Producing Game Meat to Meet International Hygiene and Food Safety Requirements in the Bush

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BACKGROUND

Over the past decade, both South Africa and Namibia has seen a huge growth in the farmed wildlife industry. A large number of these were farmers who had converted from domesticated livestock farming to either a pure game farming activity or a mixed livestock-game farming activity.

Although farmers realized the economic potential of game farming some 40 years ago, the commercial utilization of game only grew extensively during the last 20-25 years (Higginbottom and King, 2006). South Africa has progressed to become a world leader in the sustainable conservation and utilization of game species (Ebedes, 2002). It is widely recognized that game farming is the fastest growing agricultural industry in South Africa (Van den Berg, 2004) and today there is more game in South Africa than at any time in the past 100 years (Bothma, 2005). By 1998 an estimated 2300 exempted game ranches, covering approximately 3.6 million hectares (49%) of land existed in the Limpopo Province (previously the Northern Province) and in 2005 the Northern Cape Province had over 1109 exempted game ranches, totalling 19.5-22.0% of the surface area in the province whilst in the Eastern Cape Province the total number of exempted ranches equated to 12.3% of the area (Cloete, Taljaard and Grové, 2007; Hoffman, 2007; Table 1). Many cattle farmers are changing over to game farming and during the past century game farming was the fastest growing agricultural industry in the country (Van Schalkwyk, 2004). In 2000 there were 5061 "exempted game farms" registered for wildlife ranching with the provincial conservation agencies with a total land area of 10.3 million hectares. This represented an increase of 47% in areas occupied by wildlife ranches since 1993 and total estimated investments of greater than R15.5 billion (Porter, Ferrer and Aylward, 2003). Bothma (2002) estimated a total of 9000 private commercial wildlife ranches covering a surface area of about 17 million hectares or 13% of the total land. Some estimates set the conversion rate from cattle to wildlife ranching at 500000 hectares per year (Flack, 2002). In addition, many livestock ranches carry enough wildlife to allow their commercial exploitation (Bothma, 2005).

A major reason for this growth in the number of game farmers in both countries was the perception that with the abolishment of the apartheid system, the number of eco-tourists visiting South Africa would increase dramatically and they would all wish to visit farms where they can experience the "wild Africa". At the same time, the profitability of ranching with traditional livestock (cattle, sheep and goats) also decreased. There were also other incentives for farmers to change to game ranching such as state subsidy on fencing material, the fact that the purchasing of wild animals was tax deductible. A number of astute businessmen saw the farming of game as a unique business opportunity that would realise good growth on investment. This has resulted in over 20% of the farming land in South Africa presently being under some form of wildlife/game management (Table 1).

"Wildlife ranching" refers to the managed extensive production of free-living animals on large fenced or unfenced communal land (Bothma, 2002) and which is utilised in diverse ways ranging from local (biltong) hunting (53.4% of the gross income) to trophy hunting (18.1%), eco-tourism (4.7%) and game meat production (2.7%) (Van den Berg, 2004). Presently capture and sale at auc-

Table 1. Game farming/ranching as a proportion of the total surface area of South Africa.

Areas	ha	%
Government protected areas	7 500 000	6.1
Private wildlife ranches	20 500 000	16.8
Total under "industry conservation management"	28 000 000	22.9
Total agricultural land	100 600 000	82.2
Total area of South Africa	122 340 100	100

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tions, mainly for restocking, utilization for recreational hunting or cropping for the game meat market is a very lucrative business worth millions of Rands (Hoffman, 2007). Hunting includes trophy hunting (mostly by international customers) and meat hunting (mostly by South Africans) for home consumption or commercial production. Trophy hunting contributed 18.1% and local hunters 53.4% to the gross income of wildlife ranches in 2000 (Higginbottom and King, 2006). Overpopulation of game animals however causes the risk of visitors (tourists) losing the illusion of wild animals roaming in an unspoilt habitat (Hoffman, 2007). Therefore, some of the off-take of animals, whether in the form of hunting, captures for live sale or harvesting is generally seen as essential to avoid overpopulation on properties where large predators do not occur (ABSA, 2003). However, the demand for stocking of animals is on the decline and therefore an alternative for the surplus should be sought. Furthermore the time is fast approaching where only the more scarce and exotic species will fetch high prices and more "common" species will have to be marketed in an alternative way (Hoffman, 2007).

Such an alternative way to remove the surplus animals is by means of hunting or commercial harvesting.

CONSUMPTION OF GAME MEAT/VENISON

Meat production is becoming an increasingly important economic opportunity on a large number of farms (which previously mainly focussed on large-scale, extensive cattle or domesticated ruminant production) in South Africa (Van der Waal and Dekker, 2000). This phenomenon is nowhere else more evident than in the Limpopo Province of South Africa where cattle numbers have declined in favour of game ranching activities (Robinson and Lademann, 1998; Smit, 2004). Studies by Hoffman (2003) indicated that the majority (73%) of consumers in the Western Cape had eaten wildlife meat before, of which most had purchased the meat in butcheries and then prepared at home. Another study by Hoffman et al. (2003) indicated that meat from wildlife is also very popular with tourists, as 92% of them eat game meat when on tour and 88% when they are at home. Sixty to sixty-five percent of the total income from game farming is generated from trophy and game meat hunting (Van der Merwe, 2005). Van den Berg (2004) indicates that some 2.7% of the income of the billion Rand game industry is generated by game meat production. More recently, Saayman, Van der Merwe and Roussouw (2011) estimated that the contribution to real GDP of this activity (biltong hunting) to be in excess of R6 billion in South Africa. These authors noted that while on a hunting safari, a hunter spends R4130.00 on general expenses and R11622.37 on game. This results in a total of R15752.37 that an average biltong hunter spends per year on hunting. Nonetheless, in the 2005 season it was estimated that South Africa exported the deboned meat from 160 000 game carcasses (Hoffman and Wiklund, 2006). Game meat from game parks, big hunting farms and approved game abattoirs is therefore finding its way to the local and international consumer's table. Consumers are however showing an increased awareness of food issues and trends (Hoffman, 2003) and therefore animal welfare, health properties, organic environmentally friendly production and product safety have become hot topics with consumers in the past few years (Swartland, 1984; Gouws, 1999; Higgs, 2000; Bernués, Olaizola and Corcoran, 2003; DEFRA, 2003; Verbeke and Vackier, 2004; Du Buisson, 2006; Krystallis, Chryssochoidis and Scholderer, 2007). Consumers have concerns that relate to the welfare of animals, especially where intensive farming practices are followed e.g. the contaminated cattle feed debacle in Belgium (Hoffman, 2003). South African game animals are mostly wild and generally farmed on extensive free range farming systems (without any supplementary feeding) or semi-intensified (with supplementary feeding) with minimal contact with humans.

Traditionally meat has been seen as an overall healthy, nutritious food necessary for the maintenance of good health (Higgs, 2000). However, various health reports have caused consumers to consider red meat as unhealthy. This negative health image that many consumers have of red meat is due to its predominantly saturated fat that is associated with health risks. Schönfeldt (1993) indicated that this is a good reason for health conscious consumers to look for a healthier alternative. Therefore, current trends among consumers worldwide show a shift towards buying lean meat cuts from animals whose meat have a low fat content (Hoffman, 2003; Webb, 2003). In response to this trend there is an increase in the marketing of meat derived from "wild" animals such as deer (venison) and African game species (Malmfors and Wiklund, 1996; Wiklund, Stevenson-Barry, Duncan and Littlejohn, 2001; Hoffman, et al., 2003; Hoffman and Cawthorn, 2012). Game meat does not have a high fat content and is low in energy (kJ) and cholesterol but high in protein (Pauw, 1993; Bothma, 2004). Furthermore, game meat can comply with the nutritional guidelines that places increasing emphasis on reducing the ratio of n-6/n-3 poly-unsaturated fatty acids in the diet (Hoffman, 2004; Smit, 2004; Hoffman, Kritzinger and Ferreira, 2005; Hoffman and Cawthorn, 2012), which was shown to be favourable with respect to the risk of coronary heart diseases.

The food retail industry is focusing consumers' attention on "organic" and "natural" products (Van der Merwe, 2004). This prompted consumers to become more interested in organic foods that also represent the healthy, animal welfare and environmentally friendly food that they desire. The modern consumers perceive that hormones and antibiotics are not used in these animal production systems and that organic meat is therefore free from antibiotics, added hormones and genetically modified feed. Due to the nature of extensive or semi-intensive farming systems, South African game meat is described as an organic product as it contains no antibiotics, growth hormones or other chemicals such as fertilizers used in conventional farming systems (Pauw, 1993; Hoffman

and Bigalke, 1999; Jansen van Rensburg, 2002; Bothma, 2004; Hoffman and Wiklund, 2006; Bekker, Hoffman and Jooste, 2011).

Food scares such as Bovine Spongiform Encephalopathy (BSE) in beef in England and Europe, classical swine fever and foot-and-mouth disease in South Africa and lung disease in Botswana and Namibia highlights public awareness with respect to product origin, production methods and how safe it is to eat (Luten, Jacobsen, Bekaert, Saeb and Oehlenschläger, 2006; Bekker et al., 2011; Bekker, Hoffman and Jooste, 2012; Magwedere, Shilangale, Mbulu, Hemberger, Khaiseb, Hoffman, and Dziva, 2013). Although food safety is perceived by consumers as a given, attitudes towards meat safety greatly affect consumers' overall choices and the meat types available for sale. This offers the game meat industry and the legislators (national and international) a motive for mandatory or voluntary implementation of quality assurance strategies (including food safety) along the food supply chain (Krystallis, Chryssochoidis and Scholderer, 2007). However, the climate of recent political change in South Africa and its fragmentation into a greater number of provinces has led to increased inconsistencies in policy and regulations between provinces, and this has resulted in inefficiencies. At present the game meat safety is regulated and managed on a reactive basis through the inadequate Meat Safety Act (Act 40 of 2000) that does not make provision for the game industry. Draft regulations to be promulgated under the said Act has been in the process of being formulated for several years, but has not been promulgated yet. Furthermore the legislation ruling game, hunting or harvesting and the subsequent handling of game meat is fragmented in the different levels of government and no uniform system that manages meat hygiene and safety from the "farm to the fork" exists for the whole of South Africa. Different Departments i.e. Agriculture, Health and Environmental Affairs at all levels of government are involved in different ways, all trying to regulate the same industry, but with very little liaison and cooperation between themselves and with little input from the game meat industry (Bekker et al., 2011).

The significant growth in human population and advancing agriculture necessitates researchers to obtain knowledge of the potential of game meat as an alternative source of proteins, minerals and other nutrients (Smit, 2004). There is an urgent need for more precise information on the status, dynamics and policy implications of this rapidly emerging industry in order to ensure increased levels of national consistency and coordination in policies and legislation (Higginbottom and King, 2006; Bekker et al., 2011).

THE FORMAL GAME MEAT SUPPLY CHAIN

For meat to enter the formal game meat supply chain it has to adhere to the strict regulation of the Meat Safety Act and if it is to be exported, it also has to adhere to the regulations as stipulated by the importing country.

The fact that the game animals harvested are all wild and free roaming makes it impossible to capture and transport these live to traditional formal abattoirs. This has necessitated the industry to adapt and develop harvesting methods that are suitable for the different species and the terrain. Both in South African and Namibia the terrain wherein these animals are found could vary from the arid zones, to the Karoo to the mountainous regions or the bushveldt. In each of these terrains, different species and different methodologies need to be applied for the harvesting of the animals.

Although numerous different wildlife species are harvested, there are a number of production traits and harvesting activities that are common to all these species. The harvesting should be done in a humane manner so that the animals do not suffer any undue stress. Yet at the same time the methodology used should be economical and be highly efficient. In the latter the number of animals removed per time unit is of special importance. The method employed should also ensure low wounding percentages and minimal damage to meat. The method employed should also cause a minimum disturbance and scattering of the herd. The animals harvested should form large herds and should allow the selectivity of correct ages and sexes. When the harvesting procedure is completed, the remaining animals must show no association of this activity with humans.

The terrain wherein the animals are harvested must be suitable for rapid carcass retrieval. The animals must be bled efficiently. Thereafter the animals must be presented for carcass inspection and transported to the breaking plant where in the cold chain and good hygiene practises are maintained.

SUSTAINABLE HARVESTING OF GAME/ GROWTH AND HARVESTING RATES

The ideal harvesting system should allow for the management of population structures of different wildlife species without adversely disrupting their population growth rates. Harvesting should be economical and the period of harvesting should be as short as possible. The harvesting team must ensure that the end product is of high quality. It is therefore extremely important that the cold chain is maintained throughout the game meat value chain. The ideal harvesting system should allow only minimal ecological and physiological disruption and must be ethically and aesthetically acceptable to the game producer as well as the consumer.

The natural growth rate of an undisturbed population is equal to the birth rate and natural deaths. Various phases of growth of a population maintain different growth rates resulting in a typical sigmoidal (S-shaped) growth curve. It is sometimes difficult to know in which growth phase a game population is at a given moment. The observed growth rate as calculated from trends observed during successive game counts can be used when determining

the harvesting rate. Theoretically the harvesting quota will be equal to the growth rate which will result in a population with constant numbers. In semi-arid to arid environments, as occur in South Africa and Namibia, the rainfall and thus primary production are highly variable. Animal biomass must be managed to ensure that the carrying capacity of the vegetation is not exceeded and that ecosystems are not damaged. The harvesting quotas, in combinations with other forms of utilisation, such as own use, trophy hunting and live capture for sale, should be carefully determined to take all these factors into account.

Growth rates on a ranch can be manipulated by changing the availability of water and food or in a more direct manner by hunting, which can have two main impacts namely, direct reduction in wildlife numbers, and managing game population gender ratios to enhance production. Wildlife numbers will grow to exceed carrying capacity, particularly in fenced areas, and will then cause ecosystem degradation. Populations managed for production should be held on the steep slope of the sigmoidal curve and significantly below maximum carrying capacity to ensure that:

- Optimal production is achieved;
- Animals are in good condition and breeding well;
- Rangeland condition is protected.

Harvesting Quotas

Harvesting game, in order to keep populations below the ecological equilibrium, results in more environmental resources utilized. This improves the productivity and survival rate of game. However, a game population which is reduced to too few animals will result in the population shifting to a slow-growth phase and it will thus take longer for the population to recover to a harvestable state. The correct gender ratio is also important to manage for optimum growth. Various techniques exist to calculate the harvesting quota for different game populations. Game harvesters should familiarise themselves with the important variables which are taken into account in using various techniques to determine game harvesting quotas (Bothma, 2002).

Selection of Game to be Harvested

Whatever the objective of the harvesting operation is, animals from both sexes must be harvested to maximize reproduction potential. However, selective harvesting of one sex group is often required since most natural game populations have a surplus of males. Reducing the males leaves lactating females and females in gestation with more environmental resources, especially in the dry winter times. The general rule is to have three (3) females for every male in a population. Enough males of the correct age must however remain in the population to ensure successful breeding with the females. A single male will tend to chase around young animals and in the absence of competition from other males will not breed that well. This defensive territorial behaviour plays an important role ensuring optimal reproduction of game.

Selecting certain age groups for harvesting for meat production is recommended. A percentage of young animals in their first year can be harvested before the onset of the dry winter months. In any game population there are females that do not contribute to the population growth and should be harvested first. It is important to keep young females that can be added to the breeding group the following year for an optimal yield. When selective harvesting of males are done, some young males that are not yet of trophy status should also be left to ensure that they will become replacement males in the following year.

Although selective harvesting has certain advantages, random harvesting distributed proportionally over the population is the generally recommended practical approach. Selective harvesting by species may result in a decrease in numbers of one species and an increase of the other. This may have an influence on the environmental resources and ecology.

When and Where to Harvest

The time of harvesting is important especially during mating and birth seasons and a rest period of at least a month before and after each of these periods is recommended. Disruption can influence the impregnation and implantation of the embryo. Game should also not be disrupted during mating (negative growth rate) or calving/lambing (unethical) and mothers should not be separated from their off-spring (infants may starve to death).

The mating season for African ungulates is usually in the late summer (February – March). Offspring are normally born in late spring (October – November). Knowledge of the gestation period is required, for example, the Springbok has a gestation period of five and a half (5½) months, the kudu seven (7) months, the Red Hartebeest eight (8) months, Gemsbok nine (9) months and the Hartmann's Zebra twelve (12) months.

In South Africa and Namibia the night culling/harvesting season for game harvested for commercial meat production usually commences in April and ends in August.

The terrain must be suitable for the harvesting operations to take place. Harvesting at night can only occur where the area is not too rocky and where harvesting vehicles can drive around at night. Every harvesting operation is different and game species to be harvested must be selected accordingly. This is extremely important in areas where ecosystems are fragile and where disturbance can take many years to repair.

Maintaining a Sustainable Population

The aim of sustained harvesting is to remove a certain number of animals every year from the game population without resulting in a long-term decline of the population. Short-term changes in population sizes are required to adapt to the highly variable climatic conditions in Na-

mibia. When a game population remains fairly stable in the long term it is at an ecological equilibrium. It is recommended that a game population should be harvested every two to four years and this can increase the production of some species by 10-20%.

Mitigation of Harvests with Other Forms of Sustainable Use

Game ranchers benefit from wildlife in different ways, through both consumptive (trophy hunting, capture and sale of surplus live animals, own use and harvesting for meat production) and non-consumptive use (tourism). When the rancher allows trophy hunting on his/her farm, maintaining an excess of males on the ranch is preferred and the level of surplus can then be determined by the profitability between harvesting for meat production and trophy hunting. Young mature males usually obtain optimal trophy quality only at the age of five to six years. Tourists on the farm should not be exposed to the harvesting operations. Although harvesting for meat exports is conducted in an ethical way, tourists from an urban environment may not like to be exposed to the realities of meat production systems. Remember, they came from far to appreciate the live animals!

HARVESTING TECHNIQUES ADAPTED TO THE TERRAIN

The type of harvesting technique employed will be governed by the species and the amount of animals that are being harvested, as well as the habitat and the vegetation present in the harvesting region. Another contributing factor is the importance of the stress induced by the use of a specific harvesting method on the animals being harvested. The ante mortem stress induced by the harvesting or slaughter method will negatively affect the meat quality attributes of domestic livestock as well as game (Veary, 1991; Wiklund, Andersson, Malmfors, Lundström and Danell, 1995; Hoffman, 2000; Kritzinger, Hoffman and Ferreira, 2003; Hoffman and Wiklund, 2006; Laubscher, 2009; Van Schalkwyk and Hoffman, 2010).

Thus the use of a specific harvesting technique must be selected to ensure the least amount of stress, resulting in the highest meat quality. The amount of stress and method used however is depended on the marksmanship of the hunters being employed. The other governing factor determining the method used is the costs and thus the efficiency of the harvesting method. If the harvesting process is not conducted in an efficient manner it will result in an increase in labour costs, due to more time needed to complete the harvesting operation as well as the fixed costs per unit (animal) removed. If accurate shooting is not practiced it will also contribute to the costs, since Bothma stated in 2002, that the ammunition costs can accounted for up to 30% of the costs. These costs are associated with the need for more ammunition and through the drop in productivity due to animals being missed or wounded and the increase in damaged carcasses as well as the negative effect on meat quality due to stressed animals (Ruggiero and Ansley, 1992). Thus if an efficient method is not used it will increase the associated costs and thus directly affect the price of the game meat and the profitability of the harvesting operation.

There are four general requirements to ensure the successful harvesting of animals:

1. Instantaneous death;

2. Minimum disturbance of population;

3. Animal should be used to human presence;

4. For a carcass to be exported they must be shot in head or high neck area.

These factors are further explained as follows:

Instantaneous death – in other words the animal must be humanly slaughtered. This would result in the least amount of ante mortem stress endured by the animals, which would have positive effects on the resulting meat quality.

Minimum disturbance of the population – The animals being harvested must not be severely distressed or effected by the harvesting operations. This is achieved by not pursuing the same herd continuously and thus causing a particular herd severe distress which could cause a fatality or increase the animals "wildness" or behaviour towards humans, which would negatively affect future interaction with people (tourism).

Make the animals accustom to presence and activities of people by frequently interacting with them throughout the year during the normal ranching activities. This will possibly make the animals less skittish when harvesting operation commences.

If carcasses are destined for export or for fresh meat consumption—carcasses must be in an unspoiled condition and thus are required to be shot in the head or high upper neck area.

The techniques used by the commercial industry are however continuously being adjusted as to harvest the most amount of animals in the least amount of time and thus make the process as cost effective as possible. The following techniques are commonly employed by the South African game meat industry to harvest game animals for meat production purposes.

Night Harvesting

The most commonly used and most popular method of harvesting game is night cropping for the removal of most animals on a large scale (Veary, 1991; Lewis, Pinchin and Kestin, 1997; Hoffman, 2000; Kritzinger, Hoffman and Ferreira, 2003; Hoffman and Wiklund, 2006; Le Grange, 2006; Van Schalkwyk and Hoffman, 2010). This method has been proven to be the most effective and to produce the best quality game meat. The method employs the use of strong spotlights, scoped rifles and modified vehicles

on specifically dark, moonless nights. The absence of the moon light makes for more effective immobilisation of the animals since the high intensity spotlight is more effective at blinding the animals (Bothma, 2006; Le Grange, 2006). The animals are thus also easier to approach and less skittish, which makes it easier to locate and harvest more of the animals in a shorter time period.

Hunting commences shortly after dark and continues to the dawn the following day as to make use of the full advantage of the moonless night conditions (Kritzinger, Hoffman and Ferreira, 2003). Animals are located using the spotlights on the back of the vehicle operated by an assistant. The animals are spotted by the reflection of their retinas in the light. While the high intensity spotlight temporarily immobilise the animal they can be shot by the driver which is also the marksmen—this eliminates the possibility of confusion or misunderstanding between the driver and marksmen and thus ensures more precise and efficient cropping of the animals (Hoffman and Wiklund, 2006). Firing should only commence if a clear shot is possible (Kritzinger, Hoffman and Ferreira, 2003) as to ensure small possibility of wounding animals. The use of spotlights on moonless nights enables the marksmen to shoot from relatively close distances ranging from 25 to 100 meters. It is however not uncommon to harvest animals at distances, ranging from 40 to 200m. However, it is found on average, that shots at ranges exceeding 150m resulted in unacceptable levels of inaccuracy or missed shots. This is especially true, when lighter calibre rifles are used and there is a strong prevailing wind condition present. These environmental circumstances are frequently found in the South African plains (Karoo) where plains game species are harvested and thus must be taken into account when selecting the appropriate harvesting method. This is also true when selecting the correct rifle calibre for accuracy and for best suitability in a particular situation - as depending on the size and game species being harvested the rifle calibre will have to be adjusted accordingly to still humanely and effectively kill the animal. To increase efficiency in larger scale operations and where the terrain allows for it, several hunters may be employed simultaneously. This increases the rate of off-take and thus the amount of animals being harvested in a given time period. The harvesting of animals however requires that only head or high necks shots be achieved (Van Schalkwyk and Hoffman, 2010), with the use of high-velocity, small calibre rifles. The use of smaller calibre rifles and good shot placement ensures minimum carcasses losses and effective hygienic culling of the animals. Von la Chevallerie and Van Zyl (1971) found that these type shots resulted in the least amount of carcass damage in springbok and impala, while shots in the shoulder and buttocks region can account for up to 20% and 50% of carcass meat wastage, respectively. A good-quality telescopic sight is also a necessity, since open sights do not provide the accuracy required, especially at ranges closer too and exceeding a 100 meters. If the correct combination of rifle and marksmen is used and a high density herd is being targeted, which has been well adapted to human interaction: An average time between the culling of animals, by a single marksmen, in such a herd of impala can be 28 seconds, with a maximum time of 3 minutes and 18 seconds and a minimum time of 2 seconds as (Lewis, Pinchin and Kestin, 1997). Animals however must be collected as soon as possible after being shot and exsanguinated, preferably within 10 minutes of death, to diminish the chances of not finding the carcass and to ensure effective exsanguination of each animal. The collection of carcasses is also of high importance where a large population of predators are present since they might compete with the cropping team with the recovery of the carcass as they become more aware of the hunting routine (Le Grange, 2006). Once the hunting vehicle has shot a sufficient number of animals or 120 minutes (Van Schalkwyk and Hoffman, 2010) has passed since the first animal was shot, they are brought to a temporary field abattoir in close proximity to the harvesting area. This processing area/field abattoir is setup to efficiently process the animals with adequate lighting and processing equipment before they are transported to the commercial abattoir facility to complete processing and packaging of the products (design and procedures are described in more detail in Van Schalkwyk and Hoffman, 2010).

This technique has been found to induce the least amount of ante mortem stress on the animals being harvested and thus holds beneficial effects on the resulting meat quality attributes (Von la Chevallerie and Van Zyl, 1971; Veary, 1991; Kritzinger, Hoffman and Ferreira, 2003; Laubscher, 2009; Van Schalkwyk and Hoffman, 2010). Other main advantages of the night harvesting technique include the fact that a higher percentage of the animals can be shot in the head or upper neck area and that animals in a herd are less distressed by this harvesting procedure). The lower temperatures associated with harvesting at night may also contribute to less deleterious effects on meat quality, aided by the absence of flies at night. The disadvantages of harvesting at night are that wounded animals are more difficult to recover and with the absence of moonlight, the method is also unsuitable in areas where dense bushveldt vegetation occur, since it would be difficult to locate and spot the animals. It is also harder to distinguish between different sexes when both males and females have horns (sexually dimorphic, i.e. red hartebeest) (Ruggeiro and Ansley, 1992; Bothma, 1996). If the harvesting team is not familiar with the terrain, it can prove problematic in locating the animals and predict the animal movement at night.

Additionally the amount of moonless nights suitable for night harvesting are limited to two weeks per month and thus with a growing demand of the expanding export market, insufficient numbers of game can be harvesting in such a short period and thus alternative methods like day harvesting must be utilized to supply the market (Le Grange, 2006). Alternatively, additional vehicles have to be sent out to harvest the animals; this may add costs per

unit removed. Night harvesting is limited as some species are not suited to be harvested at night. Species such as the kudu tend to look away from the spotlight or close their eyes whilst zebra and wildebeest tend to be more skittish and stay tightly packed together, which presents a more difficult target when harvested at night. The wildebeest dark colour also makes it harder to identify its head in the telescopic sight at night and a zebra's stripes make it hard to distinguish between individuals at night when presented in a tight moving group. Some species are however perfectly suited to the use of this method, such as the springbok, blesbok and impala, which show a tendency to remain stationary and present an easier target when caught in the spotlight, due to their more tameness or territorial nature. Another trend noticed by Ruggeiro and Ansley (1992), which could be a disadvantage of night harvesting, is that the night harvesting teams tend to tire during the harvesting operation which leads to a decrease in accuracy levels and efficiency the longer the harvesting sessions precede. The night harvesting method may also be more expensive compared to harvesting during the day, since labour costs at night tend to be one and a half times those of day costs. None the less, one highly efficient company managed to remove 8 000 springbok over a seven night period.

Conventional Hunting and Day Harvesting

This harvesting technique is suited for all game species and animals are either hunted on foot or from a vehicle or they are ambushed at waterholes or from a hide placed in a specific location. Which of the these techniques will be utilized will be determined by the farming enterprise, for example if the farm focuses on eco-tourism it will not hunt animals from a vehicle as they will became more skittish and game viewing will become more difficult (Lewis, Pinchin and Kestin, 1997). It is also considered unethical to hunt game at waterholes, but it is none the less a very effective method when hunting for game which occurs in small groups, for example warthogs or for nervous game such as Bushbuck or Nyala which occur in dense bushveldt areas where walking and stalking is virtually impossible. The kudu is also prone to approaching feeding points although feeding point is not as successful when used to attract some other species such as impala (Hoffman and Wiklund, 2006). In most cases a rifle or bow is use to humanely kill the animal. It has been suggested that the use of a bow causes the least amount of disturbance, and thus would ensure a higher quality meat. This however has not been proven. Advantages of this technique, especially when on foot, are that animals can be stalked and thus less stress can be induced by the hunting method. Animals can also be selected according to age, sex or social structure and thus specific animals can be targeted and removed from the populations (Bothma, 2006). This technique is very valuable from a farming or management point of view, but it however only practical if not applied commercially or when the purpose of the hunt is to bag a trophy animal or remove a small number of management animals and thus not ideal for the cropping of a large numbers of animals. It is thus only beneficial to the farm enterprises whose focus is on tourism or trophy hunting and possible "biltong" hunters.

Alternatively, specially modified vehicles and gear (similar to that used during night harvesting) can be used to achieve a reasonably high off-take rate. This method is easily practised or utilized on all the common game species, since it is easier to spot the animals during the day compared to at night. The setup is similar to night harvesting, with the spotters on the back of a vehicle and with the driver being the marksmen minus the spotlight. The marksmen can achieve a higher success rate since animals can be clearly spotted and more easily distinguishable from its surroundings and at longer distances (excess of 150m) during the day when compared to the conventional night culling operations. The increase in distance however may lead to higher occurrence of wounded animals and thus a well-trained and experience marksmen is a necessity, as at longer distances wind plays a more prominent role and animals might be more skittish since they are able to spot the "harvesting team/predator" easier. It is however easier to located wounded animals and carcasses during the day than a night. This decreases the amount or risk of shooting losses due to the animals getting away or disappearing due to bad light. Other advantages include; animals can be easily located and can be selectively cropped by the marksmen being able to distinguish between sexes (even those classes which are sexually similar in appearance) as well as different age classes and social groups.

Boma Harvesting Method

Where the bush is very thick and the off take rate is very limited using any of the night or day harvesting methods described, the animals are herded into a boma and culled whilst inside. Boma harvesting incorporates the same techniques use in the mass capture of animals for relocation or live sales. The game is herded into an artificially constructed funnel shaped boma (Figure 1), made out of dark colour plastic (a colour which is best suited with the type and colour of the vegetation present for camouflage purposes) or strong durable material, by the use of a helicopter, vehicles or man power. The direction from which the wind is blowing plays a critical role in setting up such a boma structure as to not alarm the animals when they are herded towards it as most ungulates possess a very keen sense of smell (Le Grange, 2006). The material or dark plastic utilized prevents the animals from challenging and escaping out of the boma because they cannot see through it and thus perceive it as being a solid wall or object. The funnel shape of the boma channels the animals away from the herding party and into the smaller part of the boma (Figure 1). As they moved further into the funnel shaped area the available space decreases. The process is further helped by progressively closing gates of plastic behind them as they move further into the fun-

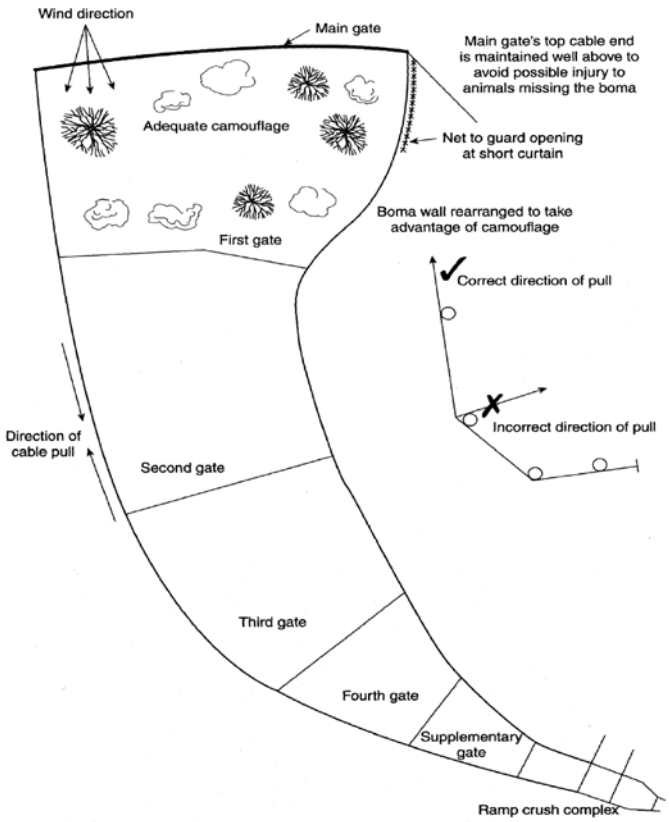

Figure 1. Setting up a plastic boma for game capture (Le Grange, 2006).

nel and closer to the killing complex (Figure 1). As they reached the final narrow section (Ramp crush complex, Figure 1) of the boma the animals can be separated and kept in different compartments (Le Grange, 2006). It is here however where the cropping method differs from capture method by the animals being herded in smaller groups and then into a small enclose space ("killing acre") and culled using a small calibre silenced rifle (Hoffman and Wiklund, 2006; Le Grange, 2006).

Once the animals have reached the last section of the funnel before entering the killing acre, it is recommended that they be kept or left to relax for a short period (>2 hours) before culling operations can be commenced (Hoffman and Wiklund, 2006).

The culling operations however entails that the captured animals be separated into smaller groups of ± 10 animals per group. They are then herded into the smaller compartments or into killing blocks located in the ramp crush section of the boma (Figure 1). The animals are usually culled from an elevated position using a silenced rifle. This culling of the small group of animals normally takes approximately 60-90 seconds (Hoffman and Wiklund, 2006). Once the animals are all down the carcasses are removed and exsanguinated at a different location, some distance away from the killing block as to not alarm the next group of animals than will be herded into the killing block. The carcasses are then transported to the mobile field abattoir where further processing will commence.

The boma harvesting method is very adaptive and ideal for use in dense bushveldt areas where the terrain and landscape is not as accessible to vehicles. In such terrain the animals can rather be herded to open more accessible areas for the processing trucks and refrigeration vehicles to gain access as to make processing and harvesting more efficient. The long distance herding of animals could however negatively affect the subsequent meat quality attribute of the harvested animals, by severely stressing the animals, which could lead to mortalities, bruising and other detrimental meat quality affects such as white muscle capture myopathy. These factors can however be managed as the success of this technique is based on the design and experience of the team or personal employed (Le Grange, 2006). Some species are however more susceptible to use of this method than others. The rate of success of the capture and herding of the animals into the killing block is affected by the degree of harassment (stress during capture) the animals have to endure before they animal will challenge the wall and try to escape. If the animals are however handled and herded correctly the degree of stress can be kept very low and the efficiency of the method increased. This process also allows for a large number of animals to be culled and processed within a relatively short period of time. It also ensures that no wounded animals are left behind in the processing area, as might be the case with the use of night harvesting methods. This process also allows for the selective culling of animals in the population and thus some individuals (trophy or very young animals) can be selected for breeding purposes and set free.

From a meat hygiene perspective this method is also ideal since all the animals are processed and inspected at a central processing location and thus easy maintenance of hygiene and inspection of carcasses by authorities is possible (Le Grange, 2006). The use of smaller or light calibre rifles also causes less damage to the carcass. According to Hoffman and Wiklund (2006), no research has been conducted on the effect of this cropping method on the subsequent meat quality attributes. However animal behaviour and especially rutting behaviour of males when placed in such enclosed space might cause the death of younger males if an older bull is present and tries to establish dominance. This behaviour or fighting between males and captured individuals of species such as impala, kudu, waterbuck, gemsbok, blue and black wildebeest, red hartebeest and eland was also noted by Bothma (1996), when animals were captured and kept in holding enclosures. Especially the species with horns should be very carefully handled since they can inflict serious injury to other animals in the group. The above mentioned fighting and pushing can also cause bruising and negatively affect meat quality of the future harvested animals.

Most species can be culled using this boma method. Some species however require special attention, such as the eland, kudu and waterbuck which are known for their jumping ability and can present a problem if stressed—as

they might try to jump out of the enclosure. This can however be controlled or prevented by installing netting over the top of their specific holding boma. Species that are easily herded like the eland, impala, springbok and blesbok are well suited for the use of this method (Le Grange, 2006). Species such as the kudu however should be handled with extreme caution as they become extremely nervous and difficult to herd. Other species such as the buffalo will not challenge the enclosure or plastic wall as long as they are not able to see through the erected walls. The disadvantages of this method are that the use of a helicopter to herd the animals is very expensive and thus large amount of animals must be targeted to make this method cost effective. It also requires a large well trained and experienced work force and lots of material and preparation time to commence with efficient culling procedures. The correct terrain and available camouflage is also essential to design a suitable and efficient workable boma (Le Grange, 2006). Thus other cropping methods might be preferred when dealing with fewer animals or terrain not suited for this method and when meat quality is of the highest importance.

Helicopter Harvesting

This method utilizes a helicopter and a 12 gauge shotgun with a very tight choke setting as to minimize the potential of wounding animals by concentrating the spray pattern of the lead shot. The use of a semi-automatic shotgun has shown to give the shooter the ability to shoot as many as six animals in succession running in a line (Le Grange, 2006). Animals are shot from an altitude of around 6 meters in the head or upper neck area and collect by supporting ground staff or if the terrain is inaccessible, the carcasses are hung from the landing rungs of the helicopter. Helicopter harvesting has the advantage of being able to access remote locations easily and also being able to selectively harvest animals. The helicopter is also more suited for terrain where dense vegetation makes locating animals more difficult on foot or by vehicle although the collecting and locating the carcasses may still prove difficult. Other advantages include that it is relative quick and efficient and a larger area can be harvested compared to the boma method. A quick population estimate can also be made of the available animals during the harvesting operation. This method however requires high capital investment and professional expertise and is also the most expenses to operate. Another disadvantage to this method is that it may inflict unnecessarily high stress (due to exercise/fear) and bruising on the animals as well as damage to fences when larger animals attempt to escape the property. This method will thus produce a lower quality meat. Veary (1991) however noted similar muscle ultimate pH values as obtained during night harvesting. Le Grange (2006), however commented on experience obtained in Zimbabwe, that high levels of adrenaline where released in the animals during helicopter harvesting and the excessive increase in body temperature result in extremely rapid meat decay (most probably due to high ultimate pH values and the occurrence of dark, firm and dry meat), usually rendering the carcasses unfit for human consumptions. Although this method has been successfully used for impala, blesbok, springbok and buffalo in Africa as well as red deer in New Zealand (Le Grange, 2006) the vegetation must be taken into account since areas of savannah type vegetation are not suited for this method. The open nature of the terrain and the skill and accuracy of the shooter will severely affect the success rate and efficiency of this technique. Good communication between the pilot and ground crew is also essential so that carcasses can be recovered quickly and bled out efficiently. In many cases the ground crew use GPS navigational equipment to locate the carcasses rapidly as they need to be gutted as soon as possible and placed in a cooling facility to reduce the possibility of decay (Le Grange, 2006).

MEAT LOSS DURING HARVESTING

Meat loss during harvesting according to Von la Chevallerie and Van Zyl (1971) can be attributed to three possible circumstances:

- Animals shot and not recovered during the harvesting process;
- Discarded meat unfit for human consumption due to bullet damage or the wounding of animals;
- A decline in meat quality because of *ante-mortem* stress to which hunted and wounded animals are subjected.

These circumstances are all commonly found during the harvesting procedures but are managed in such a way as to diminish the possible losses or negative affect on the meat quality. Animals which are shot and not recovered by the harvesting team are due to various physical factors present during the harvesting of the animals. Such factors as the vegetation density or terrain accessibility can affect the efficiency of tracing wounded animals during the harvesting process. The type of species being harvested and type of technique used can also contribute to this. Marksmanship and fatigue is also of great importance when looking at the amount of meat loss due to wounding or misplaced shots as was concluded by Ruggeiro and Ansley (1992). This is especially true, when lighter calibre rifles are used and there is a strong prevailing wind conditions present. The correct calibre, scoped or silenced rifle and proficient marksmen is thus of utmost importance to ensure the least amount of meat wastage, due to wounding or inaccurate bullet placement. As also stated by Laubscher (2009), the correct placement of shots and the use of proficient marksmen can decrease losses as the preferred shots would yield the least amount of wastage. The preferred shot being the high neck area or head, which ensures the humane death of the animal (Lewis, Pinchin and Kestin, 1997), resulting in no wastage of the meat if shot in the head and less than 2% loss, if shot in the high neck area (Hoffman, 2000). The loss in meat

due to damage caused by a neck shot is considered negligible when compared to the value of the rest of the carcass. Head shots are however preferred since they usually result in instantaneous death of the animal and thus the least amount of stress and best quality meat. While a neck shot may result in paralysis and may not render the animal immediately insensible and stress can thus come into play and is also considered to be less humane when compared to head shots (Lewis, Pinchin and Kestin, 1997).

Traditionally, hunters (especially trophy hunters) prefer to aim for the animals shoulder rather than for its head or neck since it gives the shooter a larger and more stationary target and less chance of missing the intended animal. This type of shot is usually placed at the top of the fold at the back of the foreleg, where the large vital organs (heart and lungs) are located as well the major blood vessels and nerves. A bullet in this area will either hit the heart, resulting in massive haemorrhage or it will damage the lungs and large blood vessels, resulting in lung collapse and a "quick" death. Although this type of shot placement can result in up to 20% carcass damage as reported by Von la Chevallerie and his co-authors (1971) (Table 2), it is the preferred shot by hunters because it is the most likely to result in the death of the animal. Even if the exact target area is not hit, damage caused by the bullet in this vital area, will either result in death (even if not instantaneous) or at least causing zero or poor mobility and thus preventing the animal from escaping. This then gives an opportunity for a second shot which should be sufficient to kill the animal. The chance of wounding an animal in the gut or lower extremities is however increased when aiming for the body and in terms of hygiene the gut shots should always be avoided since contamination of the carcass from the stomach and intestinal contents may occur, which is considered to be unacceptable from a meat hygiene point of view.

Another factor which can contribute to the losses experienced during harvesting is the behaviour of the animals (Lewis, Pinchin and Kestin, 1997), since males generally respond more actively to disturbances than females and show an increase in response when in breeding herds, leading to a higher percentage of animals being wounded.

Table 2. Bullet damage from shots at various localities as a percentage of total carcass weight (adapted from Von La Chevallerie et al., 1971).

Locality of the bullet wound	Percentage of carcass damaged
Neck	3.18
Neck and shoulder	15.66
Shoulders	20.58
Shoulders and ribs	22.22
Ribs	5.47
Back	12.47
Other (e.g. stomach, hind quarters)	15.61

Lewis, Pinchin and Kestin (1997), however suggested that the use of a silenced scoped rifle can further increase the efficiency of the culling process by increasing the percentage of animals shot per herd by decreasing the disturbance distance caused when firing upon the herd.

FIELD DRESSING OF CARCASSES: FIELD DEPOT

As soon as possible, within 10 minutes, after shooting the animal it is exsanguinated. Thereafter it is either hung onto the side of the hunting vehicle (small antelope such as springbok) or loaded onto a ramp at a minimum slope of 20° to facilitate bleeding. If the field abattoir is close-by and reachable within 30 minutes, it is recommended that the white offal of shot game be eviscerated at the field abattoir where proper lighting is available. Alternatively, the white offal may be eviscerated in the field. The latter is typically conducted with large game so as to reduce the carrying load/weight on the vehicle. The carcasses are then transported to the field abattoir/depot.

There are strict guidelines that must be followed regarding the outline and composition of the field depot. These guidelines encompass a wide range of topics from cleaning water, type of frame, carcass flow, carcass health inspection, traceability and loading and transport in a refrigerated truck to the breaking pant. Van Schalkwyk and Hoffman, (2010) give a full description of the requirements and applicable regulations.

The carcasses are loaded with their skin on into the cooler truck. Retaining the skin ensures that the carcasses do not dry out as most wild game species do not have a subcutaneous fat cover. The carcasses are then transported to a registered abattoir where they are received, given a second health inspection and then processed further. This processing consists of removal of the skin and deboning of the carcass into primal and/or value added products. These are then ether sold locally or exported.

CONCLUSIONS

With the various techniques developed by the South African and Namibian game meat industry, they are able to meet to the requirements of most importing, including the European Community, countries. In fact, the traceability system (farm to fork) developed by the game meat sector is far superior to that utilised by the formal meat sector. As such, these southern Africa countries can definitely produce game meat that meets the internal standards. With the increasing threat of global warming, the wild life industry will develop further and stronger as this industry utilises species that have evolved over the years to adapt to the harsher environments.

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