18 months (Bulls)	3.5 yrs	12.1	No data	No comment	Bull/Cows
7	26	3 yrs	No data	No data	No data	75	No	Bull
8	20	No Comment	No Comment	No data	14	100	No	Bull/Cows

[#] ICP – inter calf period
* Number of cows calved that were mated per annum

Table 7.3 Nutrition management as applied on the eight buffalo farms questioned for management

Farm number	Supplementary feed	Year round feeding	Mineral Lick	Veld type
1	Yes	Yes	Yes	Sour + planted* (Smutsvinger)
2	Yes/No (Bull camp)	Yes	Yes	Sweet
3	Yes/No (Bull camp)	Yes	Yes	Mixed
4	Yes	Yes	No	Mixed
5	Yes	Yes	Yes	Mixed
6	Yes/No (Bull camp)	No	Yes	Planted (Eragrostis/Smutsvinger)
7	Yes	No	Yes	Sour
8	Yes	Yes	Yes	Sour

*Refers to cultivated pastures

Table 7.4 Breeding herd composition (excluding bull camps) of seven buffalo farms questioned for management

Farm number	Size (ha)	Tot number of buffalo	Bulls	Cows	Juvenile	ha / buffalo
1	4500	250	55	118	77	18.0
2	710	96	2	70	24	7.4
3	190	46	1	30	15	4.1
5	1508	134	4	57	73	11.3
6	780	225	8	139	78	3.5
7	710	163	46	88	29	4.4

1.3. Parasite and disease control

Most of the farms practise some form of disease and parasite control in their management strategy. Table 7.5 shows the products used for disease and parasite control by the farms questioned.

Table 7.5 Products used for parasite and disease control on six buffalo farms questioned for management

Treatment	Farm number				
	1	2	3	5	6
Deadline	Regular*	Regular			Regular
Amipor		Regular			Regular
Delete all					Regular
Endotape				As required**	
Ivomec	As required				
Panacur					Regular
Covexin 10	As required		Regular		Regular
RB51					Regular
Smithburn's					Regular
Pasturella			Regular		
Vit. B	As required				
Gielie's dip			Regular	Regular	

*Systematic application of the products, annually, bi-annually or even quarterly
**Treatment of animals when incidence of the parasite or disease is high or when visible signs of the negative effects of the parasites or diseases are noted

Three of the farms (2, 3 and 6) utilised regular application of the interventions following a traditional treatment plan as would be used for cattle. Two of the farms (1 and 5) applied the 'regular' treatment plan for ectoparasites and followed a 'when needed' approach for endoparasites. Farm 4 was a fairly new farm and strived to keep the management of the animals as natural as possible, so no treatment had been administered and would only be done when needed. Farm 7 and 8 had no data and no comment respectively as a response to treatment for parasite and disease control.

2. Infrastructure implemented

Table 7.6 indicates that the majority of the buffalo farms visited (8 out of 11) are located in either Savanna (farms 2, 4, 5, 7 and 8) or Grassland (farms 1, 3 and 6). Table 7.6 also indicates the uses of or reasons for having the farms. Three of the farms visited (farms 3, 6 and 10) were all strictly for breeding purposes to sell live buffalo and run as a business. Three of the farmers (farms 2, 4, and 8) bred the buffalo for the owners' own quality of life and preferred the lifestyle associated with game farming. These are the farms where the primary residence of the owner was situated on the farm. The farms utilised for lifestyle generally have a higher incidence of vehicles traveling on the farm and thus roads and houses need to form a part of the infrastructure planning process. More human-buffalo contact is also likely and should be borne in mind when planning handling facilities and fencing/gates to ensure safety as far as possible. Leisure was another reason provided for owning a buffalo farm (farms 1, 5 and 11) and differs from a lifestyle investment by being used more as a holiday destination/home than a permanent residence. The leisure farms do not differ much from lifestyle farms in terms of infrastructure if a permanent employee is placed in charge of the farm during the owner's absence. These farmers typically have other sources as their main income and kept the buffalo as a side-line income. Tourism as a source of income was utilised on three of the farms (7, 8 and 9). The final reason for keeping buffalo was for hunting on the farm, with two of the farms (7 and 11) utilising this as an alternative source of income.

Table 7.6 Biome, farm use and income status of 11 buffalo farms questioned for infrastructure

Farm number	Biome	Farm use	Main income
1	Grassland	Leisure, Breeding (buffalo, sable, roan, kudu)	No
2	Savanna	Lifestyle, Breeding (buffalo, sable, nyala, kudu, golden gnu)	Yes
3	Grassland	Breeding (buffalo, sable, colour variants*)	No
4	Savanna	Lifestyle, Breeding (buffalo)	Yes
5	Savanna	Leisure, Breeding (buffalo, sable, colour variants)	No
6	Grassland	Breeding (buffalo)	No
7	Savanna	Tourism, Hunting, Breeding (buffalo)	No
8	Savanna	Lifestyle, Tourism, Breeding (buffalo, roan, sable)	Yes
9	Fynbos	Livestock farming, Tourism, Breeding (buffalo)	Yes
10	Fynbos	Breeding (buffalo)	Yes
11	Nama Karoo	Leisure, Hunting, Breeding (buffalo)	No

*Species exhibiting coat colour that is not common to their species (golden gnu, black springbuck, etc.)

2.1. Containment and restraining

Table 7.7 indicates the fencing used by the farms questioned. Each province has its own minimum requirements for fencing of buffalo and the acceptability of these differ between areas and municipalities. In most cases buffalo are not seen as dangerous game, but rather as disease reservoirs and thus require special fencing. In all provinces a certificate of adequate enclosure (CAE) needs to be obtained to register as a buffalo farm and keep buffalo. A CAE is issued only on application and only after inspection of the property has confirmed that the game animals (buffalo) will not be able to escape from the property under normal circumstances. Seven of the farms (1, 2, 3, 4, 5, 7 and 8) had 2.4 m high fencing with 19 strands. All six of these farms are used for lifestyle/leisure/tourism activities apart from being buffalo farms and had general game such as kudu (*Tragelaphus strepsiceros*) on the farm that the owner wanted to contain as well. The minimum height requirement for fencing (CAE) in the Northern Cape, Limpopo, North-West, Mpumalanga and KwaZulu Natal provinces is 2.4 m which is where these farms are situated. Three of the farms (6, 9 and 10) had 1.8m high fencing. These are the minimum fence heights required by law for the Western Cape and Freestate provinces, which is the location of these farms. The minimum fence height requirement for owning buffalo in the Eastern Cape and Gauteng provinces is 1.4 m, which is where farm 11 (Eastern Cape) is located. All of the farms had electrified fencing to contain the buffalo, but this is only a requisite by law in the Northern Cape, Western Cape and Mpumalanga provinces. Electrified fencing is done in an offset manner where electric wires are set at 225-450 mm away from the fencing at 400, 600 and 1200 mm above ground with earth wires on the 400 and 1200 mm off set positions along with the electrified wires carrying 5000-12000 volts. Fencing is thus only to keep buffalo in, rather than keep predators out as when farmed with other smaller game animals and livestock.

The use of a boma can simplify handling of animals greatly. Table 7.7 indicates the different bomas of the farms visited. These can vary in structure from modified cattle yards to large, highly sophisticated structures. Eight of the 11 farms (1, 2, 3, 4, 5, 7, 10 and 11) had bomas with walls that were too high for the buffalo to see out of and the walls were constructed of thick conveyor belts reinforced by cables and poles (wood or steel). Farm 6 utilised an old cattle pen as boma and claimed it to be more than sufficient as the buffalo want to see their surroundings. Farm 9 utilised an old livestock ‘kraal’ that had high concrete walls. This seemed highly effective, but would prove more expensive than conveyor belt walls and not more effective. Farm 8 provided no info with regards to the boma and would not allow a site visit.

The gates used between camps were in most cases fairly standard 3 m wide swing gates that are manually operated (Farm 1, 6, 7, 8, 9, 10 and 11). All farms provided wide enough gates for trucks to enter except for farm 4, however, this farm utilised a passive capture technique and the gate to enter the farm and boma area was wide enough for a truck to enter. Farm 2 and 3 utilised motorised sliding gates, which proved less time consuming than the manual gates, but more expensive. Farm 5 had 4 m wide manually operated swing gates that consisted of 2 x 2 m swing gates on each side. This method provided easier access and space for larger trucks to turn.

Table 7.7 Fencing, boma and gates used on the 11 buffalo farms questioned for infrastructure

Farm number	Fencing	Boma	Gates
1	2.4 m, 19 strand, 3 wire electrified	2 m, conveyor belt wall, 100 m^2, 15 m clear ground around	3 m manual swing gates
2	2.4 m, 19 strand, 3 wire electrified with trip wire and mesh foundation	1.8 m, conveyor belt wall, 2000 m^2	3 m motorised sliding gates
3	2.4 m, 15 strand, 3 wire electrified, concrete foundation	3 m, conveyor belt wall, 400 m^2	3 m motorised sliding gates
4	2.4 m, 19 strand, 4 wire electrified inside fences	3 m, conveyor belt wall (passive capture)	2.5 m wire gates
5	2.4 m, 19 strand, 3 wire electrified, conveyor belt foundation	3 m, conveyor belt wall, 400 m^2	4 m manual swing gates
6	1.8 m, 15 strand, 3 wire electrified	1.8 m, pipe cattle enclosure, 600 m^2	3 m manual swing gates
7	2.4 m, 15 strand, 3 wire electrified	3 m, conveyor belt wall, 400 m^2	3 m manual swing gates
8	2.4 m, 15 strand, 3 wire electrified	No data	3 m manual swing gates
9	1.8 m, 15 strand, 3 wire electrified	2 m, concrete wall (cattle kraal), 600 m^2	3 m manual swing gates
10	1.8 m, 15 strand, 3 wire electrified	3 m high conveyor belt wall, 400 m^2	3 m manual swing gates
11	1.4 m, 5 strand, 3 wire electrified	3 m high conveyor belt wall, 400 m^2	3 m manual swing gates

2.2. Feeding and drinking

Table 7.8 indicates the veld types of the farms visited. Four of the farms (2, 9, 10 and 11) had sweetveld grazing, but only farm 2 utilised the advantages thereof. Farm 9 and 10 both had high numbers of buffalo on small areas and made use of planted pastures and supplementary feeds. Farm 11 is situated in an area with very low annual rainfall and low grazing capacity, so supplementary feed is supplied throughout the year. The remaining seven farms (1, 3, 4, 5, 6, 7 and 8) claimed to have sweetveld of varying degrees of 'sweetness'. None of the farms indicated that they had only sourveld.

All of the above farms supplied supplementary feed except farm 9, which only provided a mineral lick and utilised rotational grazing of irrigated, planted pastures (Perennial ryegrasses, kikuyu, barley and eragrostis). Inverted tyres (Plate 8.9) was the most popular feed bowl used, with seven of the farms (3, 4, 6, 7, 8, 10 and 11) making use thereof. Farm 5 used conveyor belt bowls that provided most of the advantages of the inverted tyres, but were elongated to facilitate the feeding of more than one buffalo per bowl (Plate 8.8). These were moved monthly to reduce parasite load and to reduce the trampling effect on the surrounding grazing. Farm 1 and 9 had no feeding bowls. As mentioned above, farm 9 did not supply their buffalo with supplementary feed and thus had no need for feed bowls. Farm 1 only fed low quantities of supplementary feed to the buffalo (1 kg pellets/buffalo/day) as the buffalo camps were 2 500 ha in size and thus, with the high availability of grazing little additional feed was needed. The feed was used to attract the buffalo to the vehicle for observational/inspection purposes and thus feed was given on sight of the buffalo and was fed on the ground.

Lick composition differed slightly for the different farms, but for most part consisted of a basic mineral lick. These were also supplied in inverted tyres on six of the farms (1, 6, 7, 8, 9 and 11) for mostly the same reasons as for the feed. Four of the farms used a designed lick trough called “oom Gielie’s” (OG) lick trough or dip trough (will be discussed under dipping infrastructure). Farm 6 used a combination of inverted tyres and OG lick bowls/troughs. In this case the tyres were left permanently and the OG lick trough only used during times of parasite treatment. Farms 4 and 10 had no lick bowls as the buffalo were supplied with a complete ration all year round, which supplied all the needed minerals and thus no additional lick was needed.

Seven of the farms (2, 5, 7, 8, 9, 10 and 11) utilised concrete water troughs or pits, either rectangular or round (Plate 8.10). Six of these were sunk into the ground and only one (farm 2) was raised above ground level like a concrete dam, which needed regular cleaning. Farm 6 utilised steel troughs, which could pose a problem with rusting (Plate 8.11). Farm 4 used hardened/treated plastic water troughs with ball valves which seemed to have an adequate durability. Farm 3 used inverted tyres with a sealed base as water troughs. In this case the farmer wanted to ensure that the animals were checked daily by the workers and forced them to do so by using water troughs that needed to be filled daily. Thus, using these water troughs increased the amount of labour needed. Farm 1 relied strictly on natural water sources to supply the daily water requirements of the buffalo and other game on the farm. The farm contained nine fountains that provided a constant supply of water to the farm. The management of the farm constructed catchment dams to ensure a constant supply of water to the animals.

Table 7.8 Feeding infrastructure applied on 11 buffalo farms questioned for infrastructure

Farm number	Veld type	Feed bowls	Water troughs	Lick bowls
1	Mixed sour	None	None, dams	Inverted tyres
2	Sweet	Trog tek (plastic feed bowls)	Circular Concrete dam (clean often)	OG lick trough
3	Mixed sour	Inverted tyres	Inverted tyres	OG lick trough
4	Mixed	Inverted tyres	Plastic with ball valves	None
5	Mixed sweet	Conveyor belt bowl (move monthly)	Circular Concrete pit	OG lick trough
6	Mixed	Inverted tyres	Rectangular steel troughs, ground water	Inverted tyres/OG lick trough
7	Mixed sweet	Inverted tyres	Rectangular Concrete pit	Inverted tyres
8	Mixed sweet	Inverted tyres	Rectangular Concrete pit	Inverted tyres
9	Sweet	None	Rectangular Concrete pit	Inverted tyres
10	Sweet	Inverted tyres	Rectangular Concrete pit	None
11	Sweet	Inverted tyres	Rectangular Concrete pit	Inverted tyres

2.3. Parasite treatment

Administration of the treatments is done in a variety of ways. For parasite (mostly ecto-parasites, but also sometimes endo-parasites) treatments “automised” drenching stations; special feeding troughs that apply the dose on contact with the animal; or including the dose in the feed or water are methods often used. Alternatively, using water guns or paintball guns to shoot the dip at the animals has been used. Another alternative is to place the drenching solution into an egg shell and lob this shell onto the buffalo’s back. Inoculants are administered with fall-out darts when animals are not immobilised or under sedation if more accuracy is required.

Ecto-parasite treatments can be administered in many different ways that can be equally effective (Table 7.9). Six of the farms (4, 7, 8, 9, 10 and 11) only administered treatment of parasites by hand. This meant physically administering the treatment to each animal individually by whichever method. These methods include filling an egg/paintball with the drenching fluid and launching it at the animal or diluting the dip in water and with the use of a fire fighter, spraying each animal. Farms 4 and 11 were relatively new to the buffalo breeding and had not reached the stage where dipping infrastructure seemed necessary. They also had relatively small herds (<30 animals), which meant not too much time was needed to individually treat each animal. Farm 4 also preferred to only treat buffalo when they were visibly affected by the parasites, therefore, treatment by hand was used for this. Farms 7, 9 and 10 had smaller open camps (50 ha) which allowed easy access to the buffalo and accordingly allowed treatment by hand as the animals were accustomed to having humans nearby (within 5 metres). Farm 8 had its own helicopter and the means to herd animals as needed and applied treatment from the air by means of a paintball gun. This proved somewhat expensive, but highly effective for extensive farms. Three of the farms (2, 3 and 5) used specialised lick troughs to administer dip. These lick troughs are known as “oom Gielie se lek bak” (OG). Farm 1 used the tick-off apparatus (Plate 8.15) for applying dip to the buffalo for tick control. Farm 6 used a combination of individual application by hand and OG lick trough. Hand/individual application was only used when some animals needed to be treated or when every animal only needed to be treated once. “Oom Gielie’s” lick trough was used when all the animals needed to be treated over a period and usually more than once.

Table 7.9 Ecto-parasite treatment infrastructure applies on 11 buffalo farms questioned for infrastructure

Farm number	Drenching facilities
1	Tick-off system
2	OG lick trough
3	OG lick trough
4	By hand
5	OG lick trough
6	By hand/OG lick trough
7	By hand
8	By hand
9	By hand
10	By hand
11	By hand

3. Reproduction

The data analysed from the six farms indicate an average inter-calving period of 443 days for intensively farmed buffalo. From Figure 7.1, the decrease in inter-calving period over age is shown as the power regression equation $y = 1000.3x^{-0.199}$ with a low R^2 value of 0.1118.

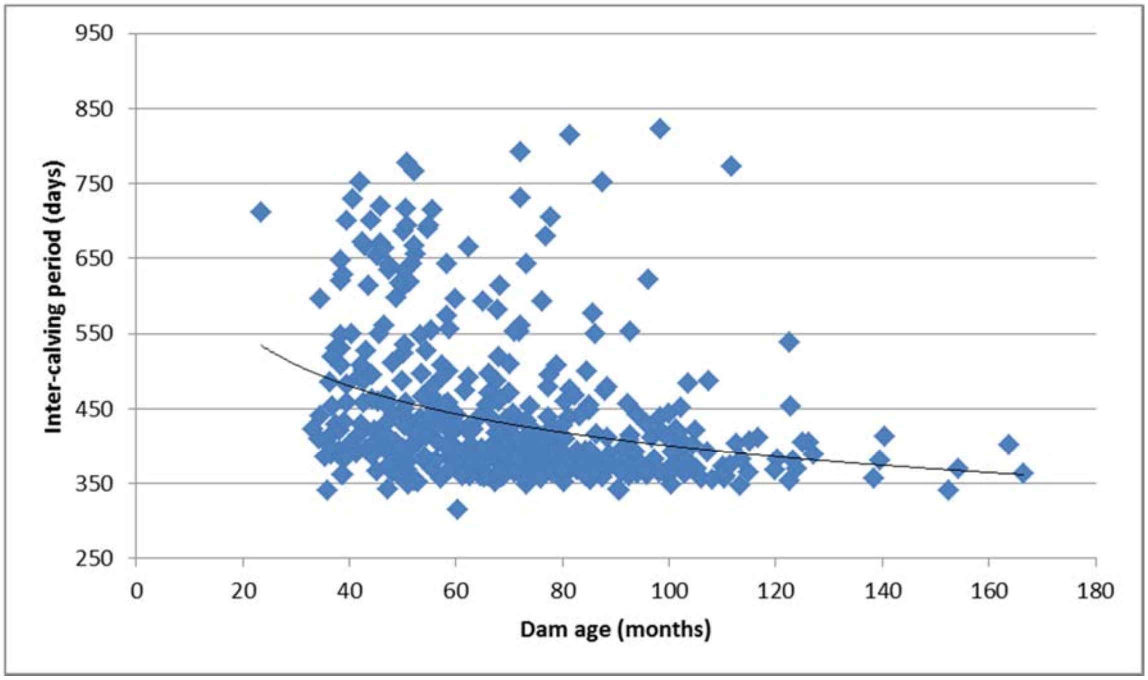

Figure 7.1 Inter-calving duration as a function of cow age of 437 cows.

In Figure 7.2, a decrease in inter-calving period is shown as the number of calves born per dam increases. Only three farms provided adequate data to establish the number of parities a cow (n=120) has had. A power regression equation $y = 548.29x^{-0.186}$ with a R^2 value of 0.1547 gave the best fit to the data.

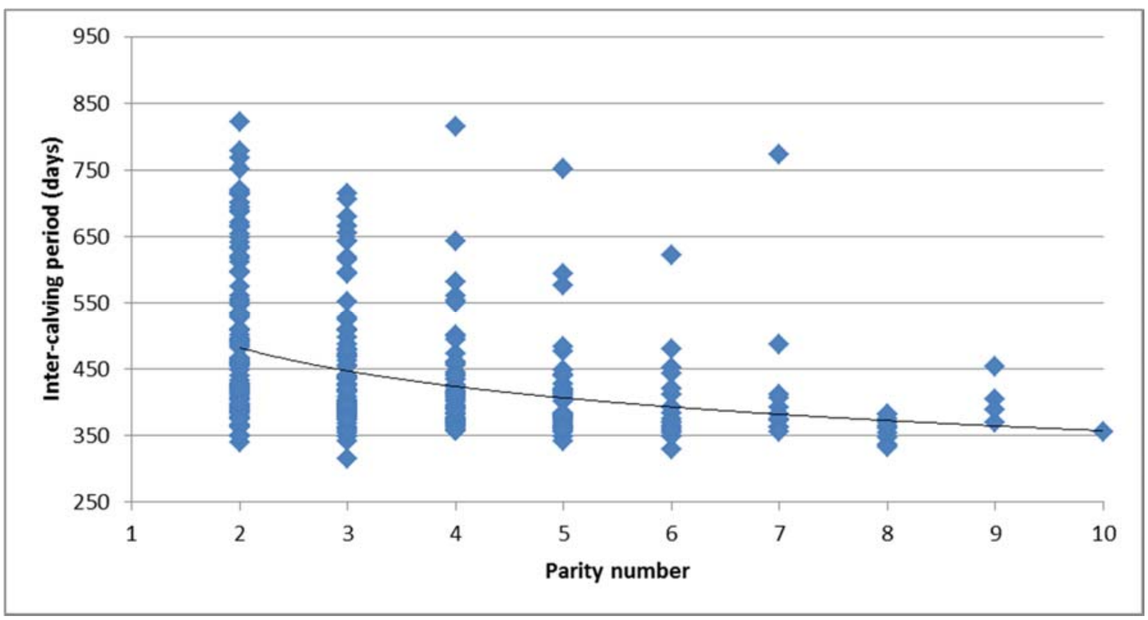

Figure 7.2 Inter-calving duration as a function of parturition number of 437 cows.

Figure 7.2 includes nine inter-calving periods from the three farms that provided adequate data, although only 1 of these farms supplied enough data for calculating the nine inter-calving periods. The average age at first calving calculated from the data of the three farms is 45.84 months or 3.82 years. Due to inadequate data points, only the first 5 parities periods were used for the average inter-calving calculations of the six buffalo farms questioned as depicted in Figure 7.3.

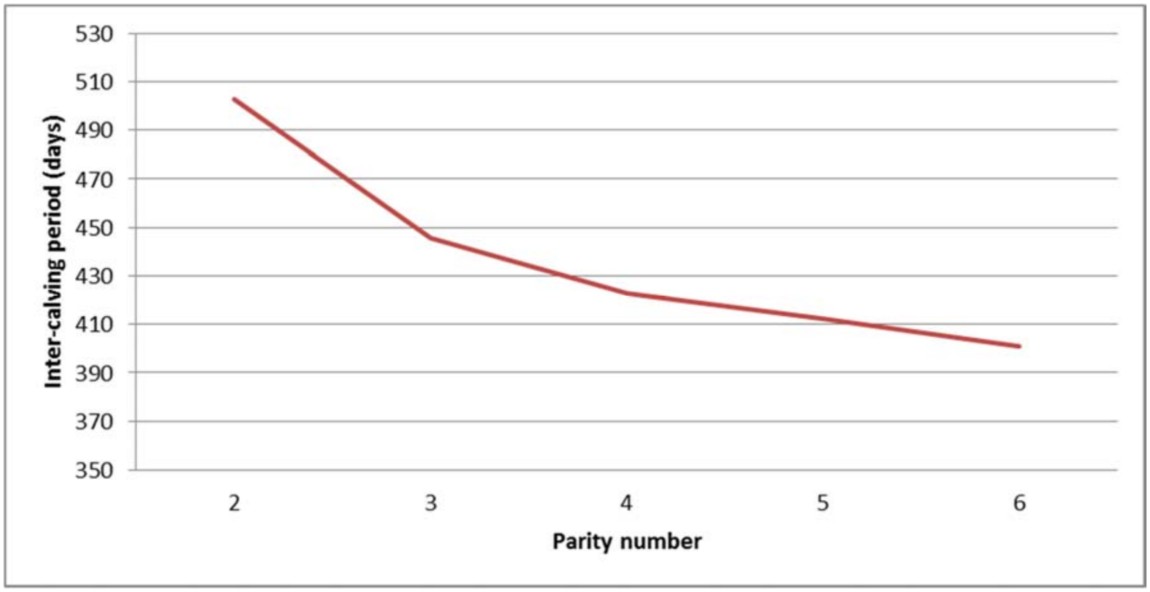

Figure 7.3 Average inter-calving duration as a function of number of parity of six buffalo farms.

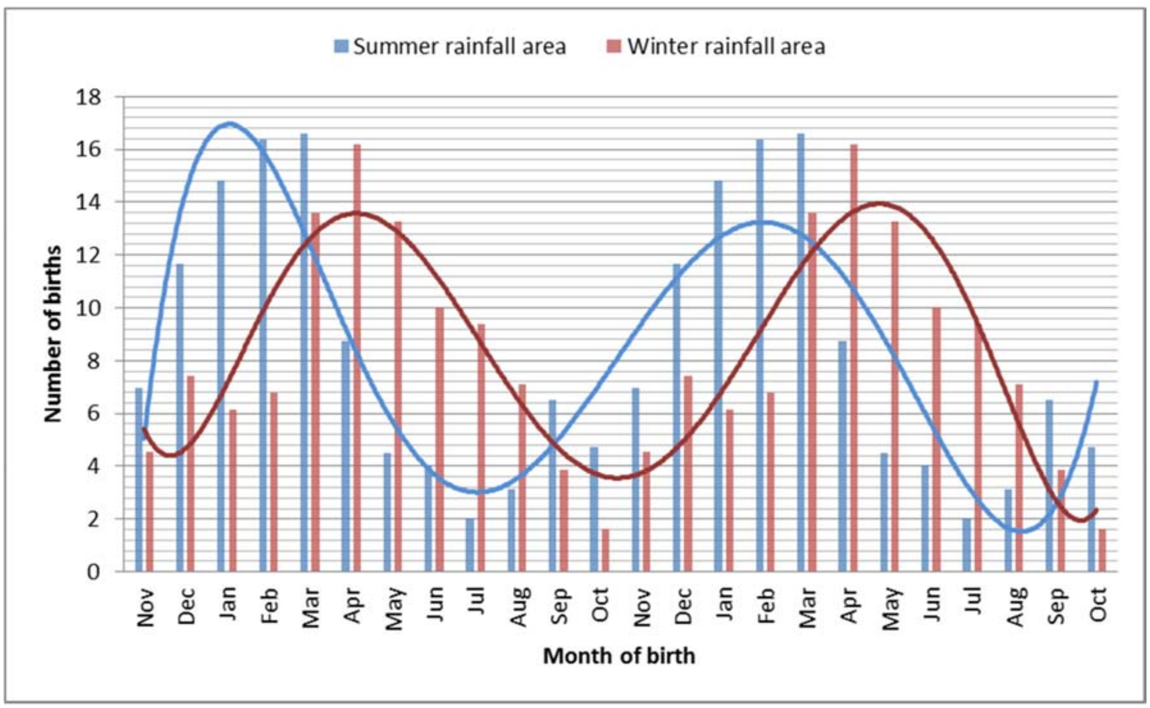

Figure 7.4 Seasonality of buffalo births of six farms in South Africa. Summer rainfall area vs winter rainfall area.

The effect of season in which the cows calved was evaluated on the data of all six farms as the birth dates of the calves were provided in all cases. Figure 7.4 indicates the percentage of births per month. As summer rains usually start in November, the graph was adapted to compensate for the year to run from summer rainy season to summer rainy season (most buffalo occur in summer rainfall areas) and was replicated for 2 consecutive years to see the pattern more clearly.

An observable difference is clear from Figure 7.4 for seasonality of births between summer and winter rainfall areas. Unfortunately, inadequate quantities of data were made available to ascertain whether the differences between the different rainfall areas are statistically significant.

CHAPTER 8

Discussion

The starting point when deciding on a management strategy for buffalo is to set a clear definition of the goals for keeping and breeding buffalo. These goals do not only include selection outcomes (horn size), but should also include reproduction parameters (age at first calving, calving percentage, weaning percentage, ICP, etc) seeing as the latter are accurate indicators of management efficiency. Buffalo management can be classified in three broad criteria when using production as the main goal namely, extensive, semi-extensive and intensive systems. Buffalo are large ruminants similar to cattle and thus many farmers apply cattle farming principles to buffalo farming. This is not completely incorrect, although it should be remembered that buffalo have adapted in the wild over centuries and have developed many different coping mechanisms to survive (Hoffman, 1989). Farming buffalo as cattle is a good starting point, but this method needs some alterations to be affectively applied to buffalo to utilise their superior survival capability for production purposes. If production is the main focus in a buffalo breeding operation, there are three factors to consider that will influence the efficiency of production, the herd, nutrition and parasites/diseases. A herd is effectively the production unit (factory) when considering buffalo breeding operations. Thus, ensuring the optimal herd dynamics will assist in achieving optimal production. The herd consists of herd members (components of the factory) that have to be managed as a whole and individually to ensure optimal production by each member. The management of the herd members are divided into optimising inputs for production (nutrition) and reducing the effect of the adversaries (diseases and parasites) on production.

Few farms in South Africa supply sufficient land for buffalo to roam free and wild, even less so in their ‘natural’ or preferred habitat (Savanna) and with the current value of land, the possibility of this occurring becomes even less likely (Sinclair, 1977; Mloszewski, 1983; Prins, 1996; Winterbach, 1998). Additionally, the risk of diseases associated with buffalo further restricts the land available to buffalo (Laubscher & Hoffman, 2012). None the less, buffalo are being successfully bred throughout South Africa in a wide variety of biomes, under different circumstances (Winterbach, 1998). To accommodate for these unfamiliar and varying habitats, infrastructure has to be built that minimizes both stress and danger for humans and buffalo and maximizes efficiency of production by assisting in the implementation of the management practices applied.

1. Farm, fencing and bomas

Even though African Savanna buffalo are associated with wild Savanna they have been known to survive in a variety of biomes. These biomes include everything from thicket to fynbos and even karoo (De Graaff *et* al., 1973; Venter & Watson, 2008). In many of these circumstances, large portions of land are needed to supply the nutrient requirement of the buffalo, or alternatively where smaller portions of land are available and less natural grazing, the buffalo are supplemented with complete feeds. Consequently, the available grazing and biome combined with the size of land available for the buffalo farming will be the dominant factor determining what the management technique should be and how the infrastructure should be set up or altered.

As in the case of farms used only for buffalo breeding (farms 3, 6 and 10), only the most basic infrastructure is required. Typically, the minimum requirements of fencing and containment of the animals will be sufficient (as mentioned in the previous chapter). The main aim will be to maximise production with as little expenses as possible used for aesthetics. A boma is not required by law, but will assist during times of loading, treatment and testing and thus, it is advisable to build a boma on all buffalo farms. Nonetheless, treatment and handling of individual animals will take place while the animal is under sedation under the supervision of a veterinarian and can then be performed outside of a boma. Keeping livestock as an alternative income warrants the additional spatial separation between the buffalo and livestock but again, only the basic infrastructure is needed in this regard. Tourism farm infrastructure requires not only the accommodation needed for the tourists, but requires well maintained roads and easy access gates, safe areas where tourists can move about without being threatened by buffalo and good aesthetics to ensure a pleasant natural/ecological experience for the tourists. Hunting farms combine the entire needed infrastructure of tourism farms with the added danger associated with hunting/guns. Furthermore, a facility to process the meat of the hunted animals will be advantageous for the farm. Setting up of such an abattoir can be done according to the Meat Safety Act which is currently under revision and if approved will enable game farmers to commercially register and sell their game meat.

After deciding on the use of the farm and the complexity of the infrastructure needed, paddocks/camps need to be set out by considering the topography, handling facility (boma) location and vegetation. If possible, an ecological evaluation of the property will assist in identifying areas of high feed production or areas likely to be overgrazed. Minimum requirements for fencing-in of buffalo range from a 1.4 m high fence without electrification as in the case of the Eastern Cape (certificate of adequate enclosure & dangerous game fencing specifications for Nature and Environmental Conservation Ordinance (No 19 of

1974)) to a double fence that is 2.4 m high and a 5 m corridor between fences with a minimum of two electrified offset wires with a minimum potential difference of 5000 V across these wires (Disease risk management directive for buffalo (*Syncerus caffer*) in South Africa). Last mentioned is in a foot-and-mouth and corridor disease control area and thus has much stricter guidelines than other areas. As mentioned the requirements differ between areas and also for the game located on the farm and thus local authorities should be contacted regarding the requirements before fencing commences. The only natural predator of buffalo is a pride of lions and in South Africa they are either present on a game farm or not. Thus, when deciding on which fencing to erect, the minimum requirements as stated by law are usually adequate except in the case of the Eastern Cape and Gauteng as 1.4 m is not an adequate barrier to discourage buffalo from breaking out. Nonetheless, buffalo have been known to escape from 2.4 m, high voltage electric fencing when given enough reason/motivation. These fencing requirements only represent the external boundaries of the farm meant to contain the buffalo, but the internal camp structure is left to the farmer's discretion. It is advisable to contact a professional consultant in this regard such as an agricultural engineer or wildlife consultant, to ensure that the fencing infrastructure is done correctly from the start.

Apart from capture, loading (translocation) and quarantine, the uses of a boma also include animal release, habituation, supplementary feeding and treatment and parasite control of individual animals (Plate 8.1 and 8.2) (la Grange, 2006). Boma placement and construction requires careful thought to ensure that the correct site is utilised. Building a boma can be expensive and the structures should thus be placed to optimally serve the largest portion of the farm.

Wild animals tend to flee from the transportation crate when released. If given too much space this could lead to increased stress levels, dehydration and even escape from the property in the case of smaller farms; activities that could all result in physical injury to the animals. Bomas (that are correctly constructed) contain the animals, restrict their movement and keep them in close vicinity to water and feed, thus reducing the risk of loss associated with translocation of game. A boma provides a mini habitat, which can be manipulated easily by the owner or manager. This allows the animals to habituate to the unfamiliar smells and sounds of their new surroundings and to learn that these are not threatening. When the habituated animals are then released they are much calmer than when off-loaded and explore the new territory with much less stress (la Grange, 2006).

Supplementary feeding is needed in drought times for game, but if unaccustomed to taking feed in pellet form animals will starve even though supplementary feed is available (Ebedes *et al*., 2010). Bomas are used to 'train' animals to take supplementary feed in unfamiliar forms by supplying the feed in combination with familiar feed sources (such as grass) in the boma. These animals are then accustomed to utilising available supplementary feed and will do so even if not placed in the boma. Additionally feeding in the boma can assist when using passive capture techniques by habituating animals to entering the boma daily (la Grange, 2006; Ebedes *et al*., 2010).

Treating injured animals and allowing a rehabilitation period for animals to regain strength is also necessary in some circumstances. A boma provides the means to do daily observations and treatments of animals if needed. Additionally, treating animals for parasites is simplified in a boma as there are many animals in a small area which decreases the time needed to carry out the needed treatment. Other than these uses, bomas are also useful in situations where daily measurements or observations need to be taken for whichever reason (la Grange, 2006). The structure of the boma will depend on the uses as well as the finances and area available.

For buffalo the boma can be re-classed as either a buffalo camp or buffalo holding pens (Raath, 1996). A buffalo camp acts as a release boma to regroup and calm buffalo that are translocated. Raath (1996) suggest a size of 1 ha (100 x 100 m) but this will depend on the number of animals housed in the camp. Supplying 100 m^2 per animal in a buffalo camp boma should be adequate. The fences should be 1.8 m high and constructed using bonnox type fencing (Plate 8.3 and 8.4) and thick poles concreted in at 10 m intervals with droppers every meter. The inside of the boma should be electrified with 3 off-set wires that deliver 9000 volts. Additionally the fence can be covered with game capture plastic which can gradually be lowered to expose the buffalo to their new environment. Enough shading (artificial or natural) for the whole herd should also be supplied with clean drinking water always being available and supplementary feed provided if the camp contains inadequate grazing (Raath, 1996).

Buffalo holding pens are quarantine or treatment bomas for buffalo (Plate 8.5, 8.6 and 8.7). Treatment bomas (10 x 20 m) are much smaller than buffalo camps and have solid or semi-solid walls with solid sliding gates in the corners to facilitate easy movement of buffalo between pens for cleaning or separation. It is also advisable to ensure that the gates are large enough for a vehicle to enter and turn inside the pen. Raath (1996) suggest that a third of the pen be covered to provide shading. The water point should also be against a fence with a small section on the outside of the pen to ensure easy cleaning and filling of the water crib. Raising the crib off the ground will decrease contamination of the water (Raath, 1996). These buffalo will be 100% dependant on feed supplied to them as they are in a feedlot scenario. Adequate feed racks with full feeds should be supplied. These feed racks should also be accessible from outside to facilitate ease of filling and also to minimise stress. It is advised not to place more than 15 buffalo together in a pen of this size (Raath, 1996).

The height differences seen in the walls of the bomas between farms can be ascribed to the handling of other game species in the same facility which have the ability to jump higher than 2 meters. A 1.8m high solid wall is adequate to contain buffalo (Raath, 1996).

Plate 8.1 Mobile capture boma used for mass capture of wild animals.

Plate 8.2 Loading ramp for buffalo into/out of boma.

Plate 8.3 Bonnox fencing used for buffalo camps.

Plate 8.4 Buffalo camp fencing with three electric wires.

Plate 8.5 Buffalo in holding pen.

Plate 8.6 Buffalo being darted for testing in holding pen.

Plate 8.7 Buffalo holding pens (boma) with elevated walkway to allow outside view.

2. Herd management

Herd dynamics are primarily influenced by the composition of the herd and the hierarchy within the herd. Herds are composed of adult males and females that make up the active production unit of the herd, sub-adults that are becoming the production unit and juveniles that are the future of the production unit. The optimal ratio of adult males to adult females will influence the reproductive efficiency and the profitability of the farm. Excess bulls that are not being used for breeding purposes can be sold as either breeding stock or for hunting purposes, which will supply a much needed cash flow at the start of a breeding operation.

Wild herds consist of 10 – 15% adult males and 55% adult females (Sinclair, 1977; Prins, 1996). This gives a breeding male to breeding female ratio of 1:5, but when compared to the 1:20 – 1:35 ratio of captive or intensively farmed buffalo (Table 7.2) it would seem that bulls are overexerted in the latter case. The difference between captive and wild buffalo breeding that could elucidate this increased ratio of males to females is three-fold. Firstly, not all the adult males in a wild herd are necessarily active breeders and attain a submissive role without breeding rights (Sinclair, 1977; Mloszewski, 1983). Secondly, the nutrition of wild herds is seldom optimal throughout the year and thus their performance is sub-optimal, whereas most captive herds receive supplementary feed to optimise production (Table 7.3)(Bartels *et al*., 1996; Prins, 1996). Lastly, wild buffalo have a specific breeding season that coincides with the rainy season to maximise survival of off-spring whereas captive buffalo conform more to year-round breeding as they are supplied with adequate nutrients year-round (Bertschinger, 1996; Skinner *et al.*, 2006). The maintenance of body condition as well as a high successful covering rate by the bulls in captive systems supports the theory that bulls are restricted by nutrition and can cover up to 35 females provided the mating season is year-round and optimal nutritional requirements are met (Sinclair, 1977). Thus, it can be concluded that the ideal/optimal ratio of breeding bulls to breeding cows is 1:30.

Dominance among bulls might also affect the reproductive capability of the desired breeding bull. Even though adult bulls attain the top rank in a herd, there is a hierarchy among bulls that needs to be established and maintained (Sinclair, 1977; Mloszewski, 1983; Bertschinger, 1996). This maintenance of the hierarchy requires additional energy if the bulls are evenly matched in their dominance and dominance displays (Table 7.2, farm 1, 6, 7 and 8) escalate to fights that could also cause injury to both bulls. Thus, the absence of other bulls that compete for mating rights contributes to the mating capability of the bull seeing as less energy is needed for hierarchy maintenance and thus more energy is available for mating activity. Additionally, if a high value bull is used for its genetics a loss might occur when an inferior bull successfully covers some of the females and calves with inferior genes are born. This also complicates predicting parentage of the calves if not using DNA parentage verification.

Dominance displays among cows seemed more prevalent from the results of the questionnaire (Table 7.2) with seven farms noting female dominance displays compared to only four farms noting male dominance displays. The three of the four farms (6, 7 and 8) that noted dominance displays by bulls utilised a 2-bull breeding herd, where an inferior adult bull was placed with a superior adult bull to keep the latter motivated. Farm 1 attempted to simulate a 'natural' environment and had >10 adult bulls with the main breeding herd in a 2500ha paddock and thus bachelor herds formed where a hierarchy needed to be maintained. Farm 7 noted only male dominance which might be ascribed to newly appointed management that just had not observed the buffalo sufficiently. The remaining four farms (2, 3, 4 and 5) had only 1-bull breeding herds and thus the breeding bull did not need to compete with any other adult bulls. Thus it would seem that dominance displays among bulls are almost always observed where more than one adult bull is located in a herd, as is the case with wild buffalo. The rationale of the hierarchy among females is primarily ascribed to access to feed, whether grazing or supplementary feed which is similar to results observed in wild buffalo herds (Beilharz & Zeeb, 1982; Prins, 1996). Similar to wild herds, the hierarchy of the herd seems to be predicted by the cows. This could be due to the high turn-over of bulls compared to cows, where cows are in the herd for most, if not all, of their lives and males rotate every three to four years (Sinclair, 1977; Mloszewski, 1983; Prins, 1996). The breeding herd is also mainly made up of females, which could add to the fact that the hierarchy of the cows determines the hierarchy of the herd. According to Prins (1996), females have a strict hierarchy and the rank held by a cow is transferred to her calves, even when the heifers reach adulthood, and seldom changes except in extreme cases of new cows being introduced or older cows being removed. This structure complicates the introduction of new females into an established herd, especially when a single female is introduced. Buffalo are herd animals and thus newly introduced buffalo (especially females) have increased levels of stress when rejected by a herd. This stress is not only due to the physical aspect of rejection, harassment and the denial of supplementary feed, but also due to the negative effects of being isolated making her more susceptible to predation and other environmental conditions. Considering most breeding operations are fenced off in paddocks, there is usually little space for the new female to flee from the harassment of the herd and thus exhaustion adds to the physical stress of the newly introduced cow.

The best way of introducing new female animals into a herd, especially heifers is by introducing them as a group (>2 animals). Single heifers that originate from different farms will congregate in a group when placed together in a boma for a week on the new farm seeing as they have a strong herd tendency. This also provides time to retest all the new buffalo for diseases whilst kept in quarantine. This group can then be introduced into the same camp as an established breeding herd with success, because the group dynamic formed in the boma will lower the stress mentioned above. Introducing a single female into an established herd is not the preferred method, but has been done with success. These females need to be monitored closely for acute signs of stress and fatigue and also physical injuries that could be detrimental. If a smaller camp system is being used, especially to implement rotational grazing, this can assist in introduction of a single female into the herd with minimal stress. Placing the new female in the camp ahead of the herd allows the herd to get used to the smell of a new herd member without being able to harass her physically. This can be done for about 2-4 weeks and then the herd can be allowed to enter the camp where the lone female is grazing. Having the herd move towards the female instead of the lone female approaching the herd seems to be more successful for integration. If this method can be combined with starving the herd for a day, they will focus more on feeding than expelling the new female, which will again lower the stress and assist in the integration of the new female into the herd. However, this method is based on personal observation and experience of farmers who have implemented the technique, but has not been proven to work in all cases. It also requires intensive management and time which could make it impractical for some operations.

In these managed paddock systems rotation of the breeding bulls is important as the risk of uncontrolled inbreeding is very high when a single breeding bull is kept in a herd for more than three years. In a wild herd (natural system) bulls are regularly replaced and have a short turn-around time of three years on average as a dominant breeding male (Sinclair, 1977; Prins, 1996). Bulls only attain breeding rights at eight years of age and lose it again by 11-12 years of age, during which time the only female animals that could pose a threat to inbreeding would be his dam or a full-sister (Mloszewski, 1983). Mating with either of these is highly unlikely as his dam should be too old by this time and full-sisters that are of breeding age will be few; it is estimated that the chances of mating between siblings is 25% at most (Krüger, 1996). Also, with a three year mating period and the fact that females only reach sexual maturity at 2.5-3 years, it is highly unlikely that the sire will mate with his own offspring (Sinclair, 1977). From Table 7.2 it is clear that bull rotation is not a priority at most buffalo breeding farms with only three of the eight farms (1, 2 and 7) having a bull rotation plan in place. The reason supplied for not rotating bulls at the other 5 farms was two-fold; quality is hard to find, and the escalating price associated with high quality bulls. Alternatively, the producer may choose to move the heifers (daughters of the bull) from the herd before they reach sexual maturity and either sell or move them into another herd. This has other complications, such as the difficulty of integrating a heifer into a herd (which is much more complicated than integrating a new bull) and also the possible effect this might have on the hierarchy of the herds and the cows themselves, causing high levels of stress. Removal of the dominant bull should only take place when a replacement bull can be put with the herd shortly afterwards. This is to ensure a minimum disturbance to the hierarchy of the herd and minimal loss of reproduction as cows might come into heat during the time that the bulls are absent.

Artificial weaning of calves took place at four of the eight farms (1, 3, 5 and 6). Farm 6 only weaned the calves (age >6 months) if the dam had been sold without the calf, otherwise the calf was left with the dam and the bulls moved to a bull camp at 24 months of age. Farms 3, 5 and 6 weaned bull calves only at the ages of 11, 12 and 18 months respectively, with the heifers remaining in the herd. Weaning takes place by sedating (done by veterinarian) the calf and then extracting it from the herd. In an intensive system, there is a risk that the dominant bull will injure younger and smaller bulls during displays of dominance. In the wild, these younger bulls would join a bachelor herd, but as there are no bachelor herds in the smaller intensive systems and there is little space for the younger bulls to escape, the risk of injury is high. Weaning between the ages of 12 - 18 months seems optimal in buffalo as bulls reach puberty by the age of 24 - 36 months and thus should be removed from the herd by this time; 24 months of age is also the time when young bulls in the wild would start forming bachelor herds outside of the main breeding herd (Sinclair, 1977; Mloszewski, 1983). Eleven months weaning might hold a risk of unnecessary stress for the cow that would be in late gestation (final trimester) if optimally producing, as the calf needs to be sedated for weaning and then moved with a vehicle to another paddock. The weaning age of 12 – 18 months is optimal seeing as the dam would have a new calf by then and will give less attention to the older calf being weaned. Additionally, weaning at 12 months will eliminate competition between the new-born calf and the previous year's calf for milk and ensure optimal nutrition of the new calf. No lactation anoestrus is seen in buffalo as cows reconceive within one month after birth, which eliminates this motive for early weaning (<6 months).

Three of the eight farms (1, 4 and 5) did fertility testing on the bulls that were sold. The remaining farms argued that fertility testing had a high risk of injury for the bull as the bull needed to be sedated and then electro-ejaculated. Three methods of semen collection for cattle exist and could potentially be used in buffalo. The method currently used in buffalo is electro ejaculation (as discussed below) seeing as the bull is sedated during the process and is only done by a veterinarian. The three methods are the artificial vagina method (AV), electro-ejaculation and lastly massaging the ampulae of the ductus diference through the rectal wall. The AV method is the most unlikely method for buffalo as it requires cooperation by the bull whilst fully awake, a very tame animal in other words. The AV method uses an apparatus that simulates the vagina of a cow. A dummy cow is then used to stimulate the bull to jump and the penis is then diverted by a handler into the AV. The AV method is undoubtedly the most dangerous method with regards to the handler and impractical for buffalo. Electro-ejaculation is more practical for buffalo as the semen collection can be done while the bull is under sedation. An electric probe is inserted into the rectum of the bull which stimulates the reproductive nerves. Stimulation is brought about by rhythmically yet gradually increasing the voltage transmitted by the probe, either manually or automatically. This method requires not only training, patience and experience, but a fair amount of skill to adjust rhythms and voltage levels to compensate for individuality of bulls and their response to the stimulus. The advantages of using this method include the fact that semen can be collected from sedated bulls and bulls that are unable to mount a cow or dummy. Additionally, there is a low risk of contamination as the processes can be controlled and no dummy is used. Alternatively the disadvantages of this method include the fact that it requires a large amount of skill, the semen is often contaminated with urine, males might resist which will inhibit collection and lastly the sciatic nerves are temporarily affected, but this can be restricted if the method is performed properly. The massage method is said to be the simplest way of semen collection, but is not commonly used in cattle and/or buffalo. Ejaculation is stimulated by massaging the seminal vesicles and ampulae. This method also requires a large amount of skill and experience. Apart from fertility testing, sperm from a high value bull can be stored and kept for up to 15 years before using it to fertilise a cow. Sperm storage is done by utilising extenders (Triladyl, AndorMed) and then freezing in liquid nitrogen (Herold *et al*., 2006).

Determining the exact age of buffalo is needed for efficient herd management, but it remains a challenge if the exact birth date is unknown. For the purposes of the study none of these ageing methods were used seeing as the farmers could all supply the birth date of the calves born on the farm with an accuracy of a month. Many extensive buffalo farmers and nature reserves/parks do, however, use tooth wear as an aging method and it has been proven effective. Nonetheless, there are individual differences and thus accuracy differs between ages, 1-5 years of age can be predicted with an accuracy of 6 months, 5-15 years with an accuracy of 1 years and 15-20 years with an accuracy of 2 years (Grimsdell, 1973). Teeth wear is accurately measured by counting cement deposition lines in teeth as well as measuring crown height for adult buffalo and tooth eruption for sub-adult buffalo (Taylor, 1988). It appears that tooth wear within a species is relatively constant and probably more influenced by diet than individual differences (Spinage & Brown, 1988). Additionally, tooth wear is effective as a method of predicting the grazing ability of a buffalo, but as for predicting exact age more research is needed when the birth date of the buffalo is not known.

The culmination then of herd management comes down to the selection, culling and breeding of buffalo seeing as large amounts of money are being paid for good breeding animals. Breeding/reproduction will be discussed in detail in later in this chapter. Selection and culling are two different actions with the same outcome, as culling is the result of selection. Selection is a multi-facetted matter that should start with the initial setting of short term and long term goals. Selecting for the biggest horns might be an end goal, but this selection could have a negative effect if pursued without taking the necessary risks into consideration and trying to do it in a too short a time. Additionally, focussing on a singular attribute will have a negative effect on other traits that might for example reduce the fertility or hardiness of the animal. Thus, careful planning after the needed research was done and efficiently recording performance of each individual and correctly applying these records are key to effective herd management and also breeding success. Selection for multiple traits is also possible, even though this requires more time and effort, but in the end is worthwhile.

Little research exists for buffalo specifically, but the basic principles of breeding and selection apply to most species and seeing as buffalo breeding is similar to cattle breeding, much of the research done on cattle can be extrapolated for buffalo. Inbreeding is a highly controversial topic in the game industry at the moment. Inbreeding is the breeding of closely related individuals to speed up the process of selection. For buffalo this has been seemingly successful up to now, especially when breeding for horn length (spread). The negative side of this is that inbreeding has a detrimental effect on fertility and hardiness seeing as homozygotes is being bred. Thus, for the short term inbreeding might prove highly effective, but in the long run could cause a break-down in the fertility of buffalo as a species to the point where animals are infertile or have difficulty calving without assistance from humans. Additionally, selecting for horn length (spread) only is speculated to have a negative effect on the manliness of the bulls. Even though this has by no means been proven for buffalo a theory is postulated that exceptional horn length without sufficient horn volume or boss thickness is due to an absence of or lowered testosterone production. Alternatively, the theory states that horn volume/boss size is positively correlated with testosterone production and effectively manliness of the bulls. The rationale for this theory is due to an extrapolation from a study done on red deer stags (Suttie *et al*., 1984). From the last mentioned study it was found that the base of the antlers (pedicles) showed a positive correlation with testosterone production which supports the theory regarding the boss of a buffalo bul. The majority of the growth of the antlers took place prior to the mating season when plasma testosterone was low, but during the mating season antler growth seized and plasma testosterone levels were high. Furthermore, the high levels of testosterone during the mating season were positively correlated with the hardening of the antlers when the antlers became clean of velvet. This then supports another theory that the when buffalo bulls become dominant (actively mating) their testosterone levels increase and the boss hardens and horn growth seizes. These theories are also supported by studies on Spanish ibex (*Capra pyrenaica hispanica*) and European mouflon (*Ovis orientalis musimon*) (Toledano-Díaz *et al*., 2007). However, a study on Iberian ibex (*Capra pyrenaica*) found that the increase in testosterone in polygynous wild bovids did not inhibit horn growth during the mating season (Santiago-Moreno *et al*., 2012). From these theories comes the warning that bulls should not be used for breeding or placed with cows from an early age (<6 years) as it could have a negative effect on horn growth and phenotypic expression of the genetic potential of the bull. It is thus clear that much research is still needed regarding this topic. Whether these theories are true or not, it is of utmost importance that any animals that display lowered fertility and production should be culled.

3. Feeding and drinking

Sweetveld, sourveld and mixed veld are the three broad classifications that grazing in South Africa is divided into (Smith, 2006). These veld types can be composed of a variety of grass species with varying nutritious quality. The main differences between these veld types are as follows: sweetveld remains palatable and nutritious throughout the year (even when mature), sourveld loses its nutritious value when it reaches maturity in the dry season and mixed veld is the intermediate between sweet- and sourveld (Smith, 2006). Sourveld can tolerate moderate levels of overgrazing whereas sweetveld is more sensitive to overgrazing, but has a shorter recovery time after overgrazing than sourveld. Sourveld generally has a higher fodder production annually than sweetveld and thus also a higher carrying capacity (Tainton, 1999; Smith, 2006). Nonetheless, sourveld often requires supplementary feed (protein) during the dry season to ensure constant productive success of buffalo. Different methods of supplying the needed supplementary feed, mineral additions and water to buffalo have been shown to be effective.

3.1. Infrastructure

The majority of the questioned farms used inverted tyres as the feed bowl of choice. Inverted tyre feeding bowls have a solid structure, present little risk of injury to the animal, are large enough to hold all the feed of each buffalo and are light enough to move if needed. They are, however, heavy enough to stay put when the buffalo are feeding and not easily capsized. The rubber of the tyres cannot rust and the tyres are very durable. The inversion ensures a smooth surface on the inner of the feeding bowl without hard edges that could harm or injure the buffalo. Another feeding method used that didn’t require any feed bowls was feeding of buffalo on sight where the farmer would drove around until he found the buffalo and then emptied a 50 kg bag of pellets on the ground in a line. So doing the buffalo were attracted to the vehicles and could be inspected daily. The negative effect hereof is that buffalo form an association with humans as a source of food and thus might lose their fear and become dangerous if not managed properly. Additionally, the silica (sand) that is ingested along with the pelleted feed increases the tooth wear during mastication, seeing as silica is a very hard and damaging substance, and thus decreases the productive lifetime of the buffalo. Other feed bowls used were plastic bowls and conveyor belt troughs. The plastic bowls were effective for feeding, but weren't durable enough and broke after being trampled or nudged by the buffalo. The conveyor belt trough was effective in cases where competition for feed was low. It also proved difficult to move alone and required two or more persons and thus was concluded to be less effective than inverted tyres.

Buffalo require about 30 litres of water daily, depending on the environmental conditions (Sinclair, 1977; Prins 1996, Du Toit, 2010). Water is of utmost importance to all wildlife and especially buffalo. A shortage of water can have the same if not more devastating effect as a shortage of feed, but in a much shorter time span. Additionally, water that is not of acceptable quality, whether toxic or unpleasant to ingest, can be detrimental to the health of buffalo (Du Toit, 2010). Thus the construction and management of water points is just as, if not more, important than feed management. Concrete dams are the most expensive at the beginning, but is also the most durable and thus pays for itself over time. Buffalo have the tendency to wallow and often climb into the water trough to cool off, thus the water trough must be able to handle the weight of a buffalo. Alternatively steel water troughs are also durable, but present a problem over time with regards to rusting. Nonetheless, farm 6 used steel water troughs successfully, which might be due to the fact that the farm is located in the centre of the country where rust is not a detrimental factor such as is the case along the coast of South Africa. Plastic water troughs are also used successfully in one of the case studies (farm 4). However, this farm had only been operational for a short period when visited and thus the plastic's durability had not been fully tested.

Plate 8.8 Buffalo cow with conveyor belt feed trough in the background.

Plate 8.9 Cow at inverted tyre feed bowl.

Plate 8.10 Rectangular concrete water trough.

Plate 8.11 Steel feed troughs showing damage due to buffalo feeding activity.

3.2. Management

Buffalo are highly effective grazers and have developed the ability to maximize intake efficiency even when grazing is scarce in drier months. Buffalo utilise bulk feed, but combine this with selective grazing to optimise their feeding time and in extreme cases they also resort to browsing as an added measure for acquiring sufficient nutrients (Sinclair, 1977; Mloszewski, 1983; Prins, 1996; Landman & Kerley, 2001; Macandza *et al*., 2004; Tshabalala, 2008; Venter & Watson, 2008). These adaptations make buffalo somewhat more resistant to drought than cattle or other domestic livestock. Buffalo do, however, compensate for drought by lowering their reproductive performance in drought years which lowers the production of the herd. Production is the main focus for most, if not all, of the buffalo farmers in South Africa so as to maximize profit. Thus, to decrease the risk of lowered reproductive performance, supplementary feed is added to the diet of the buffalo. The extent of feed supplementation differs and is influenced by three factors: the quantity and quality of natural grazing available (high correlation with rainfall), the size and area of the paddock buffalo are kept in as well as the personal preference of each farmer.

Quantity and quality of grazing is influenced by environmental conditions such as rainfall and ambient temperature. These factors are outside of the manager's control, but in addition to these factors, the stocking density of the animals has a marked effect on the quantity and quality of the grazing, which can be managed. Six of the eight farms (1, 2, 3, 5, 6 and 7) supplied adequate information regarding paddock sizes and buffalo numbers to calculate a stocking rate expressed as hectares per buffalo. These stocking densities ranged between 3.5 – 18 hectares per buffalo. Carrying capacity of grazing can be defined as the number of animals that a specific piece of land can accommodate without degrading the quality of the forage. Carrying capacity can be measured in livestock units (LU) also known as large stock units (LSU). One LSU is equivalent to a steer with a body mass of 450kg growing 500g per day by feeding on grazing that has a mean digestible energy (DE) concentration of 55%, thus supplying 75MJ metabolisable energy (ME) per day (Meissner, 1982).

The average LSU for a buffalo herd with all the different physiological stages as set out in Table 8.1 is 1.076 of a LSU. Using this value has disadvantages, for example, this value would under supply for lactating females as well as growing and adult males. Buffalo are a high value commodity and should be managed as such, so working on a higher LSU value of 1.35 would ensure that all animals in the herd are catered for in the feed calculation. Using this value, a herd of 20 breeding buffalo will need 270 ha if the carrying capacity is 10ha/LSU. Considering the questioned farms (1, 2, 3, 5, 6 and 7), the stocking densities ranged between 2.6 – 13.3 ha/LSU. Depending on the area and grazing available, most of these farms (2, 3, 6 and 7) are overstocked and the grazing cannot supply the nutritional requirements of the herd, especially in the dry season. Thus, supplementary feed is needed in all but two of the farms to supply in the nutritional requirements of the herd and ensure optimal production. Apart from supplementing protein and energy, there are mineral shortages throughout South Africa with the most prevalent being a Phosphorus shortage. Six of the seven farms provided an *ad lib* mineral lick that supplied the basic mineral requirements of the buffalo on their farm. Farm 4 did not supply a mineral lick, but they supplied a fully formulated feed that included all needed minerals at the required concentrations, so no mineral shortage would be expected.

Table 8.1 Large stock unit equivalents for different physiological stages of buffalo (adapted from Meissner, 1982)

Physiological stage	**Mass (kg)**	**ME (MJ/d)#**	**LSU***
Calf, 8 months	145	31.8	0.424
Heifer, dry, 4 years	460	79.1	1.055
Cow, dry, 10 years	530	76.4	1.019
Cow, with calf, 4 years	460	101	1.347
Cow, with calf, 10 years	530	99.3	1.324
Young bull, 4 years	500	89.6	1.195
Adult bull, 10 years	640	87.7	1.169

#Metabolisable energy
*Large stock units

3.2.1. Energy and protein

Nutrition requirements and supplementation in animals is primarily expressed in terms of energy and protein. The calculation of energy and protein requirements and supply is very complex and impractical to calculate, especially under extensive circumstances. Thus, average values as obtained from research (Meissner, 1982) are used and are combined with a safety factor when working with high value species such as buffalo.

The energy effectively used by the animal can be expressed as metabolisable energy (ME) which is measured in megajoule (MJ) and the values required for buffalo are supplied in Table 8.1. Metabolisable energy acts as the substrate during fermentation and proliferation of the micro-organisms in the rumen as discussed below.

Protein intake is said to be the main limiting factor with regards to production in buffalo (Sinclair, 1977; Prins & Beekman, 1989; Prins, 1996). This is two-fold, not only is protein necessary for metabolic function in the body of the animal, but it also plays a major role in the rate of intake. Protein is an essential part of all living organisms. Some organisms need to ingest protein in the form of high quality protein to have the necessary amino acids for life. Other animals (such as ruminants) have developed an alternative method of acquiring protein or utilising low quality protein and transforming it into high quality protein. Buffalo are ruminants and have the ability to produce protein using nitrogen from non-protein nitrogen (NPN) sources (McDonald *et al*., 2002). This ability comes from the fact that the rumen contains micro-organisms that utilise the nitrogen as a substrate to proliferate. These micro-organisms are in turn used as a source of protein (known as microbial protein) by the buffalo when digested and absorbed in the later parts of the gastro-intestinal tract (GIT). The protein requirement of an animal can be calculated by the following equation: Crude protein = Live body weight$^{0.75}$ x 4 (Köster *et al*., 1996). The cheapest form of supplying nitrogen to the rumen is urea as it supplies 2820 g CP/ kg of feed. However, urea can be toxic and is thus avoided with high value species such as buffalo. The symptoms of urea poisoning include muscular twitching, ataxia, excessive salivation, tetany, bloat and respirational defects (McDonald *et* al., 2002; Oberem *et al*. 2006).

Ruminants have been said to eat to meet their energy requirement rather than to fill their intake capacity (Scarnecchia & Gaskins, 1987; McDonald *et al*., 2002). Whether the previous statement is correct is unclear, but whether ruminants are driven by their filling capacity or not, they are restricted by it. Thus, accurately predicting the intake capacity of buffalo is key to calculating the amount of nutrients acquired from the grazing and any shortages that might occur due to low quality grazing. Intake for buffalo is calculated at 2.5% of live body mass on a dry-matter (DM) basis (Owen-Smith, 2002). This intake is strongly influenced by the available protein content of the feed ingested. The limitation of nutrient acquisition due to protein can be defined as the effect of protein on the proliferation of micro-organisms in the rumen. Ingested protein provides nitrogen to the rumen micro-organisms. The micro-organisms utilise the nitrogen as a substrate to multiply. These micro-organisms are the fermenters in the rumen, which breaks-down the cell walls of plant cells and makes the nutrients in the cells available to the ruminant. The passage of nutrient rich rumen content from the rumen to the rest of the GIT where it can be utilised, is controlled by the rumenoreticular orifice, which only allows particles smaller than a certain size to exit the rumen and reticulum. The micro-organisms in the rumen break down the plant particles into small enough segments to pass through the rumenoreticular orifice. Thus, if a shortage of nitrogen (from protein) occurs, the micro-organisms in the rumen do not proliferate optimally and fermentation is decreased (Viljoen, 1991; Prins, 1996). Thus, the rumen is not emptied optimally and intake is reduced due to a lack in space in the rumen.

In summary, the quantity of microbial protein produced is dependent on the amount of organic matter ingested and fermented, whilst the fermentation and intake is dependent on the amount of ME ingested and nitrogen available in the rumen (McDonald *et al*. 2002).

3.2.2. Minerals and Vitamins

Minerals are another very important component to supplementary feed. Both macro- and micro-minerals can have a marked effect on both the health and reproduction of buffalo. As the main part of a buffalo diet is grazing under most circumstances, the mineral content of the diet is that of the grazing. The mineral content and availability of these minerals to the animal is influenced by different factors. These factors include species and stage of maturity of the grazing, the type of soil, climate and seasonal conditions, the condition of the soil such as pH and mineral content as well as fertilisation and liming will have a further effect on the mineral content of the plants grazed (McDonald *et al*., 2002). The minerals that are deficient in different areas of South Africa are Phosphorous (P), Sodium (Na), Chloride (Cl), Sulphur (S), Iron (Fe), Iodine (I), Copper (Cu), Cobalt (Co), Manganese (Mn), Selenium (Se) (Schmidt & Snyman, 2005).

Vitamins are needed in very small quantities by animals and even less in the case of ruminants as they have micro-organisms that synthesise some needed vitamins in the rumen that can be utilised by in the body. Under natural extensive conditions, the vitamin levels are usually high enough to supply the requirement of the animals. The only exception to this might be vitamin A, which is high in green feeds and could thus be low towards the end of the plant growth season (Oberem *et al*., 2006). The known vitamins in animals are A, D, E, K, B1, B2, Nicotinamide, B6, Pantothenic acid, Folic acid, Biotin, Choline, B12 and C.

3.2.3. Managing deficiencies

As with most supplementation of shortages, the most effective starting point to control or manage a mineral or vitamin shortage is to accurately predict the extent thereof. An effective way of predicting the mineral shortages of buffalo is by analysing the grazing species available on the farm at different stages of growth, and then formulating a mineral supplement that supplies the short-falls of the grazing (Schmidt & Snyman, 2005). This method might prove impractical and/or costly. Alternatively, a basic knowledge of the animal's wellbeing and behaviour, regular observation and accurate record keeping combined with a basic knowledge of the environment (type of veld, general shortages in the area, weather patterns, parasites, etc.) should suffice to indicate most shortages. The buffalo themselves are the best indicators of mineral shortages and if the animals maintain good health with 13 month inter-calving periods and the calves display optimal growth and health, then any changes made are likely unwarranted. Any changes to the "environment" may have an adverse effect on production and cause monetary losses.

South Africa has three main veld types that provide grazing; these are broadly known as sweetveld, sourveld and then the intermediate veld type known as mixed veld (Tainton, 1999). Sweetveld is characterised by the fact that it remains palatable and nutritious even when mature (all year round). Sweetveld is mostly found in areas with lower rainfall and higher temperature at lower altitudes, as opposed to sourveld which is found in higher rainfall and lower temperatures areas. Sourveld loses its palatability and nutritious quality as it matures and is thus only palatable during the growing season. Mixed veld is a combination of sweet- and sourveld and the nutritious value thereof can remain for 6-11 months, depending on the "level of sweetness" (Smith, 2006). Sweetveld tends to be more sensitive to over grazing, but has a rapid recovery when rested whereas sourveld has a higher tolerance for overgrazing, but when overgrazed has a slower rate of recovery (Smith, 2006). In short, sourveld generally has a higher carrying capacity than sweetveld, but supplementation of proteins are needed during the dry months of the year when grasses have reached maturity. Farms 1, 7 and 8 were situated in areas with sour veld and thus would need protein feed during the dry months. Farms 1 and 8 supplied feed year round and, thus, the intake of the animals just increased during the dry months. Farm 7 did not provide year round feed, but provided a mineral and protein lick during the dry months, which stimulated the intake of the low quality sourveld during the dry months and insured that no shortage occurred. The remaining farms were located in sweetveld or mixed veld areas that provided adequate feed during the rainy season and also the beginning of the dry season, but all of the farms had year round feeding schemes except for farm 6, but they utilised planted pastures to compensate for the feed shortages that might occur. Thus, if managed correctly sweetveld can supply the nutrient requirements of the buffalo year round and only a mineral lick might be needed for shortages. Sourveld might supply in the nutritional needs of the buffalo during the rainy months, but a protein/NPN lick is required during the dry months if grazing quantity is not a problem. If a general feed shortage occurs, the buffalo need to be provided with an additional feed source such a complete feed to ensure optimal production during the dry months.

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), especially for over-wintering (Maree & Casey, 1993; McDonald *et al*., 2002). By irrigating these planted pastures, the feed production of the pasture can be raised substantially and the expense of feed costs can be lowered (Maree & Casey, 1993). 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, and should be managed accordingly. Additional advantages include the fact that many of these grasses are perennial grasses and once established all that's needed for growth is sufficient water and at times fertiliser depending on the soil type. The grasses planted by buffalo farmers include digit grass, eragrostis species, barley and kikuyu. Other than grazing, the excess grass can be baled and either stored for drought years or sold as an additional income. Nevertheless, the current price of buffalo does justify the use of high quality feed and many farmers are not prepared to take the risks of lower quality feed to save on feed costs as the risks outweigh the savings for most of these farmers.

The quality feeds used to supplement buffalo can be found in different forms. These include everything from pellets to home mixed rations. The focus of supplementary feed for buffalo is on digestible protein content with a balance of ME, minerals and roughage, seeing as protein is the first limiting factor with regards to feed for buffalo. Other than supplying the correct nutrients for buffalo, the management and feeding practices of these supplements are of utmost importance. The first consideration should be to ensure that all the animals have their minimum requirements met with the feed consumed. The hierarchy in a buffalo herd complicates this management, because if not correctly managed some dominant animals might receive an over-supply and the animals at the bottom of the hierarchy might not be receiving any feed. This could be detrimental for both groups. An over consumption of high carbohydrate feed that the buffalo aren't used to, can lead to acidosis and in extreme cases death, but the absence of feed could lead to lowered production and starvation. To avoid these cases from occurring the following are general tips with regard to feed management. Firstly, when animals are introduced to a new feed they should be adapted over a 4-6 week period by supplying high levels of roughage and systematically increasing the supply of the high quality supplemental feed (pellet) from 0-100% of the calculated amount over the 4-6 weeks. The number of feed bowls should match the number of buffalo and in cases where severe dominance is observed, this number of feed bowls should be increased with 20%. Lastly, the feed bowls should be at least two and a half buffalo lengths apart to deter intimidation by the dominant animals, or in extreme cases the bowls could be placed in a large circle, still maintaining the two and a half buffalo lengths between each bowl (Shepstone, pers. comm.).

In the rainy season when the quantity and quality of grazing is high and supplies in the protein and energy requirements of the buffalo, some minerals might still remain deficient. Accordingly it is advisable to have a mineral salt lick that is available to the animals throughout the year. This lick will supply the basic needed macro and micro minerals and can be formulated to be more specific for a farm if needed. The intake of the mineral lick can be controlled by increasing or decreasing the salt concentration of the lick. However, care should be taken not to place this lick in close proximity to water as intake of water will nullify the intake control exhibited by the salt in the lick.

Buffalo are large animals that have a daily water requirement. The estimates for water requirements are around 3.4% of live body weight (Du Toit, 2005a). This requirement changes for different circumstances and environments. Factors affecting the water requirements include composition of vegetation, gestation, age and physiological condition and environmental conditions (Du Toit, 2005b). Water is an essential part of nutrition, because the rumen content has a high fluid content and needs to remain so for optimal fermentation. Watering points are needed at regular intervals to supply adequate water without the buffalo having to travel long distances. Buffalo can utilise most types of water sources, but seem to prefer artificial water holes and dams over troughs. In the case of intensive farming, it is advisable to use water sources that can be controlled. Controlled water points can be tested and analysed (which is advised when farming intensively with high value species) and also filtered if harmful agents are found in the water, as opposed to open and stagnant ground/rain water which could contain toxin producing bacteria or other harmful agents. Open ground water 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 so as to prevent contamination.

Managing nutrition and feeding is of utmost importance when working with high value species as their nutritional status has a direct effect on their production and the profitability of the entity. Management of buffalo nutrition commences as soon as implantation takes place during gestation as the feed intake of the dam becomes the feed intake of the calf. This continues after parturition as the calf is now dependant on the milk from the dam, 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). Feeding of weaned animals is often neglected as most of these are bulls that are placed in a bull camp to grow out with as little expense as possible to the farmer. Considering the fact that some of the weaned bulls might prove to be the best sellers, especially when from a good genetic background, it might prove worthwhile to also attend to their feed requirements to optimise growth and have maximum expression of their genetic potential.

4. Parasite and disease control

4.1. Infrastructure

A variety of methods can be utilised to control diseases and parasites. For the control of diseases methods include exclusion by fencing or maintaining animals in bomas (quarantine), shooting diseased animals, burning of carcasses and immunizations. The size and extensity of a game farming operation will dictate which of these methods will be optimal to use (Du Toit, 2010b). Diseases occur periodically and apart from fencing and quarantine/treatment bomas, not much can be done in terms of infrastructure for the control of diseases. Parasite control is for the most part more manageable than disease control and thus can be integrated as part of the infrastructure, especially for ecto-parasites control. Endo-parasites can be controlled by either injecting the treatment by hand or with a fall-out dart or alternatively adding the treatment to supplementary feed that is given to the animals, which are assisted by the placement and layout of the camps as well as the boma.

"Oom Gielie's" lick trough (Plate 8.12 and 8.13) is a height adjustable trough that has a roller on each side at the top. These rollers lie in a water tight container (Plate 8.14) that is slightly bigger than the roller. A dip fluid is placed in the container which is then rolled onto the neck of the animal when it stretches into the trough for lick or feed. The dip used in OG lick trough can be any contact/pour-on dip such as Amipor and Drastic Deadline. The amount of dip applied to each animal is dependent on the contact with the roller and not according to weight as most dips are recommended to be applied. The tick-off system is sprayed onto each animal passing through a corridor and is regulated by the weight of the animal. A container (Plate 8.15) with the dip fluid (most pour-on dips will work) is buried under 50 mm of soil level with the ground. Two pipes with spray nozzles are connected to the container, one spraying the animal from below and one spraying the animal from above. The applicator is placed in a corridor between a water trough and lick trough with a barrier that encourages animals to pass through the corridor. The fluid is sprayed when the animal's weight on the container causes hydraulic pressure in the container which then sprays the fluid through the nozzles onto the animal. Another methods which none of the farmers studied utilised is the Scorpion Dip Applicator (Plate 8.16) and the Duncan Applicator (Plate 8.17). The Scorpion dip applicator uses a mechanical scale that weighs the animal and then accordingly releases a dip fluid from a container on the side. The dip is applied twice, on the shoulders and rear of the animal from above. The principle is the same as with the tick-off system apart from the method of weighing and application of the dip fluid. The Duncan Applicator uses the same principle as the OG lick trough by attracting the buffalo to the feed and then applying the dip fluid on contact with the animal. The Scorpion and "tick-off" methods can be used on farms where minimal contact between buffalo and humans occur, i.e. extensive buffalo farming. These can be used with the same or even more success in buffalo in an intensive system.

Plate 8.12 "Oom Gielie's" dip trough.

Plate 8.13 "Oom Gielie's" dip trough.

Plate 8.14 "Oom Gielie's" dip trough's dip containers.

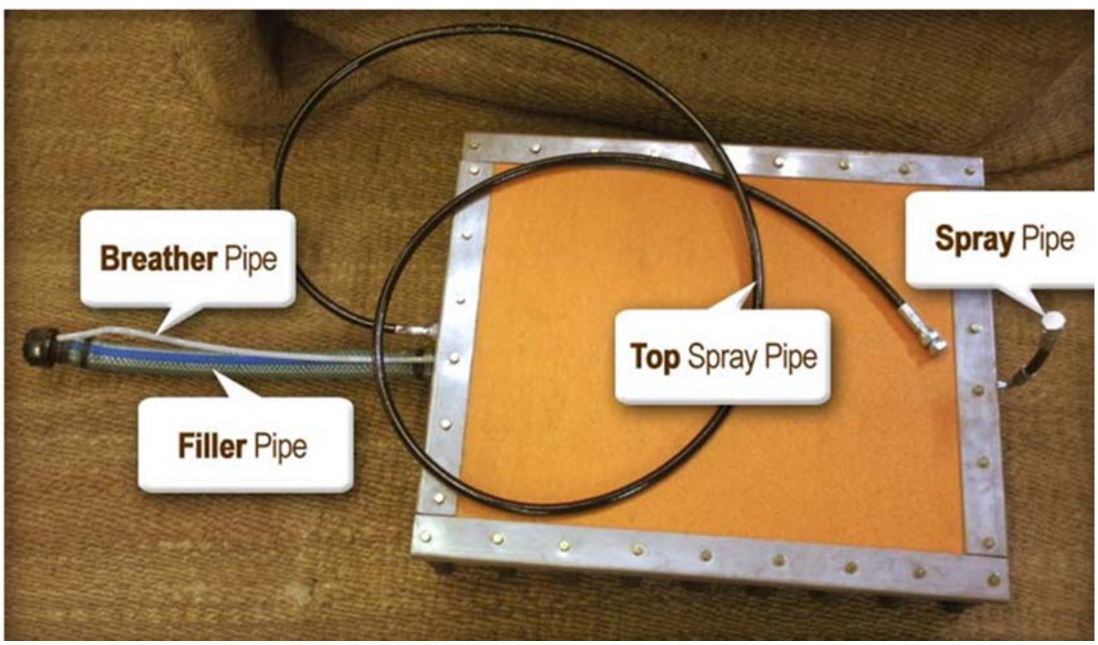

Plate 8.15 Tick-off dip apparatus.

Plate 8.16 Scorpion dip applicator being installed.

Plate 8.17 Duncan applicator being filled with feed.

4.2. Management

Buffalo are game animals that have survived for centuries in the wild. Nonetheless, interference by humans has compromised this hardiness acquired over the years by domesticating and concentrating buffalo within fenced game farms (Maree & Casey, 1993). The introduction of European and Asian cattle brought with it many foreign diseases, including both the rinderpest as well as the bovine tuberculosis (BTB) for which buffalo have been blamed. These in combination with the restricted area available to buffalo has caused a concentration of diseases associated with buffalo. Due to strict guidelines and drastic actions, many buffalo are now free of the main diseases (BTB, bovine brucellosis, corridor disease and foot-and-mouth disease) that were threatening their existence directly or indirectly (Laubscher & Hoffman, 2012). It is now only the ‘common’ livestock farming issues that remain with disease-free buffalo, such as internal and external parasites which include ticks and worms. To control these, many farmers have resorted to dipping, dosing and inoculating buffalo almost in the same way as domestic livestock. The techniques of application differ substantially from cattle as these are wild animals that should be considered dangerous, especially when under stress or threatened.

4.2.1. Inoculation/Vaccination

Inoculations or vaccines are utilised as a method of control for diseases that generally do not have a cure and are harmful to buffalo (Oberem *et al*., 2006). The diseases inoculated for in buffalo include blackleg, brucellosis, pasturella and rift valley fever. These can be done annually or whenever signs of the disease appear. As mentioned above, buffalo are extremely hardy animals and should be allowed to form their own anti-bodies to the above diseases, but seeing as it has become a high value entity, most farmers have opted for the ‘rather safe than sorry’ approach by inoculating according to a program rather than when visible symptoms appear. The long term negative effect hereof is that buffalo might lose some of the hardiness which would have been selected for by culling through natural selection. Once again this is a reminder to evaluate why buffalo are being bred.

The following inoculants (table 8.2) are used by the farms questioned for the trail and will be discussed below: covexin® 10 (Schering-Plough Animal Health Limited), RB 51 (Professional Biological Company) and Smithburn vaccine (Onderstepoort Veterinary Institute). Covexin 10 is an inoculant against blackleg. Blackleg, also known as gas gangrene, is a disease caused by the bacteria *Clostridium chauvoei* and *Clostridium feseri*. These enter through either ingestion which is followed by punctures in the mouth and digestive tract or through external injuries (Oberem & Oberem, 2011). Death can take place within 48 hours if not treated with high levels of antibiotics (Oberem & Oberem, 2011).

Symptoms include low walking ability, lowered appetite, swelling at the shoulders, back and neck that make a cracking sound under pressure due to gas formed inside these swellings. RB51 is used for the prevention of brucellosis (Oberem & Oberem, 2011). Brucellosis is caused by the bacterium *Brucella abortus* which causes abortion of the foetus at late gestation (Oberem *et al*., 2006). Death of the adult buffalo rarely occurs as they have been shown to develop antibodies to *B. abortus* and have been known to be maintenance hosts for brucellosis (Waghela & Karstad, 1986; Madsen & Anderson, 1995). Brucellosis has no cure, but vaccination with RB51 has been proven successful. RB51 is a live vaccine, so it could induce abortions in pregnant cows and should be handled with care (Cross *et al.*, 2007). Further vaccines include the live Smithburn vaccine for the prevention of rift valley fever (Botros *et al*., 2006). Rift valley fever is a viral infection carried by mosquitoes and is injected through the skin when the mosquito feeds on the buffalo (Oberem & Oberem, 2011). It only causes a transient fever in adult animals, but severe liver damage in young animals and abortions in some of the cows (Bird *et al*., 2009). Sporadic outbreaks seem to occur after heavy spring rains that provide surface water during the warmer summer times. The prevention of rift valley fever is possible with the Smithburn vaccine, but has been known to cause some abortions in pregnant animals as it is a live vaccine (Botros *et al*., 2006). There is an inactivated vaccine for rift valley fever that does not cause abortions, but for effective immunity it has to be given at least three times in short succession or requires a regular booster, which makes it less effective than the live attenuated vaccine, especially during emergencies (Ikegami & Makino, 2009).

Table 8.2 Vaccines used by the eight buffalo farmers questioned for management

Inoculant	**Bacteria**	**Disease**	**Live**
Covexin 10	*Clostridium chauvoei/feseri*	Blackleg, blackquarter, gas gangrene	Yes
RB 51	*Brucella abortus*	Brucellosis	Yes
Smithburn	Viral	Rift valley fever	Yes/No

4.2.2. Drenching endoparasitics

Drenching in most instances is for optimising production. Buffalo are similar to native African cattle in the sense that they have the ability to build up immunity towards most of the parasites found in South Africa. The buffalo that are unable to do so usually die and the species are strengthened through natural selection. The domestication of buffalo has slowed down natural selection in the areas of parasite resistance, with farmers drenching their buffalo to ensure optimal health. Additionally the fencing of game and concentration of game and parasites to smaller areas have necessitated the use of parasite treatment for game

(Oberem & Oberem, 2011). A theory has been proposed that increased incidence of parasites is positively correlated with the overgrazing and decrease of natural remedy plants such as Aloe (Bester, 2002). Drenching can be divided into two broad groups for internal and external parasites. The most common internal parasite dosing used by the buffalo farmers questioned includes Endotape, Ivomec and Panacur (Table 8.3). These all have very similar functions in that they are for the control of internal parasites with the exception of Ivomec which is for both internal and some external parasite control.

Endotape focusses on roundworm and tapeworm. Different types of roundworm exist, but in most cases roundworms are not deadly to buffalo as the buffalo have developed a resistance to these parasites (Oberem & Oberem, 2011). Roundworm places a damper on the performance of game animals and might have a negative effect on the condition of the animal (Bester, 2002; Oberem & Oberem, 2011). In the case of buffalo this decrease in production relates to a decrease in reproduction efficiency and overall profitability of the farm. The intensive farming of game animals does increase the chances of infection and selection for certain production traits could have a negative effect on the resistance of buffalo to parasites. The two main roundworms when farming intensively with game are the wire worm (*Haemonchus* spp.) which is more prevalent in roan (*Hippotragus equinus*) and sable (*Hippotragus niger*) than buffalo and false bruising (*Parafilaria* spp.) which is found in rhino (*Ceratotherium simum*/*Diceros bicornis*) and buffalo (Oberem & Oberem, 2011). These rarely cause death in buffalo, but can cause secondary infections and unsightly wounds and bruising.

Table 8.3 Endoparasite treatments used by the eight buffalo farmers questioned for management

Product	Parasite affected	Symptoms	Fatality
Endotape	Roundworm (*Haemonchus/Parafilaria spp.*)	Lowered production, secondary infection, unsightly wounds	Unlikely, resistance acquired
	Tapeworm (*Taenia spp.; Echinococcus granulosus spp.*	Lowered production	Unlikely, not often in buffalo
Panacur	Roundworm		
Ivomec	Roundworm Lungworm (*Dictyocaulus viviparous*) External parasites	Pneumonia, bronchitis	Possible if left untreated

Tapeworms occur in the intestines of herbivores and carnivores and are picked up in a cyst form during grazing. Similar to roundworms they seldom cause death, but can result in decreased performance. Tapeworms usually do not affect free living game species, as a high concentration of animals is key for the survival of the tape worms. As buffalo are now being farmed intensively this might have an effect on the susceptibility of buffalo to tapeworms (Oberem & Oberem, 2011). Herbivores also act as intermediate hosts for tapeworms when cysts get logged in the tissue and are then ingested by carnivores and/or humans that become the definitive host. The most significant of the tapeworms for the wildlife industry are the *Taenia* spp. and *Echinococcus granulosus* spp. (Oberem & Oberem, 2011). Panacur is an anthelmintic used for roundworm and covers five different roundworms in cattle, which means these are most probably also applicable to buffalo roundworms. Ivomec is an anthelmintic used for both internal and external parasites that is available as either a pour-on or an injection. The parasites covered by Ivomec include different roundworms, lungworms as well as external parasites such as lice, mites, horn flies and grubs. Lungworms are ingested during grazing as infected larvae and then migrate via the bloodstream to the lungs (Oberem *et al*. 2006). The worms develop in the lungs or other parts of the respiratory tract and cause pneumonia or bronchitis. The most commonly known lungworm in livestock is *Dictyocaulus viviparous*, which is the lungworm drenched for by using Ivomec. Internal drenching covers most of the internal parasites for cattle and thus it is accepted that the same is applicable to buffalo. An internal parasite not covered by these specific dosing elements is fluke and more specifically liver fluke which is commonly found in animals that are regularly found grazing around water sources, however, buffalo have not been known to be affected by these parasites (Oberem & Oberem, 2011).

4.2.3. Treating ectoparasites

Dosing for external parasites on buffalo is done with three products, Amipor, Deadline and Delete all (Table 8.4).

Table 8.4 Ectoparasite treatments used by the eight buffalo farmers questioned for management

Product	Parasite affected	Symptoms	Fatality
Amipor	Ticks:		
	'bont' tick (*Amblyomma hebraeum*)	heartwater (*Ehrlichia ruminatium*), abscessation	Unlikely, maintenance host
	paralysis tick (*Ixodes rubicundus*)	Paralysis	Possible if untreated
	brown ear-tick (Rhipicephalus spp.)	corridor disease/ east coast fever, ear bleeding	Unlikely, maintenance host
	blue tick (Boophilus spp.)	babesiosis	Possible, immunity attained
	Lice		
Deadline	Ticks		
Delete all	Ticks		
	Flies:		
	stable fly (*Stomoxys calcitrans*)	fly worry, reduced production	None
	horn flies (*Haematobia* spp., *Haematobosca* spp.)	irritation, reduced production	None
	cattle louse flies (*Lipoptena spp.*)	anaemia, loss of condition	None
	nuisance flies (*Musca domestica*)	Irritation, loss of condition	None
	Lice:		
	biting (red)	irritation, hair loss	None
	sucking (blue)(*Haematopinus bufali*)	anaemia	None
	Mites:		
	Demodex cafferi	hair loss, itching, euthanasia	Unlikely
	Choriopsoroptes keneyenis	hair loss, itching, euthanasia	Unlikely
	Sarcoptes scabiei	Sarcoptic mange, alopecia, hyperkeratosis	Possible
	Blackflies:		
	Simulium spp.	skin irritation/inflammation	Unlikely
	Culicoides spp.	blue tongue vector, skin irritation	Possible due to blue tongue

"Amipor" is a pour-on dip that needs to be applied once a week for three weeks. Amipor is for the control of ticks and some lice in game species. There are currently more than 200 known tick species in Africa and 37 of these are found in South Africa (Oberem & Oberem, 2011). Most of the 37 species are found on wildlife and the wild animals have seemingly developed the ability to harbour large amounts of ticks without being affected. The only requisition for this hardiness to prevail is sufficient available land, as a high concentration of animals causes a high concentration of ticks (Bester, 2002). Ticks are classified as either one-, two- or three-host species, which divides their life stages between one, two or three different hosts (Oberem *et al*., 2006; Oberem & Oberem, 2011). Buffalo are known as multipliers as the adult ticks prefer to feed on buffalo before laying the eggs. The four main tick species associated with wildlife are the 'bont' tick (*Amblyomma hebraeum*), paralysis tick (*Ixodes rubicundus*), brown ear-tick (*Rhipicephalus* spp.) and blue tick (*Boophilus* spp.) (Oberem & Oberem, 2011). The 'bont' tick is the vector for heartwater (*Ehrlichia ruminatium*) which causes mortalities in some non-resistant wildlife. Although buffalo do not display symptoms of heartwater, they have been identified as maintenance hosts that transmit the disease to susceptible animals, especially domestic livestock, via the *A. hebraeum* tick (Andrew & Norval, 1989; Allsopp *et al*., 1999; Wesonga *et al*., 2001). The more common effect on buffalo due to 'bont' tick is abscessation due to deep piercing wounds by the long mouth parts of the bont tick. The 'bont' tick also forms clusters of ticks on the host due to a pheromone secreted by the adult male tick which attracts other 'bont' ticks and only adds to the problem of abscessation (Oberem & Oberem, 2011). They occur in the northern and eastern bushveld and are not found on the highveld grasslands.

Paralysis tick is found in the Karoo and arid areas of South Africa and more specifically in hilly, rocky areas. The primary host is the elephant shrew (*Macroscelides proboscideus*) and red rock rabbit (*Pronolagus* spp.) which occur in these rocky areas (Horak *et al*., 2007). As paralysis ticks are susceptible to drying out, they are usually found on the southern slopes of the hills (Oberem & Oberem, 2011). The adult ticks are active in autumn and attach to the lower parts (feet/claws, legs, belly and inguinal area) of livestock and antelope. The female ticks produce a toxin that is released into the blood stream of the host animal when the tick feeds. This toxin causes paralysis in the host which could escalate to death if the ticks aren't removed (Jongejan & Uilenberg, 2004). Control of the Karoo paralysis tick is most effective by dipping/pour-on and proper veld management, ensuring that over-grazing does not occur (Oberem & Oberem, 2011).

The brown ear-tick (*Rhipicephalus appendiculatus*) is probably one of the most well-known ticks in wildlife farming apart from the 'bont' tick. They are found in the northern and eastern parts of the country as well as the Western and Eastern Cape. The brown ear-tick is well known among buffalo as being the vector for Corridor disease as well as East Coast fever (Perry & Young, 1995; Berry, 1996; Boomker *et al*., 1996; Stoltsz, 1996; Jongejan & Uilenberg, 2004; Oberem & Oberem, 2011; Laubscher & Hoffman, 2012). These ticks are a three-host species that feed on large mammals such as buffalo and eland (*Taurotragus oryx*) and prefer to attach itself to the inside of the ear of its hosts causing heavy bleeding and in severe cases, loss of the ear (Oberem & Oberem, 2011). Over stocking as well as keeping extra-limital species of game increase the tick loads during summer months. The brown ear-tick also has the shortest feeding time (four days) of all the mentioned 3-host ticks (seven days) which makes it more difficult to control.

Like the previous three tick species, blue ticks (*Boophilus* spp.) are one-host species that can also be treated with "Amipor" and are mainly found in the eastern part of South Africa. These are easily controlled as they are only a one-host tick, but are dangerous as they are carriers of babesiosis (tick fever) in ungulates (Bock *et al*., 2004; Oberem & Oberem, 2011). Wildlife and especially buffalo do, however, attain immunity for this disease when exposed as calves and thus it holds little threat if managed properly (Jongejan & Uilenberg, 2004).

"Deadline" is also a pour-on dip product that reduces the tick load on game animals and additionally sterilises female ticks so reproduction is inhibited. Regular application will see a drastic decrease in tick loads of a herd if resistance hasn't been acquired by the parasites. "Delete all" is yet another pour-on dip for the control of ticks, in addition it also assists in the control of different flies (Stable, Horn, Cattle Louse and Nuisance flies), kills lice and mange mites, and protects against blackflies.

Flies are found in many different shapes and sizes, different hosts, but most have the same basic life cycle (Oberem & Oberem, 2011). The Stable fly (*Stomoxys calcitrans*) is a biting fly that looks like the house fly, but is smaller and has mouth parts adapted for rasping and lapping blood. The bite of a stable fly can cause severe fly worry and transfer of *Besnoitia besnotii* and *Anaplasma marginale*, which reduces production in domestic cattle (Hunter & Wallace, 2001; Oberem *et al*., 2006). The name is derived from the fact that they feed in compost heaps and horse manure. Stable flies have been known to attack buffalo and other game animals when kept in bomas or held captive as they are associated with intensive farming of animals (Hunter & Wallace, 2001). These are not easy to control, but dips such as "Delete all" act as repellents for Stable flies.

Horn flies (*Haematobia* spp., *Haematobosca* spp.) are also biting flies that resemble the House fly although it has a smaller body and slightly elongated wings. They stay on the host and only leave to lay eggs in the dung. The main effect of horn flies is irritation which causes a reduced feed intake and consequently decreased production (Peter *et al*., 2006). They occur in large numbers on buffalo and can be controlled by using a dip (Oberem & Oberem, 2011). However, it has been reported that Horn flies quickly build up a resistance to dips as they have a very short generation time.

Cattle Louse flies also known as keds or hippoboscids are parasites commonly found on game animals. They are bloodsucking parasites of the *Lipoptena* spp. but are not commonly found on buffalo (Oberem & Oberem, 2011). Keds do cause anaemia under severe conditions and irritation to the point where loss of condition can take place (Oberem *et al*., 2006). Nuisance flies, which include the House fly (*Musca domestica*), pose little threat apart from it being an irritation. The flies can reach massive numbers wherever adequate dung and compost are available. These can be controlled by dips and sprays, especially early in the spring, as well as parasitic wasps that feed on the flies.

Lice are highly species specific and can be divided into biting (red) and sucking (blue) lice (*Haematopinus* spp.). Biting lice cause irritation and hair loss, whereas sucking lice cause anaemia especially in young animals. Lice are species specific due to their claw shape which matches the hair of the host animal (Oberem & Oberem, 2011). *Haematopinus bufali* is a sucking louse that is species specific to buffalo and commonly found wherever buffalo are located (Turner *et al*., 2004). Crowded wildlife animals or animals under stress are more susceptible to lice. Lice are mostly controlled by dips and injections in the case of sucking lice, but it seems that “Delete all” kills both forms.

Two species of mange mites are associated with buffalo, *Demodex cafferi* and *Choriopsoroptes keneyenis* (Dragër & Paine, 1980; Oberem & Oberem, 2011). Another mite found on buffalo in Zambia is *Sarcoptes scabiei*, which causes sarcoptic mange. Sarcoptic mange is symptomized alopecia and hyperkeratosis of the skin and in extreme cases death in a variety of species (Munang’andu *et al*., 2010). Mites, like louse, are mostly species specific and cannot live detached from a host for more than two days. Mites cause focal loss of hair and severe itching and can escalate to severe debilitation which warrants euthanasia in extreme cases. Mites can spread to humans and cattle in the case of *D. cafferi*, so care should be taken when handling infected animals (Dragër & Paine, 1980; Oberem & Oberem, 2011). Some pour-on dips, such as “Delete all”, are effective in killing and controlling the mites.

Black flies (*Simulium* spp., *Culicoides* spp.) are a small midge type fly that occurs in swarms throughout South Africa. The *Culicoides* species have been known to be a vector for blue tongue in buffalo as well as horse sickness in horses (Meiswinkel, 1997; Paweska *et al*., 2002). Other symptoms of black flies include irritation of the skin and also areas around the eyes and the edges of the ears might be inflamed. The male flies form swarms that hover above the ground, mating takes place when the female comes into or near to a swarm of males. Regularly changing water levels inhibit the reproduction of black flies as the immature stages require running water to survive (Adler *et al*., 2005). A repellent such as “Delete all” is mostly used to protect animals, especially livestock, against black flies.

4.2.4. Natural parasite control

Unlike domestic livestock, buffalo are a game species that have evolved under the influence of natural selection favouring survival traits rather than artificial selection favouring production traits. These survival traits should be utilised and maintained as far as possible, not only because they ensure the longevity and resilience of the buffalo species as a whole, but also because they can improve profitability by reducing expenses and increasing the efficiency with which feed is utilised.

Most of the above mentioned dips and inoculants require a regular dosage at first followed by annual or bi-annual treatments. While this system is very effective for livestock/domestic animals, it may not be sustainable in the long run as it can negatively affect the hardiness of game animals. Indigenous species have developed resistance to many of the parasites that occur in their natural habitats. This acquired resistance is affected by the environmental conditions of the area and more specifically the stocking rate (Bester, 2002). In areas that are overstocked, a shortage of feed is evident and additionally parasites are often noted at burdens that could compromise the health of even game animals. Farmers that farm intensively with game, and buffalo in particular, therefore make use of dipping and inoculation in order to ensure the optimal health of their animals. This could cause a negative breakdown of the resistance of buffalo to certain parasites, consequently weakening the species.

Thus, parasite and pasture management should be based on extensive and regular testing, thereby establishing the levels of management needed in each circumstance. Making use of manure samples to do parasite egg counts (as done by farm 5) can give an accurate indication of internal parasite load and visual evaluation can be done for external parasites (Bester, 2002; Oberem & Oberem, 2011). Evaluation of the general condition and species composition of the grazing assists in accurately predicting and supplementing any nutritional shortages that might occur. Warmer and wetter months see a rise in the abundance of most parasites as this is their preferred active time. Farmers should therefore be more vigilant for parasite activity and symptoms during spring and summer. On the other hand, grazing shortages occur during the dry months of the year and the condition of the animals should be monitored more carefully during this time. Introducing European cattle breeds into paddocks with game has also been known to reduce the tick load. This technique is effective as the ticks are more attracted to the cattle than wild ungulates, which can then be dipped every five days to lower the tick loads in a paddock (Oberem & Oberem, 2011). Having sound management practises also ensures that the natural enemies of external parasites, such as oxpeckers, remain and multiply in the area, further reducing tick loads. Furthermore, natural remedies such as *Aloe* species when consumed have been speculated to assist in ectoparasite control (Bester, 2002).

5. Reproduction parameters

As mentioned, reproduction is probably the easiest way of measuring managerial efficiency. Thus, the different parameters are discussed below.

Age of sexual maturity or first calving is often considered an important parameter regarding livestock and reproduction. The sooner a heifer is sexually mature, the quicker she becomes productive. For buffalo in the wild this is estimated or observed at between 4 and 6 years of age (Carmichael *et al*., 1977; Jolles, 2007). This differs from the average age of first calving as found for the six farms in the trial which was 3 years 9 months and 25 days, which means the average age of first conception was 2 years and 10 months. The difference can be ascribed to the constant availability of adequate feed and absence of predatory stress. Age of sexual maturity is strongly correlated to proportion of adult weight reached. The time to adult weight is in turn strongly correlated with feed availability minus energy expenditure. As the availability of feed is always adequate in intensive buffalo systems and energy expenditure is low, animals reach their mature body weight earlier than wild buffalo (Sinclair, 1974; Neethling, 1996; Jolles, 2007). The sexual maturity and reproductive performance of the bulls were not recorded, but Sinclair (1977) notes that males reach sexual maturity at 4 years, but puberty is already attained at 2 years of age. Thus, bulls should be able to commence mating as early as 2 years of age if no other adult males are present. It would also seem that buffalo bulls in an intensive breeding system that reproduce optimally, have the ability to mate up to 30 females successfully throughout the year if provided with adequate nutrition (as noted by some of the producers interviewed).

The second parameter considered when regarding reproduction is inter-calving period. Inter-calving in wild herds ranges from 13 – 29 months, depending largely on the availability of feed, the physiological condition of the dam, the body condition score of the cow and area available (Sinclair, 1977; Prins, 1996). The average inter-calving period of the six farms was 443 days ± 100 (14.7 months), which is calculated from 437 confirmed calving intervals, which is similar to the 457 days calculated by Du Toit (2003) for free roaming animals. The trial revealed a minimum of 315 days (10.5 months) and a maximum of 822 days (27.4 months) inter-calving period. This average is a little higher than the 395.8 days calculated by Skinner *et al*. (2006) for farmed buffalo, but as the latter study only included 62 calving intervals from only one farm, the results might have been biased towards highly productive cows/more efficient management. The difference between wild herds and intensively farmed buffalo seem not be the reproductive ability of the cows, but rather the consistency that can be maintained in intensively farmed buffalo production. Fluctuations occur between seasons and also years regarding environmental conditions and feed quality/availability. The feed availability factor can be optimised in intensive systems and thus the only natural factors that can cause fluctuations in the reproductive efficiency of buffalo are environmental factors (rainfall, temperature, etc.) (Sinclair, 1974). In the cases of the high inter-calving periods (>600days), the delay was attributed to increased stress by the farmers due to movement of animals and/or disease incidence. Alternatively, this could indicate a low fertility problem in a herd which can be attributed to either weak genetics in the cow or a bull that is either over-worked or has a lowered fertility. Both of these should be selected and managed against as this could weaken buffalo reproduction as a whole. In the cases where a shorter than 340 day inter-calving period was observed it is probable that inaccurate recording was done. On the other hand, the possibility exists that these might be highly productive cows that have a shortened gestation without any complications to the calf as found in cattle (Nogalski & Piwczyński, 2012).

If this is the case it should be possible to select for shorter gestation times in buffalo and thus further increase the production of buffalo cows. Literature supports this selection for cattle and seeing as cattle and buffalo are very similar should be relevant for buffalo also (Nogalski & Piwczyński, 2012). Low to intermediate heritability was recorded for gestation length in cattle ranging from 0.2 – 0.5 depending on the calculation method and parameters used where gestation could be shortened by 10 days within 3 generations in dairy cattle (DeFries *et al*., 1959; Meyer *et al*., 1990; Johnston & Bunter, 1996; Nogalski & Piwczyński, 2012). On the other hand, selecting for reduced gestation length could have an adverse effect on other reproductive parameters such as increased still births, calving difficulty and calf size (Hansen *et al*., 2004; Nogalski & Piwczyński, 2012). Other factors that might further affect the gestation length are the parity of the dam, the gender of the calf, season of birth and sire difference. Research in cattle showed that younger cows display shorter gestation (1.67 days) than older cows, heifer calves were born 2 days earlier than bull calves and calves born in the wet season were carried for longer (Johnston & Bunter, 1996; Nogalski & Piwczyński, 2012; Shehu *et al*., 2012). Furthermore it should be remembered that these selected traits will only be phenotypically expressed under optimal environmental and nutritional conditions, with higher summer temperatures shortening gestation length in cattle.

The reduction of the duration of the calving interval is another phenomenon that has been confirmed by many farmers questioned. Figures 7.1, 7.2 and 7.3 indicate the progression of the parturition number on the farms in this study and a clear decrease in calving interval is seen as the number of calvings increase. Additionally, research also indicates that the first calf is usually lighter/smaller than those born in the second and third years (Skinner *et al*., 2006). Theoretically the inter-calving period increases again after the age of 15 years (Sinclair, 1977), but seeing as little data exists of cows at this age that are intensively farmed, this evaluation was not considered in this study.

Thus, for ideal conditions where each cow has an inter-calving period of 12 months the population growth of 0.25 or 25% can be attained. From the data used for inter-calving where a definite time bracket (t) could be appointed to the data it was calculated that from the farms in the study a population growth of 0.144 or 14.4% was achieved which is slightly above the 12% as found by Jolles (2007) in wild buffalo. Theoretically 50% of these calves should be male and the other 50% female and thus to calculate effective breeding herd growth the population growth (G) could be further multiplied by 50% or by the percentage of females placed back into the herd.

6. Seasonality

A peak in the number of births is observed a month after the onset of the rainy season for the summer rainfall area and decline in the number of births with the onset of the dry season (Figure 7.4). For the winter rainfall area, the peak in births is seen in April which is a month or two before the rainy season in this area (Figure 7.4). Theoretically the main influence on timing of conception and accordingly of parturition is the availability of feed (protein) and the influence thereof on the body condition score of the cow (Skinner *et al*., 2006). Thus, there should be no seasonal difference in the farms as they provide optimal feed throughout the year and all the buffalo maintain optimal breeding body condition. This is, however, not the situation and a variety of explanations can be formulated for this. Du Toit (2003) suggested that buffalo might be photo-sensitive and that day-length would trigger ovulation. In this case buffalo are said to be short-day breeders, which relates to conception occurring between February and April. Even though this could clarify some of the differences between the summer and winter rainfall areas, the difference should not be more than a month. Another hypothesis is that buffalo conception is triggered by rain (Sinclair, 1974). In the hypothesis of Sinclair (1974), rainfall is strongly correlated with feed availability as the study was conducted on wild buffalo. Seeing as the difference in rainy season between summer rainfall areas and winter rainfall areas differ almost six months and the data does not follow this same trend, this can be ruled out as an explanation for the differences found in seasonality of births. A hypothesis suggested by one of the farmers was that the buffalo on his farm came from extensive systems where they were not fed a supplementary diet in times of feed shortage and thus simply came into cycle and continued in that rhythm. If correct, a decrease should be observed in the seasonality of births as time passes in the intensive systems, which has not been observed or recorded yet. Other triggers suggested for conception include the lunar cycle or social cues to facilitate synchrony (Sinclair, 1977; Berger, 1992; Owen-Smith *et al*., 2005). A final hypothesis that is presented here, as a trigger for conception, might be ambient temperature. Even though there is no research supporting this hypothesis, it might explain the difference between summer and winter rainfall areas seeing as the maximum ambient temperatures for summer rainfall areas are reached earlier than for winter rainfall areas and the same goes for minimum ambient temperatures. Thus, in an attempt to protect new born calves from extreme high or more probably low temperatures, the majority are born just after the time when maximum temperatures are expected. Whichever of the abovementioned hypotheses might have an effect on seasonality of births in buffalo is unclear, but what is clear is that buffalo are most probably not completely aseasonal breeders. This is supported by findings in Skinner *et al*. (2006), where 88% of births occurred between December and May in an intensive buffalo breeding system. Furthermore, Sinclair (1974) states that conception in wild buffalo does not seem to be influenced only by nutrition.

GENERAL CONCLUSIONS

African Savanna buffalo (*Syncerus caffer caffer*) breeding is currently mostly being managed on opinions and experience, but little scientific evidence exist that support these methods and opinions. This is worrisome seeing as the number and distribution of buffalo throughout South Africa is rapidly increasing. Buffalo farms occur in every province of South Africa, with the majority still found in the Limpopo province, but these now comprise less than 50% of the total buffalo farms in South Africa. Even though this study indicates the number of farms, it is still not clear how many buffalo there are in South Africa with estimates ranging between 50 000 and >100 000. Thus, more research is still needed in this area to accurately determine the status of buffalo in South Africa. Apart from the increasing distribution, the value of buffalo also keeps on increasing annually. The value of buffalo is due to the income attained from breeding (live sales) and hunting. Nevertheless, meat is a secondary product of hunting and buffalo meat is a healthy condensed protein source with a healthy fatty acid composition. The increase in value of buffalo over the years warrants research on factors that determine the effective management of buffalo.

As with breeding, management strategies also lack the necessary scientific support needed to ensure sustainable longevity of the industry. Management of buffalo is closely related to feed/veld management, parasite control and also control over the herd's reproductive dynamics. To effectively set up scientific protocols for buffalo management, each method/system needs to be evaluated to measure its efficiency. For buffalo the most important factors are reproduction and horn growth; thus buffalo should be managed to these two key indicators. The latter is a controversial issue and was not comprehensively covered in this study. The only way of measuring/evaluating the efficiency of the management strategies to optimise growth and (re)production is by taking accurate measurements and keeping adequate records of all factors that could have an effect on these.

Reproduction is probably the most important factor to ensure the profitability of a buffalo operation. Reproduction is also a trait that most visibly highlights faulty management practises if correct records are maintained. Thus, reproductive performance can be used as a parameter to measure the efficiency of management as well as the genotypic diversity of a species. From the resulting study, certain parameters were found that could function as a benchmark for measuring the reproductive health/success of a captive buffalo breeding operation. These are included under the recommendations.

The start of measuring reproductive performance is to evaluate and record the age at sexual maturity, which for buffalo is frequently calculated backwards from the age of first calving. From the data evaluated, the average age of first calving was found to be 3 years 9 months 25 days, which relates to first conception taking place at 2 years 10 months of age. This is substantially earlier than the 5 years 6 months of age documented for heifers in the wild. Thus, heifers should conceive for the first time before the age of 3 years to qualify as a good breeding cow. The next factor to consider for a breeding cow is the inter-calving period. An average inter-calving period of 443 days was found upon evaluation of the breeders' records, although this ranged between 315-822 days which indicates much room for improvement. An optimal inter-calving period for buffalo is calculated at 363 days, thus an above average breeding cow should sustain an inter-calving period of less than 400 days. For bulls the reproductive maturity stage is more complex to quantify. Bulls are able to start breeding at the age of 2 years as this is when puberty is reached. They are, however, only sexually mature by 4-6 years. Using a bull for breeding before the age of 6 years could have a negative effect on the phenotypic expression of horn length as breeding evidently stunts horn growth. Additionally, an above average breeding bull should be able to successfully fertilise a breeding herd of 25 cows in 1 year, but this can be increased if the fertilization is spread throughout the year. It is also believed that an inferior teaser bull should also be placed in the herd to motivate the alpha breeding bull, however, no records have been published that prove/refute these two theories in any way. To evaluate any farm to ascertain whether optimal breeding is being achieved, adequate records need to be maintained. For effective recording and management/treatment of buffalo, functional infrastructure is needed.

RECOMMENDATIONS

The most crucial records for management and reproduction are briefly summarised below. The origin of all “bought-in” buffalo should be recorded for each animal to assist in accurate distribution studies, which will also be linked to genotypic profiles if required.

For monitoring herd management the following records are important:

- the ratio of bulls to cows
- numbers of total and breeding buffalo
- the dates of breeding bull changes and also fertility testing results if conducted (it is in fact advisable to have these, especially on breeding bulls that have been bought)
- the dominance within and between genders and ages and age of bull calves at which the dominant bull expels or challenges them
- age of weaning, whether artificial or natural and tendencies when forming groups.

The feed management data that should be recorded include the following:

- the effective carrying capacity of the paddocks should be tested and known and how this changes over time due to grazing by the buffalo and the effect of season there upon
- time and amount of supplementary feed given
- amount of feed needed to maintain body condition score of all animals
- behaviour at feeding and drinking troughs should be noted to indicate shy and dominant feeders to enable effective feed management
- if possible annual weight gain, horn growth, age at teething and any physiological changes should be noted with exact dates for each animal. The latter requires an effective identification system.

With regards to disease and parasite management the following records are needed:

- disease occurrence and treatment used for each occurrence should be noted with exact dates and dosages
- date of inoculations, vaccinations and drenching/dipping should be noted along with dosage used, product used and method of application
- any tests done regarding parasites such as faeces samples analysed for internal parasites should be noted with date of sample taken, method used for testing and results of tests
- any evident effects due to treatment or any other changes in routine should be noted with date and observation.

Reproduction requires the following records from which different parameters can be calculated (it is crucial that all animals are easily identifiable):

- the date of birth of all buffalo is very important to determine the exact age of different occurrences
- the sire and dam of each calf should be known
- number of bull to heifer calves born should be recorded
- the age/date of different behavioural changes in buffalo should be noted, for example when bulls are moved, start fighting with dominant bull and start breeding attempts as this is the onset of puberty.

From these records the efficiency of both breeding bulls and cows can be calculated for parameters such as:

- inter-calving periods
- age of first calving
- covering ability of bull, etc.

Finally any stress situations should be recorded with date and effect, such as:

- movement
- extreme weather conditions
- days without feed or water
- any other occurrences that have a visible effect on the buffalo as pertaining to behaviour and well-being status.

Many of these recordings, especially regarding management, can be kept with little extra effort and so doing the African Savanna buffalo can be managed to perform optimally and maybe even improve the productivity of the species as a whole.

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ADDENDUM A

Chemical composition of African Savanna buffalo (*Syncerus caffer caffer*) meat

1. Introduction

African Savanna buffalo are not commonly hunted for their meat in South Africa, but are favoured as meat species in other African countries such as Botswana (Alexander *et al*., 2012). The reason for the low utilisation of buffalo meat in South Africa is due to the high value of buffalo at live sales. The high value of buffalo in South Africa, especially disease-free buffalo, is attributed to the breeding of superior trophy animals and international hunting prices. International hunters are prepared to pay in excess of R80 000 for a buffalo hunt and the live sales of buffalo far exceeds this price with a record auction price of R 40 000 000 being paid in 2013 for a single buffalo bull. Thus hunting buffalo solely for their meat is not sensible in terms of financial gain. Nonetheless, more than 170 buffalo are still being hunted annually in South Africa (Robertson, 2007) and a by-product of this consumptive use is the meat from the hunted animal. This meat should be utilised as a source of protein seeing as Southern Africa has a serious shortage of protein and game meat (including buffalo) can assist in alleviating this problem (Pollock, 1969; Asibey, 1974; Hoffman & Cawthorn, 2013). Furthermore, the situation in some areas in Africa is not one that inspires intensive production of domestic animals and thus game animals become the more acceptable protein alternative (Kay, 1970; Hoffman & Cawthorn, 2012).

Buffalo carcasses yield high quantities of meat similar (yet somewhat lower in quantity) to domestic beef cattle (Table 1). Apart from the high meat yield, research suggests that buffalo meat is associated with pleasant aromatic attributes unlike some other game meat species (Van Zyl & Skead, 1964). International consumers associate game meat with positive fat and cholesterol characteristics and thus see it as a more healthy and desirable meat than beef (Hoffman *et al*., 2003; Hoffman *et al*., 2005a; Hoffman & Wiklund, 2006; Mostert & Hoffman, 2007). Nonetheless, Crawford *et al*. (1970) compared buffalo meat to domestic cattle and suggests that the fatty acid composition of the meat is strongly correlated to the lipid composition of the diet.

Table 1 Live weight, dressing percentage carcass weight and deboned meat yield of African Savanna buffalo (adapted from Grobler, 1996)

	Sub-adult	Adult cow	Adult bull
Live weight (kg)	280-430	450-680	600-850
Dressing percentage (%)	49-52	49-52	48-53
Carcass weight (kg)	140-220	260-330	300-440
Meat yield (kg)	90-145	170-220	195-290

Apart from the meat quality and yield being comparable to that of cattle, buffalo have an inherent disease resistance and thus fewer expenses are needed to maintain the health of a buffalo herd. Buffalo are also naturally adapted to survive in habitats that would be impractical for commercial livestock and can thus utilise grazing that domestic cattle would not be able to (Kay, 1970). On the other hand, buffalo similar to cattle, are associated with diseases such as foot-and-mouth disease, brucellosis, corridor disease and tuberculosis which could have a negative effect on the opinion of the meat consumer.

The meat acquired from buffalo can serve as additional income for a game farm or can be used on the farm for human consumption (Pollock, 1969). Setting up an adequate slaughter facility that adheres to the standards of a low throughput abattoir, which can be registered as an abattoir and the meat can be sold. For buffalo meat to be marketed correctly, more research is needed to ascertain the nutritious value of buffalo meat. This chapter evaluates the effect of gender and muscle on the chemical composition of buffalo meat.

2. Materials and methods

The buffalo used for this trial originated from the Hluhluwe-iMfolozi park (HiP) in KwaZulu-Natal. The experiment was run in combination with a culling operation of buffalo that tested positive for tuberculosis (TB). This is due to the high value of disease-free buffalo, which makes disease-free buffalo meat unavailable for research purposes. The buffalo were herded into a capture boma using a helicopter. In the capture boma the buffalo were grouped into groups of approximately ten animals and placed into separate compartments. Hereafter immobilization commenced.

2.1 Sample collection

The buffalo were immobilised with a mixture of Etorphine hydrochloride (M99 - 9.8 mg/ml) and Azaperone (Stresnil – 40 mg/ml). The following dosages were used: Adult cow: 5 mg M99 + 100 mg Stresnil; Adult bull: 6 mg M99 + 100 mg Stresnil administered through a spring loaded pole syringe (Dan-Inject). On the first immobilisation each buffalo received a dose of long acting Penicillin (Lentrax) – adults received 20 ml, and long acting tranquilliser - Perphenazine (Trilafon 100 mg/ml) adult cows received 200 mg and adult bulls received 250 mg. The M99 is reversed with an intra-venous injection of Diprenorphine (M50-50 – 12 mg/ml) at a dose of 2.5 mg M50-50 per mg M99 used. After administration of the immobilising drug by the veterinarian, the animals were moved into a holding chamber where they were handled and tested for TB. Care was taken to move as quickly and efficiently as possible to minimise stress and heat related deaths. After the initial testing, the buffalo were kept in a boma for 3 days prior to being immobilised again to identify and remove the TB positive animals. During this period the animals had free access to hay (Teff and lucerne) and water. The buffalo that tested positive for TB were then placed into a boma for 10 days (fed same hay) where after they were culled using a high powered rifle (head shots). After the necessary precautions were taken and it was ensured that all buffalo were dead, the animals were lifted out of the pens and exsanguinated to ensure thorough bleeding. The bled animals were then transported to the abattoir and standard South African slaughtering procedures were applied during dressing of the carcasses. The carcasses were then placed in a cooler (±2°C) overnight before deboning.

Fourteen buffalo were culled and used in the experiment. Gender, carcass weight and age are presented in Table 2. The *M. longgissimus dorsi* (LD), *M. biceps femoris* (BF) and the *M. semimembrinosus* (SM) muscles were removed for proximal and amino acid composition and for fatty acid composition only the LD and SM were analysed.

Table 2 Gender, carcass weight and age of buffalo culled for meat trial

Gender	Carcass weigth (kg)	Age (number of permanent incisors)
Male	278	8
Male	180	4
Male	330	8
Male	158	0
Male	210	8
Male	214	8
Male	250	8
Male	186	6
Male	111	0
Female	214	6
Female	158	8
Female	146	6
Female	146	8
Female	199	4

2.2. Proximate analyses

Moisture content was determined by dehydrating 2.5 g of each muscle at 100°C for 24 h (AOAC, 2002a). Ash content was determined on a 2.5 g moisture free sample by placing it in a furnace at 500 °C for 6 hours (AOAC, 2002b). Total fat content of each sample was determined by using an ether extraction method using 50 ml diethyl ether and a Tecator Soxtec System HT 1043 Extraction Unit on a 2 g portion of dry muscle (AOAC, 2002c). The total crude protein content of each sample was determined according to the Dumas combustion method (AOAC, 2002d) from a dry, de-fatted, finely ground sample, encapsulated in a LecoTM foil sheet. This combustion occurred in a Leco Nitrogen/Protein Analyser (Leco Fp-528, Leco Corporation). Seeing as meat protein is assumed to consist of 16% nitrogen a conversion factor of 6.25 was multiplied with the Leco results to determine the total crude protein content (McDonald *et al*., 2002). An EDTA calibration sample (Leco Corporation, 3000 Lake View Avenue, St. Joseph, HI 49085-2396, USA, Part number 502-092, lot number 1038) was analysed in the Leco Nitrogen/Protein Analyser prior to each batch of protein samples, with the intention of ensuring the accuracy and recovery rate of each sample.

All of the above mentioned chemical analysis methods were tested bi-monthly for accuracy and repeatability by performing blind sample analyses as part of a National Inter-laboratory Scheme (AgriLASA: Agricultural Laboratory Association of South Africa).

2.3. Fatty acid composition

Samples (2g) were extracted from the meat (Folch *et al*., 1957) with a chloroform:methanol (2:1; v/v) solution containing 0.01% butylated hydroxytoluene (BHT) as antioxidant. Samples were homogenised for 30 s in the extraction solvent, by use of a polytron mixer (WiggenHauser, D-500 Homogenizer). Heptradecanoic acid (C17:0) was used as internal standard to enable quantification of the individual fatty acids. A sub-sample was taken from the extracted fats and transmethylated for 2 h at 70 °C with a methanol:sulphuric acid (19:1; v/v) solution as the transmethylating agent. After cooling the sub-sample to room temperature the fatty acid methyl esters (FAME) were extracted with the use of water and hexane. The top hexane phase was transferred to a spotting tube and dried under nitrogen. Fifty µl hexane was added to the dried sample of which 1 µl was injected. The FAME were analysed by gas-liquid chromatography (Varian Model 3300 equipped with a flame ionisation detector) using two 30 m fused silica megabore DB-225 columns of 0.53mm internal diameter (J&W Scientific Folsom, CA). The hydrogen gas flow rate was 25 ml/min, air flow rate was 250 ml/min and the hydrogen carrier gas (nitrogen) flow rate was 5-8 ml/min. Temperature programming was linear at 4 °C/min with the following temperature settings: initial temperature of 160 °C; final temperature of 220 °C held for 10 min; injector temperature of 240 °C; and detector temperature of 250 °C. Identification of the FAME in the total lipids of each sample took place by comparing the retention times with those of a standard FAME mixture (Nu-Chek-Prep Inc., Elysian Minnesota).

2.4. Amino acid composition

De-fatted and dried samples of 0.1 g were hydrolysed in glass hydrolysis tubes with 6 ml (6N) hydrochloric acid (HCl) and 15 % phenol sealed in a vacuum after flushing with nitrogen gas and placed in an oil bath at 110 °C for 22 h. Hereafter samples were stored at -20 °C in Eppindorf tubes. Amino acid profiling was done with the use of a Dionex high performance liquid chromatography (HPLC) unit. Preparation of the amino acids for injection into the HPLC was done by filtrating 1 ml of hydrolysed protein sample through a 33 mm Millex-HV 0.45 µm filter 55 into a second Eppendorf tube. Ten µl of the filtered sample was pippeted into an Erlenmeyer flask and 4 ml distilled water, 800 µl Borate buffer, 10 µl NorValine was added to the sample. One ml of the prepared sample solutions were then injected in the HPLC with RF2000 Fluorescence detector and a Nova-Pak C18 4 µm, 3.9 x 150 mm column using Chromeleon 6.80 software. The results were converted from moles per ml to g/100 g protein.

2.5. Statistical analysis

The data was analysed using SAS software for Windows Version 9.3. The main effects were gender and muscle type and the model was fitted using the GLM Procedure. The following equation indicates the model for the experimental design:

$$y_{ij} = \mu + m_j + g_k + \varepsilon_{ik}$$

The terms are defined as follows: μ = the overall mean; m_j = the effect of muscle type; g_k = the effect of gender; ε_{ik} = the error associated with the effects of muscle type and gender. The type III sums of squares results were interpreted as the data was unbalanced. The LS means and Bonferroni *Post hoc* tests were used to compare levels within factors. P-values smaller than 0.05 were considered significantly different ($P<0.05$).

3. Results and discussion

The effect of gender on the moisture, protein, fat and ash content of the meat is presented in Table 2. For the proximal analysis, no difference ($P>0.05$) between male (n=9) and female (n=5) were found for fat (1.8%±0.076for males and 1.9%±0.106 for females) and ash content (1.2%±0.022 for males and 1.2%±0.031 for females) although gender differed ($p<0.05$) for moisture and protein, the females having the highest moisture 77.2%±0.204 and males having the highest protein 21.5%±0.165. Although the difference between genders for protein content is statistically significant, a difference of 0.59% at a 20% fraction raises the question whether it is biologically significant?

The similarity in fat content between genders is contrary to research on other game species, springbok (*Antidorcas marsupialis*); kudu (*Tragelaphus strepsiceros*) and impala (*Aepyceros melampus*), where females had a higher muscle fat content than males (Hoffman *et al*., 2007; Hoffman *et al*., 2009a). On the other hand, the method used for fat extraction differs between this experiment and the literature cited in that the method used here is an extraction that does not include the phospholipids; their inclusion could have a substantial effect on the final fat content results. This would also account for the lower fat content compared to that found in other game species. The increase in both moisture and fat is another noteworthy finding which is contrary to what is expected as moisture normally decreases with an increase in fat content (Young *et al*., 2001, Hoffman *et al*., 2007; Hoffman *et al*., 2009a). Additionally there was a shortage in feed at the time of the trial as the buffalo culled had very little subcutaneous fat and seemed underfed (body condition score <2.5). No differences between ash was expected for either gender or muscle differences.

The proximate results of the different muscles are presented in Table 3. Differences ($P<0.05$) were found between the BF (76.9±0.212%) and SM (76.2±0.228%) for moisture, and BF (20.6±0.239%) and SM (21.7±0.258%) for protein and also between the LD

(1.5±0.110%) and SM (2.0±0.118%) for fat content and between the LD and BF (2.1±0.110%) for fat content. Similar small differences for moisture and protein are seen between muscles as was noted between genders and with a difference of <1%, the biological significance is questionable. A difference worth mentioning is the difference for fat between muscles, both the BF and SM are located in the hind quarters whereas the LD is not. The LD is a muscle involved in the structural integrity of the animal, activated with most activities and thus due to regular use would be a leaner muscle than the BF and SM. The LD is also a later maturing muscle than the BF and SM and the intra-muscular fat (IMF) is the last depot for storage of fat during the proses of maturation which might explain why the fat content is lower for the LD.

Table 3 Effect of gender on the proximate composition (means ± se) of buffalo meat

	Gender		**p-value**
	Male	**Female**	
Moisture	76.0 ± 0.146	77.2 ± 0.204	<0.0001
Protein	21.5 ± 0.165	20.9 ± 0.230	0.0444
Fat	1.8 ± 0.076	1.9 ± 0.106	0.5154
Ash	1.2 ± 0.022	1.2 ± 0.031	0.8083

Table 4 Effect of muscle type on the proximate composition (means ± se) of buffalo meat

	Muscle		
	BF*	**LD****	**SM*****
Moisture	76.9^{a} ± 0.212	76.7^{ab} ± 0.212	76.2^{b} ± 0.228
Protein	20.6^{b} ± 0.239	21.2^{a} ± 0.239	21.7^{ab} ± 0.258
Fat	2.1^{a} ± 0.110	1.5^{b} ± 0.110	2.0^{a} ± 0.118
Ash	1.2 ± 0.032	1.2 ± 0.032	1.2 ± 0.034

$^{a, b}$ Values in rows with different superscripts differ significantly (*P*<0.05)
* *M. Biceps femoris*
** *M. Longgissimus dorsi*
*** *M. Semimembrinosus*

The amino acid profiles of the meat are presented in Table 5 (gender differences) and Table 6 (muscle types) as a percentage of total protein. For the amino acid content the only differences between genders were found for Threonine and Methionine with the males having higher concentrations of both. These differences can be attributed to the higher protein content of the meat found in males and once again, the differences are so small that it is arguable whether these differences are biologically significant for gender and/or muscle type. Hoffman *et al*. (2007) indicated that amino acid composition is affected more by the feed intake (area) of game animals than gender or muscle differences. In agreement with previous studies on impala and kudu, Leucine and Lysine were the amino acids with the highest occurrence in buffalo meat (Hoffman *et al*., 2005b; Mostert & Hoffman, 2007). Differences (P<0.05) between muscle types for amino acid content were found for Alanine between the BF (5.1±0.045%) and SM (5.2±0.048%), for Valine between the BF (4.7±0.053%) and SM (4.9±0.057%) and for Histidine between the BF (2.5±0.047%) and the LD (2.7±0.047%).

Table 5 Effect of gender on the amino acid profile (means ± se) of buffalo meat

Amino acid	**Gender**		**p-value**
	Male	**Female**	
Threonine	3.8±0.027	3.7±0.038	0.0297
Serine	3.0±0.032	2.9±0.044	0.0999
Alanine	5.2±0.031	5.2±0.043	0.5373
Valine	4.8±0.037	4.8±0.051	0.7449
Methionine	2.4±0.019	2.3±0.026	0.0427
Isoleucine	4.2±0.031	4.1±0.043	0.1157
Leucine	7.8±0.062	7.6±0.087	0.1257
Tyrosine	3.2±0.034	3.1±0.048	0.1486
Phenylalanine	3.7±0.040	3.6±0.056	0.1700
Histidine	2.6±0.032	2.6±0.045	0.3084
Lysine	8.2±0.088	8.0±0.124	0.2478
Arginine	7.7±0.520	7.0±0.726	0.4495

No differences were found for individual fatty acids between gender and no biologically significant differences were found between the LD and SM muscles (Table 7 and 8, respectively). The main fatty acids found during analysis were Palmitic acid (C16:0), Stearic acid (C18:0), Oleic acid (C18:1n9), Linoleic acid (C18:2n6) and Linolenic acid (C18:3n3). The n-6:n-3 ratio for buffalo meat is 2.5 (similar to kudu, 2.22) which is lower than 4 and thus a positive ratio with regards to health (Hoffman *et al*., 2009b). Nonetheless, a lower ratio was expected as found in a study by Du Buisson (2006) on springbok (*Antidorcas marsupialis*) and blesbok (*Damaliscus dorcas phillipsi*) seeing as buffalo are also grazing ruminants and the buffalo on this trial only had access to natural grass grazing high in n-3 fatty acids.

Table 6 Effect of muscle type on the amino acid profile (means ± se) of buffalo meat

Amino acid	Muscle		
	BF*	LD**	SM***
Threonine	3.8 ± 0.040	3.8 ± 0.040	3.8 ± 0.043
Serine	3.0 ± 0.046	3.0 ± 0.046	2.9 ± 0.050
Alanine	5.1^{b} ± 0.045	5.2^{ab} ± 0.045	5.3^{a} ± 0.048
Valine	4.7^{b} ± 0.053	4.8^{ab} ± 0.053	4.9^{a} ± 0.057
Methionine	2.3 ± 0.027	2.4 ± 0.027	2.3 ± 0.029
Isoleucine	4.0 ± 0.045	4.2 ± 0.045	4.2 ± 0.048
Leucine	7.7 ± 0.091	7.8 ± 0.091	7.8 ± 0.098
Tyrosine	3.1 ± 0.049	3.1 ± 0.049	3.2 ± 0.053
Phenylalanine	3.5 ± 0.058	3.6 ± 0.058	3.7 ± 0.063
Histidine	2.5^{b} ± 0.047	2.7^{a} ± 0.047	2.6^{ab} ± 0.050
Lysine	7.9 ± 0.128	8.2 ± 0.128	8.2 ± 0.138
Arginine	8.1 ± 0.754	7.2 ± 0.754	6.6 ± 0.812

[a, b] Values in rows with different superscripts differ significantly (*P*<0.05)
[*] *M. Biceps femoris*
[**] *M. Longgissimus dorsi*
[***] *M. Semimembrinosus*

In an evaluation of the total fatty acids, the fatty acid composition did not differ (*P*>0.05) between genders or between muscle types for saturated fatty acids (SFA; male = 39.1±1.117%, female = 38.0±1.591%, LD = 38.5±1.323%, SM = 38.6±1.425%), mono-unsaturated fatty acids (MUFA; male = 32.4±0.884%, female = 31.0±1.258%, LD = 30.7±1.046%, SM = 32.7±1.127%) and poly-unsaturated fatty acids (PUFA; male = 28.4±1.700%, female = 31.0±2.419%, LD = 30.7±2.012%, SM = 28.7±2.167%). No differences were expected between genders for the total fatty acid compositions as the fatty acid composition is predominantly influenced by the dietary intake (Crawford *et al*., 1970; Hoffman *et al*., 2009b). Additionally, the similarity in the amount of intra-muscular fat between genders would also decrease the probability of finding differences in the fatty acid composition. From the data it is clear that buffalo meat has a healthy fatty acid composition, with relatively low saturated fatty acid and high poly-unsaturated fatty acid fractions when compared to domestic cattle and sheep meat (Nuernberg*et al*., 2005; Claasen, 2008). The P:S ratio of >0.7 is another positive aspect as Raes *et al*. (2004) reports this to be a healthy ratio for red meat. It was also found in a study on blesbok (*Damaliscus dorcas phillipsi*) that the fatty acid and amino acid composition differed between areas/regions. In the same study it was shown that blesbok also had a P:S ratio of >0.7 (Hoffman *et al*., 2008). The study by Hoffman *et al*. (2009b) also suggests that browsers have a higher MUFA and PUFA fraction and P:S ratio (1.22) as found in kudu and seeing as buffalo have been known to browse in times of scarce grazing, their fatty acid composition might differ between regions and/or seasons.

Table 7 Effect of gender on the fatty acid profile (means ± se) of buffalo meat

Fatty Acid	Gender		p-value
	Male	Female	
C14:0	0.6±0.060	0.6±0.085	0.9980
C16:0	18.1±0.550	17.9±0.780	0.8080
C16:1n7	1.5±0.119	1.4±0.168	0.4980
C18:0	18.8±0.769	18.7±1.089	0.9340
C18:1n9	30.5±0.852	29.1±1.207	0.3473
C18:2n6	12.3±0.864	14.1±1.225	0.2310
C18:3n6	0.04±0.053	0.2±0.075	0.1999
C18:3n3	3.7±0.256	4.0±0.362	0.4932
C20:0	0.7±0.172	0.5±0.244	0.3994
C20:1n9	0.3±0.023	0.3±0.032	0.5788
C20:2n6	1.0±0.100	1.1±0.141	0.5285
C20:3n6	1.1±0.132	0.6±0.188	0.0719
C20:4n6	5.8±0.573	5.5±0.812	0.8057
C20:3n3	0.1±0.139	0.4±0.197	0.1621
C20:5n3	1.5±0.184	1.6±0.261	0.9483
C22:0	0.7±0.306	0.2±0.433	0.3513
C22:2n6	0.1±0.070	0.02±0.099	0.5900
C22:4n6	0.3±0.036	0.3±0.051	0.4466
C22:3n3	0.2±0.153	0.4±0.216	0.6229
C22:5n3	1.5±0.249	1.9±0.353	0.3274
C22:6n3	0.9±0.298	0.8±0.423	0.8707
C24:0	0.1±0.025	0.1±0.035	0.2098
C24:1n9	0.05±0.045	0.1±0.063	0.2191
SFA*	39.1±1.118	38.0±1.591	0.5775
MUFA**	32.4±0.884	31.0±1.258	0.3668
PUFA***	28.4±1.700	31.0±2.419	0.4040

* Saturated fatty acids
**Mono-unsaturated fatty acids
***Poly-unsaturated fatty acids

Table 8 Effect of muscle type on the fatty acid profile (means ± se) of buffalo meat

Fatty acid	Muscle		p-value
	LD#	SM##	
C14:0	0.7±0.070	0.6±0.074	0.1484
C16:0	18.1±0.638	17.8±0.672	0.7388
C16:1n7	1.7±0.138	1.2±0.145	0.0228
C18:0	19.3±0.892	18.3±0.940	0.4017
C18:1n9	28.8±0.988	30.9±1.042	0.1455
C18:2n6	13.5±1.003	13.0±1.057	0.7037
C18:3n6	0.1±0.061	0.1±0.064	0.5354
C18:3n3	3.5±0.297	4.2±0.313	0.1253
C20:0	0.1±0.200	1.0±0.211	0.0036
C20:1n9	0.3±0.026	0.3±0.028	0.4175
C20:2n6	1.4±0.116	0.6±0.122	<.0001
C20:3n6	1.3±0.154	0.4±0.162	0.0004
C20:4n6	5.6±0.665	5.7±0.700	0.9218
C20:3n3	0.4±0.161	0.1±0.170	0.3210
C20:5n3	1.5±0.214	1.6±0.225	0.8343
C22:0	0.05±0.355	0.9±0.374	0.0897
C22:2n6	0.1±0.081	-0.01±0.085	0.2747
C22:4n6	0.2±0.042	0.4±0.044	0.0235
C22:3n3	0.5±0.177	0.1±0.187	0.1145
C22:5n3	1.6±0.289	1.8±0.304	0.5616
C22:6n3	0.9±0.346	0.7±0.365	0.8063
C24:0	0.1±0.029	0.1±0.030	0.3886
C24:1n9	0.1±0.052	0.1±0.055	0.4320
SFA*	38.5±1.323	38.6±1.425	0.9660
MUFA**	30.8±1.046	32.7±1.127	0.2157
PUFA***	30.7±2.012	28.7±2.167	0.4970

* Saturated fatty acids
**Mono-unsaturated fatty acids
***Poly-unsaturated fatty acids
\# *M. Longgissimus dorsi*
\#\# *M. Semimembrinosus*

4. Conclusion

From the data it is evident that buffalo meat from extensively reared buffalo has a healthy nutritional composition. A total IMF content of <2% and protein content of >20% indicates a low fat:protein ratio. More importantly, the fatty acid composition of buffalo meat is comparable to the healthy fatty acid composition that is associated with game meat. A P:S ratio of >0.7 further supports this health attribute of buffalo meat. Regarding amino acids, buffalo meat contains all the essential amino acids required in the human diet. The differences between gender and muscles were of little biologically significance even though statistical differences were noted in some cases. Thus it would seem that buffalo meat displays all of the positive attributes associated with game meat.

Although this study provides a baseline of information on the nutritional value of buffalo meat, further research is required to evaluate the effect that extrinsic (season, diet, etc) and intrinsic (age, etc) factors may have on these values. A larger sample size is also required. Also, further research is needed on the effect of supplementary feeding on the chemical composition of the meat seeing as the samples taken here were solely dependent on natural grazing for nutrition.

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ADDENDUM B

Open ended questionnaire used for interview with buffalo farmers

Name and Surname	
Farm name and GPS coordinates	
District farm is situated in	
Main occupation	

Farm Information

Veld type	Sweet		Sour		Mixed		Other
Farm uses	Game		Livestock		Crops		Other
Size of farm/s							

Buffaloes

Total number of buffalo									
Number of herds									
How many camps per herd (rotational grazing)									
Ratio of male to female per herd	Herd number	1		2					
		3		4					
		5		6					
		7		8					
Number of buffalo per camp									
Size of that camp									
How many other animals in the same camps	Game		Species		Domestic		Species		
Supplementary feed	Complete ration		Supplementary		Roughage		Other		

History

When did you start breeding/keeping buffalo							
Reason for keeping buffalo	Trophy hunting		Breeding		Tourism/ lifestyle		Other
Origin of buffalo	East Africa		Addo		Kruger		Other
Bought where and when	Breeder (which)		Auction (which)		Other		

Breeding

How often do bulls rotate (how long with same cows)	
Number of active bulls per herd	
Calving % per annum	

Additional questions were added for each farm while the researcher was making observation of the farm and the daily activities, these were not included as they differed between farms.