CHAPTER 1
OVERVIEW

1.1 Introduction

Presently in South Africa, lions (*Panthera leo*) are mainly restricted to isolated populations in national parks, provincial parks, and private game reserves (Hunter 2001). Two major factors have led to this, the most obvious being Africa's burgeoning population, with resultant habitat loss (Hunter 2001). Hunter adds "that wherever Africa's human population grows, large carnivores will inevitably decline in number". He adds that their ecological demands and potential for conflict with humans make them among the first species to disappear from an area. The second factor is more encouraging, and that is the rapidly expanding tourism industry in South Africa. This has resulted in considerable energy being devoted to restoring natural ecosystems, mainly by the initiative of the private sector. The restoration of large carnivore species to many areas where they had previously been exterminated has been one of the most prominent of these efforts (Hunter 1998). Since 1994, lions have been introduced on many game reserves, because these animals hold deep emotional appeal to the general public and are the single most sought after species for tourists visiting reserves (Hunter 1999, Mbenga 2004, Druce 2004a). Furthermore, lions also engender aesthetic and economic appeal to smaller reserves (Power 2002).

An unfortunate, but safe assumption to make is that in time to come, the ever increasing human population in Africa will place even more pressure on lions, resulting in the only free-range lions being found in enclosed protected areas. To illustrate this point, it is estimated that as recently as two decades ago, a quarter of a million lions existed in the wild. By 1999, this figure had decreased to only 30 000 (Hunter 1999).

It is important to understand that although this literature review addresses issues about lions held within enclosed areas, they are *free-ranging*. Free- ranging lions can be described as lions which are free to hunt for themselves and receive no supplementary feeding. Additionally, they are free to mate at will, establish and defend their own territories, maintain a healthy caution for humans and retain a strong preference for wild herbivores (as opposed to a preference for domestic livestock) (Kettles *pers. obs*. 2005).

Managing lion populations within enclosed protected areas produces a myriad of challenges, due to the fact that the smaller the reserve, the more intensively it needs to be managed (van Dyk 1997). Poor advice from conservation authorities or irresponsible management practices (often unintentional) implemented by landowners and concessionaires result in these challenges being compounded (Kettles *pers. obs*. 2005). This lack of management knowledge and capacity invariably results in at least one, but more often than not, several of the following consequences: inbreeding depression (Vartan 2001); the local demise of other predator and prey species (Hunter 1999a; Mills & Shenk 1992); break-outs as a result of pressure from other lions within the protected area Steele 1970); the intra- and interspecies spread of disease; and conflict with local communities in the event of stock loss or the loss of human life (Hunter 2001, Packer *et al.* 2005).

1.2 Rationale

Lions require large areas with high densities of prey species and with little human activity – requirements that are becoming increasingly scarce in Africa (Hunter 2004). Large carnivores are among the most vulnerable species in wildlife communities, and invariably are the first to disappear in the face of human pressure (Hunter 2004).

The increase in the number of lions in South Africa is mainly as a result of the installation of a democratic government and the subsequent upswing of tourism, foreign investment and internationally based hunting in South Africa. As the majority

of these reserves are relatively small and enclosed, a negligible amount of immigration and emigration of medium to large sized vertebrate species can occur. Furthermore, in many cases, size limitations allow these reserves to sustain only one pride of lions. Management strategies enhancing the attainment of economic goals, without jeopardizing long-term ecological sustainability, therefore have to be developed (Druce *et al.* 2004b).

Most of the data currently available to protected areas/reserve managers is usually a product of research carried out in larger areas with numerous prides and is therefore not entirely applicable to smaller reserves. Not all reserve managers have a background in ecology or conservation, many being farmers who have changed over to game ranching, or business people wishing to become involved in tourism. Many of these people find the available data intimidating, impractical, and inapplicable to their management needs. The transfer of knowledge from ecologists to landowners, investors, and development agencies therefore is not fast enough to keep up with the change over from cattle ranching and other land uses to wildlife utilisation (Du Toit 1995). The practitioner (manager) and the scientist face very different challenges in very different circumstances, despite working towards a common goal (Rogers 1997). Rogers adds that "scientists operate within a structure of hypothesis generation and testing, which is rewarded by the publication of their work, financial support for further research, and peer recognition. This has led to a rapid development of ecological theory that has leapt ahead of practical action". He concludes that "on the other side of the scale, conservation practitioners typically have pragmatic approaches and are forced to work within the constraints of limited budgets and have to apply adaptive management".

National legislation in the form of the National Environmental Management Act (NEMA) and the Biodiversity Act require that properties hosting lions need to adhere to a management plan. It is envisioned that the output of this study will act as a reference to managers as well as a framework to help bridge the gap between scientists studying lions and the managers of them.

1.3 Research Purpose

1.3.1 Aims

To provide and describe a broad understanding of relevant aspects of lion biology, specifically the effective management of lions within enclosed protected areas. Further, to assess the consequences of management practices/interventions on lion biology in small reserves, using the GMPGR as an example. This will provide managers with a concise, user-friendly reference source upon which unique management strategies may be moulded and conformed to best address the common challenges associated with lion management.

1.3.2 Objectives

1. To provide essential general information required for the effective management of lions within enclosed protected areas.
2. To provide guidelines for the temporary and permanent containment of lions, in order to reduce the chances of break-outs, limiting the opportunity for conflict.
3. To introduce to protected area managers strategies which strike a balance between economic goals and long-term ecological sustainability.
4. To create a reference that that assists in producing innovative and practical solutions for the management and protection of such lions.
5. To create an output that acts as a source of reference that is practical and easy to understand, thereby bridging the gap that often exists between scientists and the practitioners tasked with managing lions.

CHAPTER 2
CONCEPTUAL FRAMEWORK FOR LION MANAGEMENT

This study will be based on the key components of lion biology that consequentially require lions within enclosed reserves to be actively managed. These components (Fig. 1) include recruitment, artificial changes to their environment and social structures, ranging patterns, habitat selection and requirements as well as prey selection. Collectively, they form the building blocks of lion biology. Lion biology and tourism aspects are the main factors driving lion management. However, tourism will not be addressed in detail in this study.

Most biologists agree that some form of active intervention by man is a necessary evil, implemented in order to sustain habitats that have been altered in any way by man (Thomson 2003). 'Management' can be defined as the manipulation or skillful handling of a resource that usually involves some form of active manipulation of the biota (Spinage 1979). Management decisions must be based ultimately on the best or the best available knowledge (Whitehouse & Kerley 2002). 'Management' can also be defined as the application of manufactured pressures to counteract undesirable (as determined by man) occurrences in a game reserve, or to create desirable (as determined by man) conditions (Thomson 2003). Thomson adds that "not only must wildlife management be designed specifically to solve particular problems; it must be designed to solve these problems in a particular game reserve, as no two game reserves anywhere have the same pressure circumstances". It must be stressed, therefore, that a sound knowledge of lions and the local environment must be acquired. Careful consideration must also be given to the reasons for wishing to contain lions on enclosed reserves.

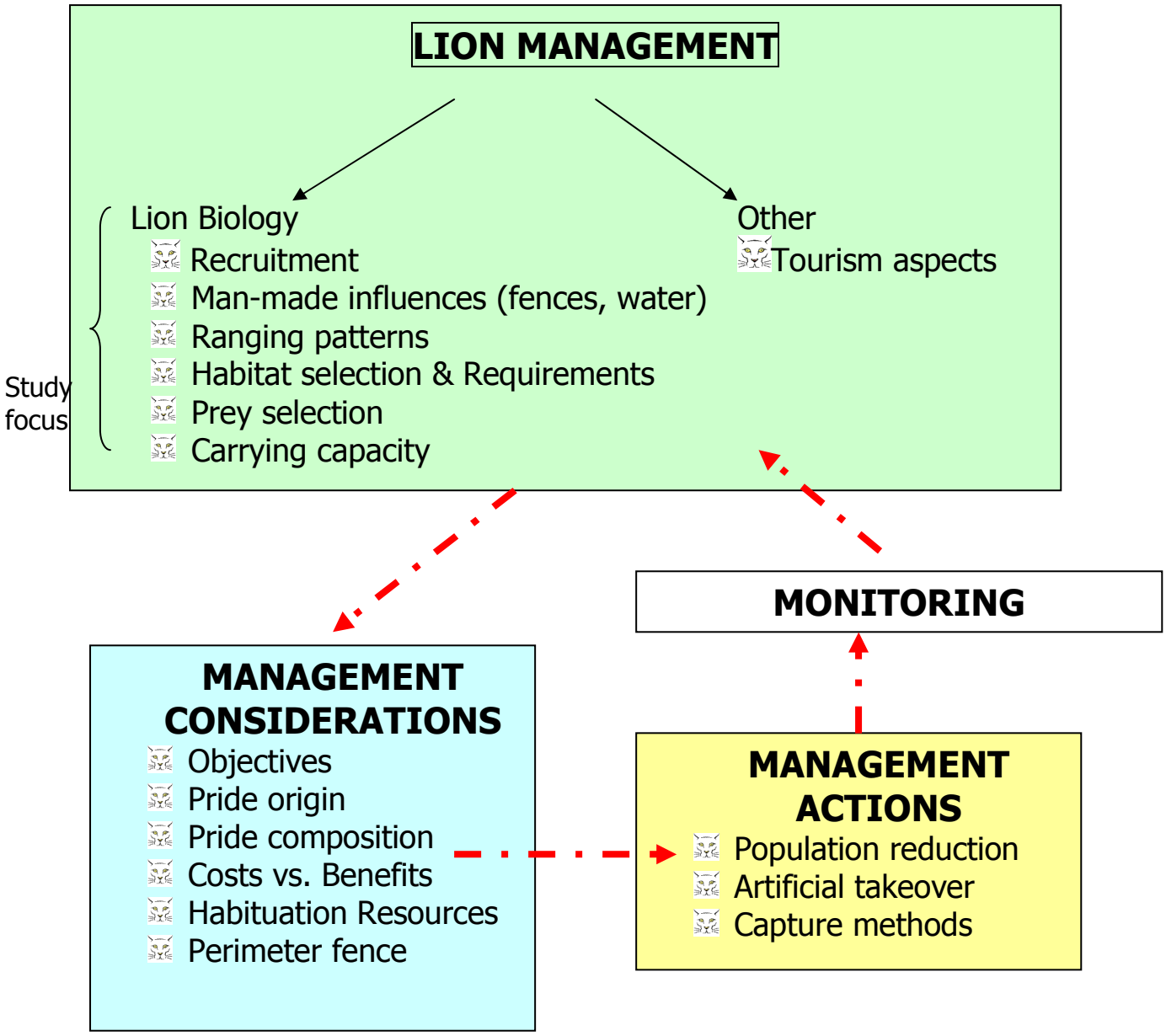

Figure 1: A proposed conceptual framework for lion management (see text for details).

Lions, being a keystone species (Hunter 2001), have the capacity to determine whether or not other species can persist in a given community, by affecting the organization of the community to a far greater degree than one would predict based only on the numbers of individuals or biomass (Primack 2000). For this reason protected area managers not only need to have a clear understanding of the management objectives of the property hosting the lions, their origins, habits and numbers, they also need to have a comprehensive understanding of the protected area's vegetation types, species diversity and richness, and their carrying capacities in order to make informed decisions (Fig. 1). A clear understanding of lion habituation (boma training) and containment (electrified perimeter fence) is also vital for the successful management of lions (Fig. 1). In order for an enclosed area accommodating lions to be ecologically sustainable, a careful balance needs to be maintained between lion and prey species. Should lion numbers become too high, prey species numbers will collapse. This in turn will result in the lion numbers collapsing. Studies conducted on the Greater Makalali Private Game Reserve (GMPGR) (Druce et al. 2004b) demonstrated that from the 6 lions originally relocated (2 males and 4 females), 35 lions were born at a rate of 11.6% per year over a period of 7.5 years. Sixty-eight lions have subsequently been removed by the management of the GMPGR between 1997 and 2007 (Kettles pers. obs. 2007). This point illustrates that lions are capable of recruiting at a rapid rate, and that managers need to be cognizant of this fact and their management strategies should include methods of manipulating pride sizes (Fig. 1). These methods could include culling, hunting, live capture and sale, and sterilization or contraception (Vartan 2001, Kettles pers. obs. 2006, Rogers pers. comm. 2006).

Not all consequences of housing lions on enclosed reserves are negative, however. If conservation is to be one of the main goals of commercial wildlife areas, the benefits of having a resident lion population far outweigh the drawbacks (Cotterill 1997). Lions act as agents of natural selection, weeding out the weak and the old of each prey species (Cotterill 1997). If lions are excluded from an area, then a large part of an entire trophic level will be missing.

Due to the factors described above, active adaptive management needs to be applied. Adaptive management is a process that allows conservation practitioners to make sense of and maintain direction in the apparent confusion of functioning natural systems (Slotow *et al.* 2003). This management philosophy is rooted in the use of scientific methods to organize a collective and growing understanding of the processes one is trying to manage. It is essentially an interactive process between planning and practice. As knowledge is gained of the local system, and of the effect of management interventions, planning and actions are revised when necessary. Simply put, this is pro-active rather than reactive management. Planning, interactive processes, monitoring, review and constant re-evaluation are integral in this management philosophy (Slotow *et al.* 2003). This management style is necessary to ensure that protected areas achieve their objectives and maintain the natural processes for which they are established (Pressey 1996).

The limited size of most enclosed reserves determines that, if the primary goal is for the reserve to be sustainable in the long-term, on-going monitoring and manipulative management intervention will be required (van Dyk 1997).

CHAPTER 3
THE BIOLOGY OF LIONS

In order to effectively manage any species, a thorough knowledge of the biology of the species is essential.

3.1 Description

Table 3.1: Physiological characteristics of lions (Smuts 1982, Skinner & Smithers 1990, Estes 1993, Mills & Hess 1997).

CHARACTERISTIC	MALE	FEMALE
Head-Body Length	2.4 - 3.3 metres	2.3 - 2.6 metres
Shoulder Height	up to 1.25 metres	up to 1.1 metres
Weight	150-260 kilograms	120 - 190 kilograms
Weight at Birth	1.1 - 2kilograms	

Lions are typically pale sandy or tawny yellow, but varying from greyish-buff to yellowish red and dark ochre; white around the mouth and on the chin, on the under parts, and inner sides of the legs. The male's mane is light brown, dark tawny, reddish-brown, or black.

The tail, just over half the length of head and body, has a large tuft of long, blackish hair at the tip, which conceals a horny spur. Only males have mane hair, which attains a length of up to 16cm on the sides of the face, the top of the head, the shoulders, around the neck and a short way down the spine. The eyes are amber in colour, the nose is black, and a prominent black mark is found at the base of the outside of the rounded ears (Smuts 1982, Skinner & Smithers 1990, Estes 1993, Mills & Hess 1997). Male lions begin growing a mane at 20 months (Kettles *pers.*

obs.) and usually have a fully developed mane (thus reaching trophy status for hunters) at 5 years (Grobler 1997, Whitman & Packer 2007).

3.2 Reproductive Biology

Lions are highly prolific breeders. Managing/limiting the size of a lion population within an enclosed protected area is probably the single biggest challenge facing managers. A thorough understanding of the reproductive biology of lions is essential if effective and timely management decisions are to be made.

a) Reproductive Season

Reproduction takes place throughout the year, but birth peaks were recorded in the Kruger and Serengeti National Parks as being between March and July (Packer *et al.* 1990).

b) Courtship

Courtship in lions may be initiated by either member of the pair, who remain in close association during this period (usually 4 to 16 days, depending how long oestrus lasts). The male follows the female at all times during this time and rests with her (Skinner & Smithers 1990). The female usually invites copulation by lordosis – a process by which the female signals her interest in mating by displaying elaborate tail movements and sinuous body posturing. Mating itself lasts about 1 minute, and is repeated every 15 to 20 minutes over a period of several hours (Rudnai 1973a).

c) Oestrus

Females are polyoestrous, with oestrus lasting for between 4 to 16 days, the period between oestrus varying from a few days to over a year. They have a post partum oestrus, but do not conceive if the litter survives, but if it is lost, a new litter may be produced within four months (Rudnai 1973a). The majority of matings do not result

in pregnancy; the level of nutrition of the female influences her fertility (Rudnai 1973b). Rudnai (1973a) observed that of the 14 matings witnessed by her in the wild, only 4 appeared to result in pregnancy.

Smuts (1982) observed that most or all females in the pride give birth at about the same time – often coinciding with the time when their prey is rearing young.

d) Gestation

Lions give birth 3.5 months after conception. Rudnai (1973a) observed a mean of 110 days.

e) Litter Size

Litter sizes vary between 1 and 4 cubs in the Serengeti National Park (Packer & Pusey 1987), while Smuts (1978) estimated litter size to be an average of 3.02 in the Kruger National Park.

f) Interbirth Interval

The mean interbirth interval is 20 months, provided that the previous litter survives to maturity. The mean decreases to 4 to 6 months if the previous litter is lost (Packer & Pusey 1987).

g) Age at Dispersal

Males generally leave the pride at between 2 and 4 years (Schaller 1972), but may be forced out much earlier in the event of a pride takeover.

Females are usually incorporated into their natal prides, but in some cases a few individuals may disperse to form new prides elsewhere (Packer & Pusey 1987) or

may form sub-groups which operate in different parts of the same territory (Skinner & Smithers 1990).

h) Age at First Reproduction

Smuts (1982) found that male lions become sexually mature at 26 months, although they usually only get the opportunity to mate when they are about 5 years old. Smuts adds that females become pregnant for the first time at about 43 months, and produce a litter every 2 years. They are capable of breeding until an age of about 15. In the absence of older, more dominant males, such as in an enclosed environment, males may begin mating at a younger age. Within The Greater Makalali Private Game Reserve (GMPGR), in the absence of older, more dominant males, males became sexually active at about 28 months (Kettles *pers. obs.* 2005).

i) Age at Last Reproduction

Female reproductive performance begins declining at 11 years and ceases at 15 years (Packer *et al.* 1988). Although the sperm of a 16 year old male is still viable (Smuts *et al.* 1978), reproduction usually ceases once a male has lost tenure of a pride. This takes place at the age of between 8 and 10 (Packer *et al.* 1988).

j) Sex Ratio

The sex ratio at birth is 1 male to 0.9 female. This ratio shifts to 1 male to 2.1 female in lions older than 5 years (Smuts 1978). This is as a result of differential rates of maturation, mortality, and emigration between the sexes (van Orsdol *et al.* 1985).

k) Cub Mortality

Cub mortality varies according to the availability of food (Smuts 1982), the availability of suitable cover to hide the cubs while females are out hunting, and the

availability of males in constant attendance to protect the cubs (Smuts 1982). Infanticide is a major factor. Studies by van Orsdal *et al.* (1985) and Packer and Pusey (1987) revealed that deaths as a result of infanticide varied from between 14 and 73%. Cub mortality as recorded in the Mashatu Game Reserve in Botswana (Patterson 1989) and the Etosha National Park in Namibia (Orford *et al.* 1988) was 40%. On the GMPGR, the infant mortality rate is slightly less than 14% (6 out of 41) (Kettles *pers. obs*. 2003). This is probably due to a combination of several factors: a lack of independent males, resulting in lower incidents of infanticide; an abundance of food, and the absence of fatal diseases (Vartan 2001).

l) Longevity

In the wild, both males and females average 13 years (Guggisberg 1961, Packer *et al.* 2005).

3.3 Social Behaviour

In their natural state, lions have relatively stable social units, with very specific requirements. Frequent social interactions amongst members of the pride play an important role in maintaining social bonds. Managers need to understand this in order that they may implement management strategies that will allow these requirements to be met within enclosed reserves.

a) Social Organization

The lion is the only cat that lives permanently in groups of mixed sexes. These groups (prides) range in size in the Serengeti from 1 to 18 females, their dependent offspring and a resident coalition of 1 to 9 males (Packer *et al.* 2005). In the Kruger National Park, Smuts (1982) observed that the average pride size was 12. He also noted that the average pride had 2 adult males, the ratio of males to females being 1 to 5.

b) Social Behaviour

Within these groups, daily social interactions play an important role. The social bonds that develop within a pride are reinforced by behaviour such as head rubbing, leaning against each other, and social grooming and licking (Estes 1991). Females typically direct most of their attention to other females and cubs, whilst males are attentive to each other. Although males serve tenure with a pride averaging only about 2 years (Packer *et al.* 1988), they invariably form bonds that last their entire lives.

c) Parenting Behaviour

Females within the same pride often synchronize the birth of their cubs, and the young are reared communally. Cubs suckle freely from different lactating females within the pride (Schaller 1972, Rudnai 1974). Mothers of young cubs will sometimes leave their cubs with another lioness, forming a 'crèche', while spending time away from the pride (Rudnai 1974). Groups of females do most of the hunting. Females leave their pride for purposes of parturition, and remain apart until the cubs are 4 to 8 weeks old, but only if cubs already established with the pride are not more than 3 months old. This is due to the fact that any female with milk will suckle any cub within the pride, and the younger members would thus suffer due to competition from older cubs (Skinner & Smithers 1990). Cubs will suckle regularly for the first 6 to 7 months of their lives, gradually suckling less after this period. Cubs remain with their mothers for 21 to 24 months (Rudnai 1973b). This observation is consistent with those observed on the GMPGR (Kettles *pers. obs.* 2005).

Males also make significant contributions to parenting in the form of protecting the cubs against strange lions, and in assisting in the killing of large animals from which the entire pride can feed (Altman 1974).

d) Vocal Communication

According to Estes (1991), the lion is capable of vocalizing in a wide range and for various reasons: roaring (territorial advertising, location of pride members, intimidating rivals, and strengthening social bonds); meowing and growling/snarling (allows lions to display a wide range of emotions, depending on the tone and intensity); coughing (usually a warning sound preceding a charge); hissing (warning/irritation); woofing (expressing alarm); and grunting (contact calling or leading up to roaring). Male lions usually roar only when they have been in recent association with females (Grinnel *et al.* 1995).

e) Olfactory Communication

Estes (1991) states that although lions take little interest in the scent of other animals, they take intense interest in the scent of other lions. He adds that they are even capable of following the scent left by the tracks of another lion. Pride males spend a significant amount of time marking their territory by spraying urine on prominent rocks, bushes, and other landmarks. Females also leave scent markings in a similar fashion, but far less frequently (Estes 1991). Male lions often make use of roads when patrolling their territory, scent marking as they go along (Kettles *pers. obs.* 2005).

f) Agonistic Behaviour

The agonistic behaviour of lions is similar to all other members of the cat family in that they flatten their ears, narrow their eyes, and hiss or snarl when annoyed and the males strut with their heads held low when displaying dominance. Also, lions lie on their backs when demonstrating submission (Estes 1991).

3.4 Activity Patterns

Lions have reasonably predictable activity patterns. Managers need to understand these patterns, as management strategies need to be implemented in such a way so

as not to disrupt/alter natural activity patterns. An understanding of these patterns is invaluable in instances where management intervention is required.

Lions lead a predominantly nocturnal life, often with peaks of activity at dawn and dusk. Personal experience has led the writer to believe that they are far more bold and aggressive at night than during the day. This does not preclude them though from being active during the day, particularly during cool weather. Lions, in common with other cats, have a reputation of being lazy animals and they spend a great proportion of their time sleeping, dozing lightly, or merely staring vacantly. Lions spend from 20 to 21 hours out of 24 each day in this state of lethargy (Hare & Lambert 1994). In spite of their apparent state of obliviousness to events around them during resting periods, they can become aggressive quickly if suddenly and unduly disturbed (Skinner & Smithers 1990).

3.5 Foraging Ecology

Lions are capable of killing large numbers of prey species each year. It is important to understand the foraging ecology of lions in order that the steady demise or even the possibility of local extinction of certain prey species can be avoided within enclosed reserves (Hunter 1998). This is as a result of virtually no immigration or emigration of medium to large vertebrate species taking place due to size limitations of most enclosed reserves (fences preventing free movement).

Lions are generalist hunters and will take a wide range of prey, from small rodents (Eloff 1973a) to young rhinos, hippos and elephants (McBride 1990). Several researchers, including Rudnai (1973a), McBride (1990), and Mills and Biggs (1993), have observed that individual differences in prey selection and killing techniques are often discernable for different prides, even in the same general area. This indicates a strong ability for learning in the lion's hunting behaviour.

Lions, males in particular, frequently scavenge. More than 40% of all food items in the Serengeti were scavenged (Packer *et al.* 1990). In more arid environments, scavenging is far less frequent. The total food items that were scavenged in the

Kalahari Desert amounted to only 4.6% (Mills 1990). Lions appear not to be fussy eaters, and will readily eat putrid meat and even fish in drying out pools (Skinner & Smithers 1990). de Pienaar (1969) observed lions eating termites and locusts. de Pienaar also recorded the killing and eating by lions of spotted hyaenas, leopards, cheetahs, jackals, civets, caracals and even crocodiles. The writer has witnessed two instances where aardvarks were killed and eaten by lions on the GMPGR, and one instance where a leopard tortoise was crushed and eaten by a sub-adult male. On several occasions the writer has also observed lions following descending vultures to kills made by other predators, or to natural deaths.

Lions hunt predominantly at night, and hunts are usually more successful when the entire pride participates (Skinner & Smithers 1990). Schaller (1972) observed that 30% of stalks were successful when the entire pride participated, while only 17% to 19% of stalks resulted in a kill when only an individual participated. During nocturnal hunting, the amount of moonlight affects hunting success (van Orsdal *et al.* 1985). Hunting is less successful when there is a partial moon, to when there is no moon at all.

Lions are expert stalkers and invariably use any available cover as well as wind (to disperse their scent away from their prey) to get as close to their prey as possible. Should their prey see, hear, or sense their presence, lions will freeze, in mid stride if necessary, until the prey relaxes before resuming the stalk. The kill/attempted kill is made after a short chase. During the final sprint, lions are capable of covering 100 metres in 6 seconds, thus allowing them to run at a speed of 60km/h over short distances (Skinner & Smithers 1990). Chases are seldom longer than 100 to 200 metres.

Lions have various methods of killing their prey, but it usually involves pulling the prey down by jumping on its haunches, and then suffocating it once it is down by a clamping bite to the windpipe. With larger prey, lions may launch themselves onto the shoulder of the prey, and lean over with one paw to pull the prey's neck aside, tripping the animal, the fall sometimes breaking the animal's neck. Small prey can

simply be clubbed with a powerful swipe from a front paw, stunning the animal and allowing the lions to kill it (Skinner & Smithers 1990). Females do most of the hunting. Males often assist with the killing of large prey species such as buffalo and giraffe.

As lions are opportunistic, they will attempt to hunt domestic animals. At GMPGR, an adult male lion was once observed making himself seen and heard upwind of two horses in a fenced paddock. Fortunately, the horses were calmed down and prevented from stampeding (Kettles *pers. obs.* 2002). It was later observed that several other lions were hiding downwind of the horses. It would appear that this was a planned strategy: the male was to scare the horses and cause them to run past the rest of the pride waiting in ambush. During telephonic interviews, Lowveld cattle farmers informed me that lions use a similar tactic to cause cattle to stampede and break out of their lion-proof stockades, facilitating the killing of the cattle.

When lions are in the vicinity of water, they will invariably have a drink after they have eaten. If any food is left over from the kill, they often return to feed again (Skinner & Smithers 1990), as they are capable of processing their food very quickly. Lions have distensible stomachs and are therefore able to consume vast amounts of meat at a time. Smuts (1982) once recorded a male lion with 30kg of meat, skin, and bones in its stomach. The stomach contents of a 10 month old cub he weighed represented 25% of the cub's total body weight.

Lions require a substantial prey base, and the larger the pride, the more prey will be needed to sustain them, especially if the prey base does not include large herbivores which live in substantial herds. Although much work has gone into determining the daily food intake of lions (5 to 8kg/day), it is impossible to convert this figure into an annual equation (van Dyk 1997). van Dyk adds that this is because lions will eat the most abundant species in an area and suggests that the available biomass of prey per hectare, and the available number of prey per lion, should be calculated. These data coupled to the factors mentioned above, will allow managers to more or less predict the impact that lions will have on the various prey species.

Major large ungulate prey species recorded in East, Central, and Southern Africa include buffalo, zebra, wildebeest, roan, sable, springbok, gemsbok, impala, kob, waterbuck, warthog and hartebeest (Makacha & Schaller 1969, de Pienaar 1969, Schaller 1962, Eloff 1973a, Eloff 1973b, Rodgers 1974, Rudnai 1974a, Mills 1984, Stander 1992, Funston & Mills 2006). While medium to large sized ungulates make up the bulk of their diets, lions are opportunists and generalist hunters, and will take a wide variety of prey. Detailed prey selection data were collected on the GMPGR between February 1998 and December 1998, and January 2000 and December 2001. During these periods lions were recorded killing 15 species. Warthog made up 30% of the kills, followed by blue wildebeest (18%), zebra (12%), kudu (10%), waterbuck (8%) impala (7%), giraffe (6%), other species combined (6%), and the remaining prey (3%) could not be identified (Druce *et al.* 2004a). During this period, the lions killed a minimum (due to the possibility of occasional kills not being observed) of between 2.2% and 3.1% of the available biomass (Druce *et al.* 2004a). Prey species varied significantly when males were present at a kill as opposed to when they were absent. More warthogs and giraffe were killed during their presence, and during their absence, more waterbuck were killed (Druce *et al.* 2004a).

3.6 Geographic Range

Lions are extremely adaptable and are able to respond quickly as conditions change. Being supreme opportunists, they are able to improvise as and when the need arises. Habitat selection/preference is therefore not a major limiting factor for managers to take into consideration when re-introducing or relocating lion populations.

Lions have a broad habitat tolerance and historically, they only were absent only from tropical rainforests and the interior of the Sahara Desert. Lions are still present in habitats varying from semi-deserts such as the Kalahari Desert (Eloff 1973b) to mountains, at heights of up to 3600 metres such as Mount Elgon in Kenya

(Guggisberg 1961). Although lions drink regularly when water is available, water is not an absolute requirement. They are capable of obtaining their moisture requirements from prey and even plants (such as the tsama melon in the Kalahari Desert), and can thus survive in very arid environments (Eloff 1973b). Water is thus not a prerequisite in habitat selection, but is preferred.

Lions once ranged from northern Africa, through south-west Asia, west into Europe and east into India. Guggisberg (1961) states that they disappeared from northern Africa and western Asia only 150 years ago, but were already extinct in Europe 2000 years ago. A small population of approximately 190 individuals remains in the Gir Peninsula in north-western India (Skinner & Smithers 1990). In South Africa, lions now occur only in National Parks, Provincial Parks, and private game reserves, having become extinct from the Cape Province during the 1860s, and the rest of the country shortly thereafter (Skinner & Smithers 1990).

An unfortunate but safe assumption to make is that in time to come, the ever increasing human population in Africa and the subsequent pressure this will place on habitats suitable for hosting lions will place even more pressure on lions, resulting in the only free-range lions being found on enclosed protected areas. To illustrate this point, it is estimated that only two decades ago, a quarter of a million lions existed in the wild (Hunter 1999). The most comprehensive survey of the African Lion completed to date has recently been published by the International Foundation for the Conservation of Wildlife (IFCW) and Conservation Force. This study estimates that the overall sub-Saharan lion population stands at 39 373 (Graham 2005). The census indicated that of this total, 3% are found in Western Africa, 7.3% in Central Africa, 40% in Eastern Africa, and 49.7% in Southern Africa. The study also revealed that lions are still present in 34 African countries and that approximately half of the aforementioned total population is resident in some form of protected area and that the largest populations within protected areas are found in Eastern and Southern Africa (39% and 35% respectively).

3.7 Population Demography and Limiting Factors

It is important to understand the factors that regulate lion populations; the habits, the age structures, and the pride dynamics, because these factors may require manipulation from management in order that management objectives may be met.

Lions live in a matriarchal society, the core unit being the pride, consisting of a group of usually related females and their cubs (Schaller 1972, Packer *et al.* 1991). Pride sizes vary considerably, and are usually smaller in arid areas (Eloff's 1973 study in the Kalahari Gemsbok National Park revealed a mean of 2.2 females per pride) whilst in the Ngorogoro Crater, prides containing up 20 females have been recorded (van Orsdal *et al.* 1985). This demonstrates that pride size is positively correlated with the availability of prey species as the Ngorogoro Crater has an abundance of prey species throughout the year (von Orsdol *et al.* 1985).
Each lion pride occupies a territory that it defends against intruders. The size of the territory depends on a variety of factors – the number of lions in the pride, the type of habitat, the abundance of prey, and the ease of catching it (Schaller 1972). Females usually retain the same territory for life, but the males stay only as long as they are able to defend themselves against rival males. Pride members often split up into smaller sub-groups throughout the pride range, and each individual spends a considerable amount of time alone (Schaller 1972, Bertram 1978). Males frequently patrol their territories by roaring and marking (spraying prominent rocks, trees, or bushes with urine). This often takes place away from females and the rest of the pride (Guggisberg 1961).

A single male or a coalition of up to 7 holds tenure over the pride, and effectively excludes strange males from siring cubs with pride females (Packer *et al.* 1991). Competition amongst males for pride tenure is intense, the average tenure being 2 (Packer *et al.* 1988) to 3 (Stander 1991) years. Infanticide is common when males take over a new pride; most females with dependant offspring lose their cubs within a month of a takeover, and those that are pregnant lose their cubs shortly after giving birth. Older cubs and sub-adults sometimes survive, due to their ability to

escape from infanticidal males. These cubs are evicted and must fend for themselves, although occasionally their mothers will leave with them and remain apart from the pride until the cubs reach independence (Bertram 1978). Young females are usually recruited into their mother's pride, although occasionally they disperse and form new prides. Young males nearing sexual maturity are also ousted from the pride, becoming nomads until they are able to acquire their own tenure (Smuts 1976). Males are thus assured paternity during their short reproductive lifetime, which is usually only as long as their tenure. Following a takeover, females display heightened sexual activity, attracting other males and thus encouraging competition, which will ensure that the fittest or biggest coalition will secure tenure. They do not conceive during this period, and only once tenure has been stabilized, will breeding resume (Smuts 1978). The sex ratio at birth is 1 male to 0.9 female. This ratio shifts to 1 male to 2.1 female in lions older than 5 years (Smuts 1978). This is as a result of differential rates of maturation, mortality, and emigration between the sexes (van Orsdol *et al.* 1985).

Lion populations are usually regulated either by 'bottom-up' processes (e.g. food limitation) that are inherently density dependent or by 'top-down' processes (e.g. natural enemies such as predators or parasites) that operate independently of population density (Kissui & Packer 2004). When food is limited in populations, reproductive output declines through reduced pregnancy rate, delayed maturity, and/or lower survival as the population approaches the carrying capacity, and density-dependent effects contribute directly to population regulation through competition for food (Sinclair *et al*. 1985; Mdumu *et al*. 1999). Infectious disease can have a significant impact on population size (Holmes 1982, Scott & Dobson 1989) and may persistently hold populations below carrying capacity (Sinclair 1979, Mitchell & Power 2003).

Food shortages are known to play an important role in infant mortality through abandonment (Packer & Pusey 1984) and starvation (e.g. Packer & Pusey 1995);
While social behaviour can also have an impact through infanticide (Packer 2001) and territoriality.

Although lions are sensitive to all these factors, disease outbreaks appear to be the single biggest factor capable of reducing carrying capacity. In 1962 an outbreak of *Stomaxys* resulted in an 80% decline in the Ngorogoro Crater lion population, while a 34% decline was observed in 2001 due to a combination of tick borne diseases and canine distemper (Kissui & Packer 2004).

3.8 Interaction with Other Predator Species

In most situations, lions display intolerance to other predator species. Managers of protected areas need to be cognizant of this fact, as it may have negative consequences to their management objectives, particularly if game viewing is an objective.

In most cases, the relationship between lions and other predators is competitive, and, in some cases, predatory. Lions often kill and sometimes eat other carnivores, including leopards and cheetahs, although this is not common (Estes 1993). The survival of cheetah offspring is also strongly affected by lion predation (Laurenson 1994). Hyaenas sometimes are killed by lions, but are very rarely eaten. On the GMPGR, some lions seem to tolerate the presence of hyaenas more than others (Kettles *pers. obs*. 2006). A coalition of 2 males that were removed as part of an artificial takeover exercise in 1999, used to actively seek out and annihilate hyaena dens. The lions that replaced these individuals appear to be more tolerant, with only two hyaena deaths being attributed to lions since 1999 (Kettles *pers. obs*. 2004). Two cheetahs have also been killed by lions on the GMPGR, one of which was partly consumed (Kettles *pers. obs*. 2002). Lions are also a key limiting factor to wild dog populations (Creel & Creel 1996). Wild dogs will also avoid areas of high prey density as a mechanism to avoid high densities of lion (Mills & Gorman 1997; Creel & Creel 1997). It was observed in Pilansberg National Park that re-introduced wild dogs limited their moving at night, and when they did, they avoided roads and the central section of the park which hosted high lion densities (van Dyk & Slotow 2003).

Monitoring conducted on the GMPGR has revealed that there is a definite correlation between the movements of lions in relation to those of cheetahs and leopards. Maps produced by GIS clearly indicate that whenever possible, leopards and cheetahs go to great lengths to avoid lions, utilizing largely opposite core ranges (Delsink 2003). It has been observed that leopards will temporarily abandon parts of their territory during extended visits by lions. Cheetahs, having no fixed territory, simply avoid them (Delsink 2003).

An interesting relationship seems to exist between spotted hyaenas and lions. The two species are very competitive; each tries to take the other's kill (Estes 1993). Hyaenas often rob lionesses of their kills by constantly threatening them, and even biting them. When males are present at a kill, however, hyaenas are more respectful and usually wait for the lions to move off a safe distance before claiming the spoils. Despite the aforementioned, there is a positive correlation between the numbers of lions and the numbers of hyaenas: the more lions there are in an area, the more hyaenas are bound to be present too. The exact reason for this phenomenon is not yet properly understood (Creel & Creel 1996).

3.9 Threats

Undoubtedly, the greatest threat to lions is human encroachment on their territory. Humans reduce habitat suitable to lions and eliminate prey species. Whenever man replaces the natural prey of lions with domestic stock, conflict is inevitable (Hunter 1998) and the result is the lions end up being trapped, poisoned, shot, or driven out of the area as a result of persistent persecution.

Lions are becoming increasingly scarce outside of national parks and protected areas. This may lead to genetic impoverishment of small and isolated populations and may lead to declines and susceptibility to disease (Hunter 1998). Many of the reserves and protected areas in Africa are coming under increasing pressure. The demand for more land in order to grow more food and rear more domestic stock in

the hope of providing a higher standard of living does not bode well for lions. The question of land has become a very powerful tool at the disposal of politicians, to be manipulated in whatever manner secures the most votes.

The simple truth is that lions are simply too large and too competitive (Hunter 1998) with humans to co-exist anywhere but in areas where they can receive effective protection and management.

CHAPTER 4
RESEARCH METHODOLOGY

4.1 Background

This research is based largely on, but not limited to, practical experience acquired by the author over a period of 13 years on the GMPGR in the Limpopo Province of South Africa.

In 1994 the management of the then newly established GMPGR embarked on one of the first attempts in South Africa to re-introduce free-ranging lions (a viable breeding pride not contained within an enclosed camp, and free to hunt for themselves) onto an enclosed area where, apart from the odd nomad, lions had been extinct for several decades. At the time very little data that pertained to a re-introduction of this type were available, and no successful models existed on which management could model their strategies.

Largely, by means of a combination of a process of trial and error, consulting other wildlife practitioners with similar projects, and with the help of the Universities of KwaZulu-Natal (Durban Campus) and Pretoria, the GMPGR management was able to develop a sustainable management strategy.

During the past 13 years, all management interventions, procedures, and lion population dynamics on the GMPGR have been meticulously documented and recorded. This included monitoring, translocation, contraception, hunting and artificial takeovers (the removal of a dominant male coalition, and its replacement with another, unrelated coalition). The methodology applied in compiling this study is simply the synopsis of the GMPGR management's findings and experiences, some of which subsequently been successfully applied on other reserves. In addition, several private game reserves were visited, or telephonic interviews were held with the resident managers. These interviews investigated the following issues: (1) size

and physical characteristics of the property, (2) size and sex ratio of the resident lion population, (3) prey species population, (4) most commonly predated species, (5) pre and post reintroduction monitoring procedures, (6) applied management interventions (prey species supplementation, hunting, contraception, translocation and artificial takeovers).

In addition to the above, extensive research through long-term monitoring relevant to lion biology and lion management methods were conducted, as the successful management of lions on enclosed reserves hinges on a well thought out, all encompassing and long-term monitoring and evaluation regime, which ties into and feeds the active adaptive style of management. van Dyk (1997) stresses that the first 12 months of monitoring of lions and prey species post-relocation are particularly important.

On the GMPGR, all the lions were identified and a field identification kit was composed. This was done by differentiating distinguishing physical characteristics of each lion, such as spot whisker patterns, scars, tattered ears, colour and size/shape of manes, patterns behind the ears and finally size, as lions of equal age often differ in size. As the pride grew, or as characteristics changed, the file was updated. These detailed data and identikits have been compiled and maintained since the lions were introduced (Delsink *pers. comm. 2006*). Data were collected from guides during game drives, research staff, and habitat maintenance staff. Whenever possible, GPS co-ordinates were taken of the sighting position and details of their activities were recorded, e.g. feeding, kill species, hunting, sleeping, patrolling, etc. The collation and analysis of these data resulted in trends pertaining to spatial utilization, core vs. total range use, and feeding ecology (Delsink *pers. comm. 2006*). Prey species have also been monitored by annual aerial game censuses (Peel 2006), and by maintaining a mortality register. These data have assisted management in generating effective adaptive management strategies via either the supplementation of prey species declining in number, or the removal of lions to alleviate the predation on these species.

4.2 Limitations

The study is based on the most recent information at hand, but should be viewed as a living document, due to the fact that as knowledge of lions grows, more effective methods and procedures for their management are bound to develop.

The study did not investigate in depth issues relating to the treatment of diseases and injuries, which typically are common amongst lions. These issues are best left for qualified veterinary surgeons to deal with.

Due to the infancy of the relatively new management practices of contraception and artificial takeovers amongst lion populations, very little published data are available on the subject.

CHAPTER 5
MANAGEMENT CONSIDERATIONS AND APPROACHES

5.1 Management Considerations

5.1.1 Considerations Prior to Re-introduction

Lions are a keystone species and therefore require special attention in terms of management. The following essential steps need to be taken before acquiring lions for re-introduction:

1. The team responsible for the re-introduction and long-term management of the lions should acquire an in depth knowledge of the species.
2. A comprehensive audit of the property to host the lions must be carried out. This audit should include the suitability for lions, size, prey species numbers and water availability.
3. The goals and objectives regarding the reason for the re-introduction must be carefully considered. Are the objectives biological or aesthetical (tourism)?
4. How will the re-introduction affect the achieving of other goals, e.g. the breeding of rare or endangered prey species (if applicable) such as roan antelope, sable antelope or disease-free buffalo or the hosting of other predators such as wild dogs or cheetahs?
5. An adaptive management policy should be adopted and a management plan must be set in place.
6. A sound knowledge of the numbers and trends of prey species must be acquired and maintained.
7. A sound knowledge of the numbers and trends of other predator species must be acquired and maintained.
8. A long-term monitoring initiative must be put in place, observing ranging patterns, breeding behaviour, predation, and effects on biodiversity.
9. Permission to host lions must be obtained from the relevant provincial authorities, as well as from immediate neighbours.

10. The perimeter fence of the reserve needs to be brought up to a standard that is acceptable to the Department of Environmental Affairs and Tourism.
11. A site must be selected (central in the reserve if possible) for the construction of the holding facilities (boma), and the construction thereof must of a high standard.
12. A list with contact details of medical doctors, capture experts, veterinary surgeons, and people experienced in managing lions and wildlife consultants in the proposed area and beyond must be compiled. When lion's situation deteriorates, it can do so quickly.
13. Acquire a veterinary medicine chest, a serviceable dart gun with darts and an easy to prepare anaesthetic such as Zoletil® which must be easily accessible for emergencies (break-outs, snares, etc).

5.1.2 Management Objectives

Acquiring lions is a major responsibility for the managers of a developing reserve, and careful planning and a clear objective is crucial to measure the success of the re-introduction (van Dyk 1997).

The necessary modifications to perimeter fences, the construction of a suitable boma, modifications to camp sites, staff quarters and houses as well as long-term expenses associated with lions (predation, veterinary costs, etc) make lions one of the most expensive species to host on an enclosed reserve. A thorough cost versus benefits analysis, therefore, needs to be undertaken. Protected area managers, particularly those who manage smaller reserves of less than 5000 hectares, may reconsider the viability of hosting lions once they have completed this exercise.

Ideally, when compiling objectives for lion management, the following should be taken into account (adapted from Slotow *et al.* 2003):

- *Goals:* What are management's long-term goals? For example, they could be to create a competitive tourism destination, to rehabilitate an area to

its former splendour by introducing species that were formerly exterminated, or to enhance biodiversity.

- *Baseline information:* Objectives should take size of reserve, rainfall, vegetation types, resident mammal species, and all available resources into account.
- *Monitoring procedures:* These should commence before the re-introduction and should continue after the relocation.
- *Research:* Research findings assist managers in making the right decisions, and allow others to learn and adapt from the knowledge gained.
- *Realism:* Objectives that cannot be achieved serve absolutely no purpose. Ensure that objectives are realistically attainable in order that goals may be achieved.

5.1.3 Carrying Capacity

According to Bothma (1997), the protected areas hosting free-ranging lions need to be large in order to provide the basic resources required for such large social carnivores. Lions require a substantial prey base, and the larger the pride, the more prey will be needed to sustain them, especially if the prey base does not include large herbivores which live in substantial herds. Bothma (1996) recommends that lions not be kept on an area of less than 1000 hectares. He does not state, though, as to how many lions can be kept on 1000 hectares. A study carried out by Power (2002) on a 1500 hectare enclosed game reserve hosting a pride of eight lions, devoid of any other large predators, concluded that a pride of this size will result in prey reductions to the extent that prey species will have to be replenished on an annual basis. This would suggest that 1500 hectares is thus too small a property to sustainably host lions. Based on observations of the GMPGR lions, and on interviews with reserve managers who manage enclosed lion populations, this study deduced that a pride of 6 lions (2 males and 4 females) will require at least 5000 hectares if management goals require that the lions be free-ranging and self-sufficient (able to sustain themselves). Any area smaller than this will require the periodic re-supplementation of prey species. It has been suggested by Estes (1993) that a

density of 12 lions per 10 000ha can be maintained in savannah areas with a large biomass of prey species. This suggested number should be approached with caution, as Estes was referring to lions in open, unfenced areas (Kettles *pers. obs*. 2005). Prey species are thus free to move in and out in search of forage and water. In such situations, lions are able to follow their prey if the need may arise. More arid areas would obviously carry less prey species, thus limiting the carrying capacity for lions even further. Estes (1993) observed that 1 lion per 8 000 to 16 000ha is sustainable in arid areas such as the Kalahari Desert.

A '*Lion Feeding Unit'* (LFU), which is the equivalent to one adult lioness and its prescribed daily feeding unit, is calculated to be 4.3 kg (Power 2002). A male lion's daily feeding unit is 1.5 times that of a lioness. Power's study concludes that a stocking rate of 6 to 7 LFUs/100 km² is recommended, providing the reserve falls within a savannah veld type with an annual rainfall of 500-700 mm and that no other predators are present. This number can be exceeded, and other predators may be present, the proviso being that an active monitoring process must be in place and managers must have the data and authority at their disposal to maintain direction and apply active adaptive management (Kettles *pers. obs.* 2006).

An important factor to consider is the likelihood of other large carnivores occurring within the same area. The presence of leopards, hyaenas, cheetahs, and wild dogs must be noted and an attempt must be made to determine their numbers, as they too will affect the prey base, which in turn will affect the lion carrying capacity of the area (Kettles *pers. obs*. 2006). This should form part of the ongoing monitoring process.

The key to successful lion management is not how many lions an area can carry, but rather how many lions should be carried in order to achieve the management goals (van Dyk 1997). Lion populations can be manipulated to achieve the set out goals. Again, this re-emphasizes the importance of monitoring.

Previously, predictions of the potential population size of large predators were based on space use rather than resource use (Hayward *et al.* 2007). Hayward *et al.* (2007) demonstrated that the population density of large African predators was significantly related to the biomass of significantly preferred prey and/or the biomass of prey in their preferred weight range.

Table 5.1 indicates the free-ranging lion densities in several enclosed game reserves in South Africa. These densities obviously change frequently due to natural processes or management interventions. Whilst interviewing the managers of the reserves listed below, a common management principle shared by all is the need for determining the number of adult (male and female ratios), sub-adult, and juvenile lions the property requires to achieve its goal at any one time. Sub-adults can easily be removed or population control measures can be implemented to keep the population more or less at the desired number.

Representatives from all the reserves listed below stressed the difficulties involved in finding alternative reserves suitable as relocation venues for lions removed in order to keep their lion populations at sustainable levels. It appears that the market for lions is saturated. Two game reserves (whose managers requested not to be identified) have resorted to euthanasing their excess lions, as they cannot acquire permits to relocate these animals due to beaurocratic red tape. Of the properties listed below, Kapama Private Game Reserve, Thornybush Private Game Reserve, Shamwari Private Game Reserve and Karongwe Private Game Reserve (formerly Edeni) are required to supplement prey species on a regular basis, due largely to relatively dense lion populations in relation to the size of the reserves. Phinda Resource Reserve also supplements prey species, but nor as frequently as the reserve listed above. Thornybush and the GMPGR include contraception as a form of their population control, while Kapama will initiate a contraception programme during the course of this year (Ferreira *pers. comm. 2005*).

Table 5.1: Lion density in 2006 on some of South Africa's enclosed game reserves.

Conservation Area	Size (Hectares)	Lion Population	Density/100 km²
Makalali Pvt. Game Reserve	24 000	21	8.75
Phinda Resource Reserve	17 000	24	14.1
Thornybush Pvt. Game Reserve (2 Prides)	12 000	11 & 9	16.6
Karongwe Pvt. Game Reserve	8 500	9	10.5
Kwandwe Pvt. Game Reserve	16 000	9	5.6
Selati Game Reserve	27 000	6	2.2
Shamwari Pvt. Game Reserve	18 000	19	10.6
Kapama Pvt. Game Reserve 1	10 000	18	18
Kapama Pvt. Game Reserve 2	8 000	8	10

Source: Telephonic interviews with reserve management in July 2005: Shamwari: O'Brien, Thornybush: Pieterse, Kwandwe: Sholto-Douglas, Karongwe: Owen, Selati: Niemann, Kapama: Ferreira, Phinda: Pretorius.

5.1.4 Pride Origin

Careful consideration must be given to the origins of the lions to be introduced for several reasons. It is imperative that lions that are to be free-ranging, originate from an area where they have had as little interference from humans as possible. Lions that originate from zoos or other places where they have been kept in unnatural conditions, such as "lion breeding projects" are to be avoided. Such lions are sometimes incapable of hunting for themselves and their aberrant behaviour as a result of their close association with humans tends to make them extremely dangerous. Upon release, they are prone to seeking human contact and may not respect fences or other barriers (van Dyk 1997, Bothma 1996). There has not been a single successful re-introduction of hand-raised lions anywhere in Africa (Kruger Times 27 March 2005).

For this reason, only wild, free-ranging lions should be considered suitable for re-introduction. Recently, lions fulfilling this criterion have become freely available, as numerous smaller game reserves have reached the stage where they are able to sell surplus lions. An obstacle currently facing lion managers is the difficulty in obtaining permits for the movement of lions (purchasing or selling) due to a new national policy under discussion.

van Dyk (1997) recommends that particular attention must be paid to:

- Where the animals came from originally (bushveld, savannah, arid area, etc.).
- The characteristics of the pride should be determined (aggressive, shy, cattle raiders, etc.). This can be done by interviewing stakeholders from the area where the lions come from.
- Their genetic variability.
- Their diet preferences.
- The history of their management.
- The reasons they are being sold (problems?).

Blood samples should be analysed in order to ensure that they are not carrying any diseases. Feline Immunodeficiency Virus (FIV) appears at this stage to have no significant negative health effects on lions (Hoffmann-Lehmann *et al.* 1996). Most lions in South Africa are FIV positive (Rogers *pers. comm.* 2006), so this need not be a limitation.

5.1.5 Pride Composition

When re-introducing lions onto a reserve for the first time, van Dyk (1997) advises to release a small group of reasonably young lions (2 to 3 years old), preferably with a male coalition rather than a single male. A ratio of 2 males to 3 females is advised, as the ratio will be easily managed initially. van Dyk maintains that the advantages

of such a pride include their initial inability/inexperience to kill large, valuable prey species; the females are more likely to remain together, facilitating research and the birth of cubs will be extended. Bothma (1996) recommends a ratio of three or more females per male. At the time of re-introduction, the GMPGR's nucleus pride was 2 males and 4 females (Kettles *pers. obs*. 1995).

On a property with single pride status, the advantage of a coalition over a single male is simply that, being males, they cannot fall pregnant, thus slowing down the birth rate, and that from a tourism point of view, they are more sought after.

5.1.6 Genetic Considerations

It is likely that the long-term effects of inbreeding are likely to have a serious impact on the breeding success and survival of the pride (van Dyk 1997). Bothma (1996) maintains that the males introduced need not be from the same pride as the females. This is in fact preferable, as it will enhance the genetic diversity of the pride. Dr Peter Rogers (*pers. comm. 2006*) explained that his experience at Kapama Game Reserve revealed that females from different prides can sometimes be successfully re-introduced together, providing they have had adequate time to bond within a boma, initially with a fence between them if necessary. He added, though, that this could sometimes fail, as there is no guarantee that they will accept one another. In the event of such an exercise being successful, genetic diversity will be further enhanced.

Artificial takeovers are also an important tool in manipulating genetic diversity and are discussed in more detail elsewhere in this study.

5.1.7 Costs Versus Benefits

It is often economic factors rather than ecological factors that determine the conservation effort allocated by landowners to a particular species (Cotterill 1997). Cotterill adds that a delicate balance exists between ecology and economics.

In South Africa, the tourism industry has resulted in considerable energy being devoted to restoring natural ecosystems. The motivation behind the re-introduction of lions in many areas where they had previously been extirpated has largely been based on financial, rather than ecological, principles. The deep emotional appeal engendered by lions (Hunter 1998) in the general public, and the fact that they are the single most sought after species for tourists visiting reserves (Hunter 1999a), means that lions act as a draw card, benefiting landowners financially.

In order for enclosed tourist based areas hosting lions to remain sustainable, the costs and benefits need to balance (Cotterill 1997). Preferably, the benefits need to exceed the costs (*pers. obs*). Cotterill adds that predation costs increase in proportion to the number of lion resident on a particular area until a point is reached where the predation costs no longer can be counteracted by income generated from the lions (tourism or trophy hunting). The lion population therefore needs to be maintained at a level of at least equal to, or preferably below the ecological carrying capacity in order to be financially viable.

The only way to determine these carrying capacities is through monitoring and experience gained over time.

5.1.8 Boma and Lion Habituation

Once a suitable pride of lions (based on the criteria described earlier) have been sourced, they need to be relocated to a holding/habituation facility, commonly referred to as a boma.

This measure should be considered essential, the reasons being (van Dyk (1997):

- The lions need to become accustomed to electric fences in order to respect such barriers.

- It allows the animals to become accustomed to the new sights, sounds, scents, and possibly, new pride members in the new area.
- It allows the animals to recover from the stress associated with the capture and transportation process.
- The animals need to recover from the effects of the tranquilizing drugs used during the relocation exercise.

The boma needs to be at least 1 hectare in area (10 000m²) and it should contain open areas, trees for shade, and bush for refuge. The boma should be positioned centrally on a quiet part of the reserve, far away from the property perimeter. The fence of the boma needs to be reinforced to a higher specification than the legal minimum prescribed by the Department of Environmental Affairs and Tourism (DEAT) for perimeter fences, as it is essential that lions cannot escape from the boma, because if they do, the likelihood of them being able to escape from the reserve exists. The boma should instill in the lions a respect for fences. The boma on the GMPGR consisted of 2.4m high Bonnox® netted fencing, reinforced with 5 horizontal 12mm steel cables spaced at roughly half metre intervals. Steel droppers were fastened every 1.2m, Y-standards were spaced at 10m intervals, and railway tracks were used as anchor posts, spaced at 20m intervals. Four electrified wires, each with an earth wire running parallel with it, were mounted along the inside and outside of the fence, spaced as follows:

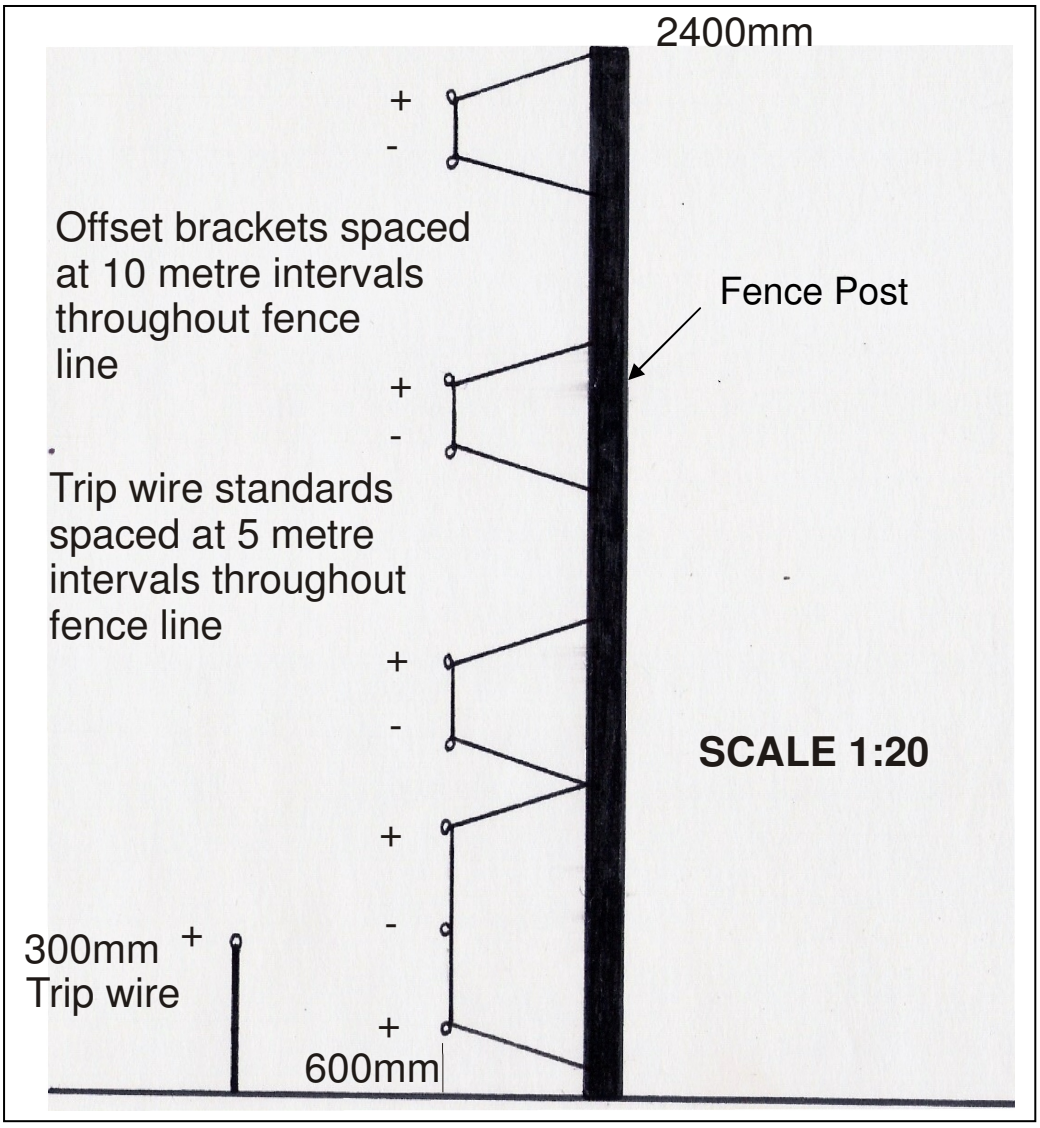

Figure 2: Diagram Illustrating Fence Electrification Requirements (McLaughlin *pers. comm*. 2006)

Bottom Strand: 200mm above ground with 450mm double offset bracket

Second Strand: 600mm above ground with 450mm double offset bracket.

Third Strand: 1600mm above the ground with 450mm offset bracket.

Fourth Strand: 1500mm above the ground with 450mm offset bracket.

Top Strand: 2000mm above the ground with 450mm offset bracket.

Double offset brackets are the most effective method of combining live and earth wires.

In addition to the electric wires mounted on the fence itself, a trip wire was erected 600mm in front of the fence at a height of 300mm to discourage predators and warthogs from digging under the fence. This was achieved by cutting Y-standards to the desired length, hammering them into the ground, and attaching "Nail-On" insulted bobbins, manufactured by Meps Electronics®. A Meps 500 Super Energizer® was used to electrify the wires, and 9700 volts was maintained.

At the time of re-introduction of lions (1995), no guidelines existed as to what the specifications for a lion boma should be. The illustrated boma design was conceived and built after the designs of the bomas used by commercial lion breeders were reviewed. Although not entirely necessary, a larger habituation area (14 hectares in extent) surrounding the small boma on 3 sides with an inter-leading gate between the two was built (Figure 3). Although some may view this boma as being over-specified, the advantage is that it can be used as a larger, more natural habituation area for the final acclimatization period of the lions. Furthermore, the bigger boma provided a more natural environment and allowed for less interaction with humans. Vehicles could easily enter this section and drive around in it, thus allowing the lions to become accustomed to vehicles, a necessity if tourism is a management objective. The lions were housed in the small boma for a period of 37 days before the inter-leading gate was opened, thus allowing them into the big boma in which they remained for a further 53 days before being released. During these periods, the lions were observed at least 3 times per day, and the bomas were inspected for possible damage.

Great efforts were made to prevent the lions associating the arrival of food with humans, as this could have dire consequences later on. A tower was constructed and hidden behind a Hessian blind that allowed carcasses to be dropped into the boma on a pulley system. Initially this system scared the lions, but they soon became acclimatized to it. A problem encountered within a few weeks, however, was that the lions associated the arrival of their food with the arrival of the vehicle delivering it. Even though the lions could not see the off-loading and the hoisting of the carcass, an association was still made between the vehicle and food. The

objective of the tower/pulley system was thus defeated. This approach was changed to having two vehicles driving around the outside of the boma, the drivers of which had radio contact with each another. The first vehicle would spot the lions and call in their position and hold their attention, the second vehicle would drive to the furthest point as possible away from the lions, and drop a carcass over the fence. The lions would always find the carcass, as they tended to patrol the fence. This exercise became even easier once the lions were in the big boma (Kettles *pers. obs*. 1994).

After a total of 90 days, the lions were released onto the greater reserve. The habituation period in the boma was successful, as apart from one lioness and her cubs escaping through a section of fence damaged by a flooding river (they were quickly re-captured), no other problems were experienced with regards to lions attempting to break out the fences. The boma was also successfully used to habituate two male lions in 1999, and again in 2006, as part of artificial takeover exercises (Kettles *pers. obs.* 2006).

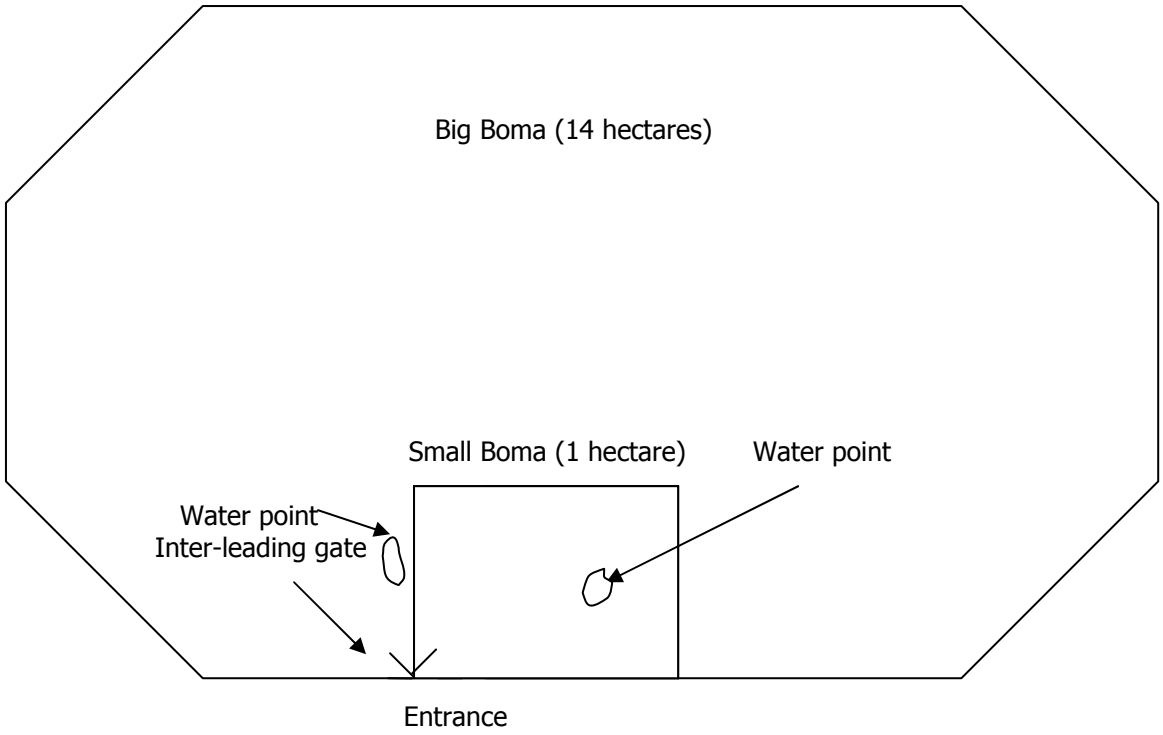

Figure 3: The Boma built on Makalali Private Game Reserve.

5.1.9 Perimeter Fence Requirements

The requirements for the perimeter fence around the protected area are identical to those described in the section outlining the requirements of the boma, except that normal 2mm or 2,6mm steel wire can be used instead of Bonnox netted wire. The fence needs to be 2.4m high with a minimum of 22 horizontal wire strands (excluding the offset electric and earth wires).

5.2 Management Approaches

The management initiatives listed below were carried out over a period of 13 years. It is hoped that the practical and practicable nature of these initiatives will allow reserve managers to feel at ease and confident when applying lion management practices.

5.2.1 Population Reduction

Enclosed reserves do not allow for emigrations or immigrations. Furthermore, this fact combined with a single pride status, means that natural mortality rates amongst lions are very low.

5.2.1.a) Hormonal Contraception

The management objectives on the GMPGR are to keep the lion population as close to 21 as possible. The GMPGR objective is to maintain the pride dynamics to 2 adult male coalition, 6 adult females; and a mixture of 6 to 8 sub-adults and cubs (total lion population goal: 12 to 14). This structure has worked well for management, as tourists are able to see lions regularly on the 24 000 hectare reserve, and the pride has a good cross-section of adults, sub-adults, and cubs. More importantly, monitoring efforts have revealed that this number does not have a negative impact

on prey species numbers. Annual game census results have shown that the prey species numbers actually marginally increased between the period of September 2004 to September 2006 (Peel 2006).

Previously, the desired pride size was maintained by simply removing excess sub-adults once they reached the age of 16 to 22 months. These lions were readily sold to emerging game reserves wishing to re-introduce lions. During the past 6 years, however, it has become increasingly difficult to sell these lions as virtually all the other small, enclosed reserves also have excess lions, and the market has collapsed due to over-supply. Furthermore, the draft DEAT National Lion Management Policy forbids the selling of free-range lions to reserves smaller than 1000 hectares, or to lion breeders. This limits the market even further. Besides the above, the selling free-ranging lions to managers of small areas or breeding projects where the lions are kept in small enclosures is undesirable from an ethical point of view. Tour operators or members of the press finding out that properties are supporting the 'canned lion hunting' industry can cause irreparable damage to the reputation of a tourist venue.

In view of the above factors, a decision was made to implement a contraception programme on the GMPGR. The objective was not to stop the lionesses from breeding entirely, but rather to slow down their rate of breeding by administering the contraceptive GnRH analogue Deslorelin to selected females on a rotational basis. The remainders were allowed to breed as per normal (Kettles *pers. obs*. 2006). This halved the management problem, as the reserve now had smaller, more manageable groups to sell. A further motivation for adopting this management strategy was that a pride without any cubs or sub-adults is unnatural. By rotating the target females, all are afforded the opportunity to breed.

Deslorelin works by blocking the hormone GnRH secreted by the pituitary gland. GnRH controls the oestrus cyclicity in cats. Thus, under this method, lions will not have an oestrus cycle (Bertschinger *et al.* 2001). Administering Deslorelin involves anaesthetizing the lioness and inserting a slow-release implant subcutaneously in

the neck region. The implant is cylindrical, approximately 2mm in diameter and 4mm in length. This renders the implant completely invisible and ensures that there is no irritation. The implant is effective for a period of 18 months (Bertschinger *et al.* 2001), and field studies have revealed that thereafter, the lionesses cycle normally, but will only conceive after their second or third cycle. Technically, the procedure is thus effective for 2 years. Monitoring on the GMPGR has substantiated this (Kettles *pers. obs*. 2006).

Deslorelin is not to be confused with the earlier progesterone implants. There have been accounts of progesterone causing emasculation or sterility in lionesses. To date, no behavioural or health related side-effects have been noted (Bertschinger *et al.* 2001). Successful programmes of a similar nature to this have subsequently been initiated on the Thornybush, Touchstone, and Mabula game reserves, with similar results.

5.2.1.b) Hunting

The hunting of adult lions appears to be an option, considering the high trophy price of these animals: up to R150 000.00 for a big maned male and R30 000.00 for a female (Niemann *pers. comm*. 2006). The hunting of lions is an emotive subject amongst the general public and owners/managers of lions should be made aware of the possible pitfalls. Properties reliant on tourism as a source of income could face boycotts from those tour operators who are not in favour of hunting.

It must be born in mind that by the time a male is huntable as a trophy, namely at least 5 years old (Grobler 1997), he has already consumed far more than he can be sold for in financial terms (Kettles *pers. obs*). Based on Power's observation that the average male lion eats 6.5kg/day (2002), a lion would have consumed 11 863 kg of meat by the time he was 5 years old. Assuming that the game the lion has eaten is worth an average of R20.00/kg, this equates to R237 250.00. A lioness would eat 0.5 times less, but the exercise would still not be viable. Adult male lions are sold live for anything between R20 000.00 and R100 000.00 (van Altena *pers.comm.*

2007), while adult females are sold for between R10 000.00 and R25 000.00 (van Altena *pers.comm. 2007*). The vast majority of these lions end up being hunted at their new destinations anyway, at a large profit (Kettles *pers. obs*. 2006).

The hunting of free-range lions on enclosed reserves only becomes viable when:

1. The reserve is hosting too many lions and the numbers of prey species are being negatively affected;
2. Inbreeding is occurring, or is about to take place, and new genes are required in the pride;
3. Certain individual animals are too old to be of value to the pride or management; and
4. A problem animal needs to be removed due to it having developed undesirable habits such as repetitive break-outs, becoming overly aggressive/familiar towards humans, killing other lions uncharacteristically, etc.

5.2.1.c) Other Population Control Measures

Other methods worth considering in managing population numbers are the vasectomisation of males, sterilization of either the males or the females, and culling.

The vasectomy procedure is straightforward and safe. The lion needs to be anaesthetized and a section of each *vas deferens* is surgically removed, effectively sterilizing the male. The only drawback to this procedure is the fact that its effects are permanent. Depending on the management goals of the reserve, this could be the quickest and easiest way of stopping breeding. Vasectomies have been successfully applied to lions on the Selati Game Reserve and the Madikwe Game Reserve (Rogers *pers. comm. 2005*).

Sterilization, through castration or hysterectomies is not a feasible option in a game reserve. Removing the testes of a male lion can result in mane loss, while the

sterilization procedure for lionesses is a relatively complex operation requiring a long recuperation period (Rogers *pers. comm. 2005*). Given the nature of lionesses (hunters), the risk of the wound caused by the operation taking excessively long to heal, and possibly becoming infected, is high. Additionally, sterilized lionesses tend to gain excessive weight (Rogers *pers. comm. 2005*).

The culling of sub-adults is an option for manipulating population growth. This formed part of the former Natal Parks Board management regime, as population pressure from within the Hluhluwe/Unfolozi complex forced young males to break out of the reserve regularly, and they became a menace amongst the rural communities living on the outskirts of the reserve (Whyte *pers. comm. 2005*). This method is flawed in some cases this may cause lionesses to have cubs more frequently than would be the case without human interference (depending at what age the sub-adults are culled) .

5.2.2 Artificial Takeover

In open systems, a male coalition holds tenure over the pride, and effectively excludes strange males from siring cubs with pride females (Packer *et al.* 1991). Competition amongst males for pride tenure is intense, the average tenure being two years (Packer *et al.* 1988) to three years (Stander 1991). Infanticide following a takeover, as well as territorial disputes resulting in mortalities, is not common on enclosed reserves as a result of only 1 pride being present. Furthermore, inbreeding will occur unless management intervenes. Although the long term-effects of inbreeding are not fully understood, it will likely have a serious impact on the breeding success and survival of the pride (van Dyk 1997).

On the GMPGR, the problem of inbreeding was addressed by initiating an artificial take-over, whereby in 1999 and 2006, the 2 male coalition was removed, and new unrelated 2 male coalitions from a different gene pool were introduced (Kettles *pers. obs*. 2007). The results were exactly as would be expected from a take-over in an open system. Upon their release from the boma, the 2 new males sought out the

female pride, asserted their dominance and killed all the cubs. What was not anticipated, however, was that the new males would kill the oldest and most dominant lioness, after a hunt lasting 1 week (Druce *et al.* 2004b). This particular lioness was very old (approximately 14 years) and was probably at the end of her reproductive life anyway.

This exercise resulted in management being able to achieve its objectives of introducing new genes into the pride and of preventing the old males from breeding with their progeny. Another important consideration is that in the GMPGR case, its original lions were swapped for the new ones from Kapama Game Reserve, resulting in the only costs being the relatively low capture and transport costs of the GMPGR lions. Kapama management covered the capture and transport costs of their lions.

The success of this initiative has resulted in similar exercises being carried out on other game reserves.

5.2.3 Capture Methods

In accordance with regulations set out by the South African Veterinary Council, the chemical immobilization of animals is not permitted in South Africa by persons who are not suitably qualified (Rogers *pers. comm.* 2005). However, in utter emergencies, it is acceptable for example, when a lion is trapped in a snare or has broken out of a protected area and is endangering the lives of people or domestic stock, that lions can be immobilized by people responsible for the management of the animals.

McKenzie and Burroughs (1993) state that the following precautions should be taken when immobilizing lions:

- Always dart lions from the safety of a vehicle or shelter.
- Always keep a lookout for other members of the pride, as they will look for a missing pride member and may charge with little provocation.

- A competent and experienced marksman with a heavy calibre rifle must be close at hand. Heavy calibre handguns could be worn on the hips of operators as a form of defense, at last resort.
- Avoid capturing females with cubs.
- Limit the number of people at the site of the capture.
- Make sure to thoroughly wash hands after touching lions in order to avoid ingesting potentially harmful bacteria.

Lions require relatively large darts (3 to 5ml) and the darts can be delivered via any of the commercial dart guns available (McKenzie and Burroughs 1993). Gas operated dart guns such as the Dan-Inject® system are preferred as they are very quiet and the gas can be set ensuring a relatively gentle delivery, minimizing the risk of injuring the lion (Grobler *pers. comm. 2006*). Needles need not be longer than 40mm, and they preferably should be barbed or collared, as these remain in the lion, facilitating identification (McKenzie and Burroughs 1993).

A wide range of drugs are available, the best known being Zoletil® (McKenzie and Burroughs 1993). This is the only drug recommended to be administered by non-professionals due to its ease of use and non-lethal effects in the event of a slight overdose (McKenzie and Burroughs 1993). Medetomiline®/Ketamine® cocktails are the presently preferred drugs used by veterinarians. They have the added advantage of being reversible, whilst Zoletil® cannot be reversed, and it may take several hours for the animal to recover completely (Rogers *pers. comm. 2006*).

McKenzie and Burroughs (1993) recommend Zoletil® dosage rates of 3mg/kg for females and 3.5mg/kg for males, although up to 10mg/kg has been used safely. McKenzie and Burroughs (1993) add that the duration of incapacity is related to the dose, and higher doses are justified if the animal is to be maintained under anaesthesia, for example when lions have to be transported.

When handling anaesthetized lions, always be aware of the possible presence of other lions. Also, keep the lion level, ensuring that it can breathe freely, and monitor

for possible regurgitation. The state of anaesthesia must also be monitored to ensure that the lion does not recover unexpectedly (McKenzie and Burroughs 1993).

5.3 Management Summary

Having researched the biology and ecology of lions in depth during the course of this literature review, having worked closely with lions, and having experienced all the practical implications of their management during the past 12 years, I have found that the single biggest challenge in lion management is population control. For this reason, Component B of this dissertation will focus on population control measures which could be applied by the managers of enclosed reserves.

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