EVALUATION OF CHEMICAL IMMOBILIZATION AND TRANSLOCATION OF SELECTED WILD HERBIVORES AT YANKARI GAME RESERVE AND SUMU WILDLIFE PARK, BAUCHI STATE, NIGERIA

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MAY, 2014

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MAY, 2014

DECLARATION

I declare that the work in this thesis entitled "**Evaluation of Chemical Immobilization and Translocation of Selected Wild Herbivores At Yankari Game Reserve And Sumu Wildlife Park, Bauchi State, Nigeria"** has been performed by me in the Department of Veterinary Surgery and Radiology, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria under the supervision of Professor A.Z. Hassan, Dr A. Abubakar and Professor A.B. Ogunkoya.

The information from the literature has been duly acknowledged and a list of reference provided. No part of this thesis has been submitted elsewhere for a degree or diploma at any Institution.

Mohammed ABDURRAHMAN	……	……
Name of student	Signature	Date

CERTIFICATION

This thesis entitled "**EVALUATION OF CHEMICAL IMMOBILISATION AND TRANSLOCATION OF SELECTED WILD HERBIVORES AT YANKARI GAME RESERVE AND SUMU WILDLIFE PARK, BAUCHI STATE, NIGERIA"** By Mohammed ABDURRAHMAN meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to my entire family and the Wildlife Conservation Societies.

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I give thanks to Almighty Allah (SWT) for enabling me reach this phase of life, even against all odds.

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ABSTRACT

The study was conducted to assess the suitability or otherwise of the capture and restrain techniques as well as the transportation of wildlife in the Yankari game Reserve and Sumu Wildlife Park, Bauchi State using chemical immobilization. A total of twenty five (25) wild herbivores were captured and translocated during this study. Chemical immobilization or anaesthesia was conducted using a combination of an opioid, etorphine hydrochloride at an average dose of 7 mg and a tranquilizer belonging to the class of alpha 2 agonist, medetomidine to potentiate the etorphine Hcl. effect in the same remote delivering dart at an average dose of 6 mg. The animals were successfully anaesthesized after 5 to 15 minutes for all the species captured and there was no statistical significant difference ($P>0.05$) between the recumbency and recovery time among species. Azaperone was also used as a short acting tranquilizer before the administration of the reversal agent Naltrexone which antagonizes the effect of the etorphine. Perphenazine was used alongside with azaperone during the cause of translocation as a long acting tranquilizer. No animal was lost during the cause of translocation and as such the combination of Perphenazine and Azaperone was judged satisfactory. This work proved that the mixture of etorphine Hcl. as an anaesthetic drug and medetomidine as a tranquilizer facilitated handling and reduced stress of free-ranging animals. In conclusion, this anaesthetic combination has proven to have rapid onset, safe, effective and potent. The anaesthetic reversal was rapid with minimal undesirable side effects.

TABLE OF CONTENTS

Cover page……..……I

Declaration.....II

Certification III

Dedication.....IV

Acknowledgements..... V

Abstract.....VI

Table of contents.....VII

List of tables.....IX

List of figures..... X

List of plates.....XI

List of appendices XII

CHAPTER 1: INTRODUCTION..... 1

1.1 Back Ground of the Study 1

1.2 Statement of Research Problem..... *4*

1.3 Justification ……4

1.4 Aim of the Study *5*

1.5 Objectives of the Study *5*

CHAPTER 2: LITERATURE REVIEW 6

2.1 Importance of wildlife *6*

2.1.1 Direct values..... *7*

2.1.2 Indirect values *7*

2.2 Capture of wildlife..... *7*

2.3 Physical capture methods of wild herbivores..... *8*

2.3.1 Capture by means of spotlight..... *8*

2.3.2 Capture by means of pole- lassos *8*

2.3.3 Capture by means of drop nets *9*

2.3.4. Capture of herds by means of funnel traps and net-and –plastic corrals..... *10*

2..3.5. Capture by mmeans of chemical immobilization……11

2.3.5.1. Darting equipment……...11

2.4 Drugs used for Wildlife Capture or Immobilization *13*

2.4.1 Tranquilizers/neuroleptics..... *13*

2.4.2 Opioid analgesics..... *16*

2.4.2.1 Morphine derivatives..... *19*

2.4.3 Hypnotics and sedatives *23*

2.4.4 Alpha-2-adrenoceptor agonists..... *24*

Detomidine *25*

Medetomidine *27*
2.5 Translocation *29*
2.5.1 Types of translocation 29
2.5.1.1 Introduction 29
2.5.1.2 Re-introduction 30
2.5.1.3 Re-stocking 30
CHAPTER 3: MATERIALS AND METHODS 31
3.1 Study areas *31*
3.2.2 Drugs and other materials *33*
3.4 Methodology *36*
3.4.1 Capture technique *36*
3.4.2 Parameters assessment *36*
3.4.3 Translocation of captured animals *38*
CHAPTER 4: RESULTS 43
4.1 Capture records made in and out of yankari game reserve and sumu wildlife park 43
4.2 Wildlife species captured 43
4.3 The physiological activities 43
4.4 Vital parameters 44
4.4.1 Rectal temperature 44
4.4.3 Respiratory rate 44
4.4.4 Arterial blood oxygen (SPO2) 44
CHAPTER 5: DISCUSSION 55
CHAPTER 6: CONCLUSION AND RECOMMENDATION 60
6.1 Conclusion 60
6.2 Recommendation 60
Reference 61
Appendix 70

LIST OF TABLES

Table 3.1: Drugs utilized for the chemical immobilization and medical treatment of Wildlife Yankari Game Reserve and Sumu Wildlife Park, Nigeria……..33

Table 3.2: Other materials required for chemical immobilization and medical treatment of wildlife…….....……..…..34

Table 4.1: Average doses of drug used for individual specie during chemical Immobilization……53

LIST OF FIGURES

Fig.3.1. Map of Bauchi State Nigeria…… ……..……..31

Fig. 4.1. Distribution of Captured Animals by Sex from the Yankari Game Reserve and Sumu wildlife Park, Nigeria …….……..……....44

Fig. 4.2. Distribution of Captured Animals Activities……..……..45

Fig. 4.3. Condition of Captured Animals at Yankari Game Reserve and Sumu Wildlife Park, Nigeria……..……...……46

Fig. 4.4. Distribution of Captured Animals Drugs Effect and Reversal State……47

Fig. 4.5. Distribution of Captured Animals Mortality and Morbidity State……...48

Fig. 4.6. Distribution of Captured Animals Temperatures……..49

Fig. 4.7. Distribution of Captured Animals Respiratory rates…….50

Fig. 4.8. Distribution of Captured Animals Pulse rates……...51

Fig. 4.9. Distribution of Captured Animals Arterial blood oxygen…….52

LIST OF PLATES

Plate 3.1: A waterbuck in a holding pen (boma) after capture……..38

Plate 3.2: Locally constructed crates used for translocation of wildlife……...39

Plate 3.3: Animals loaded in a crate being lifted with a crane onto a truck for translocation……40

Plate 3.4: Animals loaded on a truck ready for translocation…….41

LIST OF APPENDICES

Appendix I. Average of vital parameters of all the animals captured 70
Appendix II. Average time to recumbency and standing 71
Appendix III. Sex of captured animals 72
Appendix IV: Condition of captured animals 73
Appendix V:Showing location and the level of activity before capture 74
Appendix VI: Collapsed pole syringe (Jab stick) A 76
Appendix VII: Folded stretcher 77
Appendix VIII: Ear tag applicator (A), with an ear tag (B) 78
Appendix IX: Immobilization drug Etorphine HCL (Captivon®) 79
Appendix X: Short acting Tranquilizer Azaperone (Stresnil(R)) 80
Appendix XI: Long acting Tranquilizer Perphenazine 81
Appendix XII: Reversal agent Naltrexone (Trexonil(R)) 82
Appendix XIII: Darting of Zebra (a) at 50 metres from a stationary vehicle. A giraffe (b) in the background 83

CHAPTER ONE

INTRODUCTION

1.1. Background of the Study

Chemical immobilization or anaesthesia of free-ranging mammals is a form of veterinary anaesthesia conducted under the most difficult circumstances (Nielsen, 1999; Kreeger *et al.*, 2002). For many species, researchers use a mixture of anesthetic drugs and tranquilizers to facilitate handling of free-ranging animals and to reduce stress (Arnemo *et al*., 2006; Kreeger and Arnemo, 2007).

Indications for chemical immobilization in wildlife include physical examination, reproductive manipulation, medical and surgical treatments (Klein *et al*., 1997) as well as translocation (Swan and Naude, 1992).

Anaesthetic agents, opioids, hypnotics, sedatives, tranquillizers (neuroleptics) and neuromuscular blocking drugs are the groups of drugs most commonly used for the immobilization, capture as well as translocation of wildlife. Other drugs are used for chemical reversal of central nervous system and neuromuscular depression, and for cardiovascular and respiratory support following or during such chemical restraint. Immobilizing drugs are all potentially dangerous to humans and animals and should, therefore, be handled with care (Swan and Naude, 1992).

Immobilization or the chemical restraint of wildlife has replaced, or is used in conjunction with, various types of physical restraint and capture methods (Swan and Naude, 1992). The availability of suitable drugs has dramatically improved the safety and cost-effectiveness of handling, capture, transportation, and adaptation following translocation of wild animals. Before the advent of suitable drugs, the capture and

transportation of many wild animals, particularly the larger species such as elephant (*Loxodonta africana*) and rhino (*Diceros bicornis*), was extremely difficult and hazardous. With certain antelope species, physical restraint was formerly virtually impossible due to the phenomenon of stress-induced mortality such as capture myopathy (Swan and Naude, 1992).

Irrespective of the methodology, capture is a potential stressful event for free ranging wildlife (Koch, 1987; Haulton *et al.,* 2001; Fahlman *et al*., 2008). Capture procedure impacts not only on animals physiological and physical parameters, but may also result in behavioral alterations following capture and handling, which calls for an assessment of the potential short-term and long-term disturbance effects on study animals and research results (Laurenson and Caro, 1997; Cote *et al.,* 1998; Cattet *et al*., 2008; Morellet *et al*., 2009). Growing public awareness of animal welfare issues will in future lead to increasingly stringent ethical measures on the handling and treatment of non-domesticated animals. In particular, it will lead to, amongst other things, the increased use of chemical immobilization and stress management (Swan and Naude, 1992).

The capture of bears (*Ursus arctos*) with an oral mixture of honey and strong spirits by Winckell in 1820 is probably the first documented case of the use of chemicals to restrain wild animals (Jalanka, 1991). From then on, a number of oral mixtures were used with variable success (Hupka, 1926; Berge, 1938; Montgomery and Hawkins, 1967; Thomas *et al.,* 1967; Done *et al.,* 1975; Meuleman *et al.,* 1984; Fowler, 1982; 1986). Oral administration of anaesthetics and tranquillizers for the capture or handling of wild animals has been described as virtually impossible and frustrating (Severinghaus, 1950; Larsen, 1963). The length of the induction period and the degree of sedation or immobilization achieved when using this route of administration are

highly unpredictable (Fowler, 1982; Jones, 1984). The true birth of chemical restraint of wild animals coincides with the use of the first 'drug dart' by Hall and co-workers in 1953 (Pienaar, 1973).

Neuromuscular blocking agents, ranging from early synthetic curare (Hall *et al.*, 1953; Post, 1959), nicotine salicylate (Crockford *et al.*, 1957; Post, 1959; Rausch and Ritcey, 1961; Larsen, 1963; Hawkins, *et al.*, 1967; Montgomery and Hawkins, 1967) and strychnine salts (Jalanka, 1991) were the first agents successfully used to provide chemical restraint. Then major drawback of these early drugs however, was that their safety margin, particularly when used in larger animals was too narrow (Jalanka, 1991). A significant breakthrough was made in 1960 (Harthoorn, 1962). The author while working with the ranger team of the Natal Game and Fish Preservation Board, he pioneered the use of a mixture of morphine or synthetic morphine, hyoscine, and various tranquillizers (Hofmeyer**,** 1973). The development and use of newer, extremely potent synthetic and semi-synthetic opioids (fentanyl, etorphine, carfentanil), cyclohexylamines, phenothiazine derivatives, and alpha-2-agonists, then followed. These groups of agents, alone or in different combinations, now form the basis of non-domestic animal immobilization (Harthoorn, 1971, 1973, 1976; Beck, 1972; Haigh, 1982; Hatlapa, and Wiesner, 1982; Fowler, 1986; Jalanka, 1991).

The characteristics of an ideal immobilization drug for darting wild animals can be summarized as follows: an effective dose should not exceed the quantity that can be carried in an appropriately-sized dart syringe preferably less than 3ml which should have suitable stability and rapid absorption into the systemic circulation. It should have a rapid onset of action resulting in sufficient immobilization with a long enough duration of effect, wide margin of safety (at least 3-fold) and rapid elimination from the

body. An ideal immobilization drug should have no drastic effect on pregnant animals, no permanent damage to the animal and no tissue irritation. It should also have minimum effects on cardiorespiratory function, recovery and induction periods. It is also important that an ideal immobilization drug should adequately calm the animal, should have minimum risk to personnel handling the drug, should have a reliable antidote (Done *et al.,* 1975; Hatlapa and Wiesner, 1982; Jalanka, 1991) as well as reduce the animal's awareness of its surroundings to minimize fear, distress, and pain (Harthoorn, 1976).

1.2 Statement of Research Problem

The growing interest in wildlife consultations as well as the growing popularity of keeping captive wildlife species has increased the need to immobilize and translocate them. As of necessity, wildlife cannot be handled as in the case with domestic animals. Inappropriate handling and immobilization has been known to result in injury or mortality on the part of the wildlife and occasionally personnel.

1.3 Justification

There is paucity of information on the capture, restrain and transportation of wild animals either within zoos or in the wildlife parks in Nigeria. This is an area that is well established and documented in other countries (Arnemo *et al*., 2006). It is important that all veterinary treatments, including wildlife medicine and surgery should be of the highest clinical standards and based on the best scientific evidence. It should also uphold the highest standards of animal welfare, even of conservation importance, and have a good likelihood of a successful outcome.

1.4 Aim of the Study

To assess the suitability or otherwise of the capture and restrain techniques as well as the transportation of wildlife in the Yankari game reserve and Sumu wildlife park Bauchi State using chemical immobilization.

1.5 Objectives of the Study

1. To document wildlife species often captured and translocated from the Yankari Game Reserve and Sumu Wildlife Park to other locations.

2. To conduct a retrospective study to document the common captured, restrain and transportation methods employed at the Yankari Game Reserve and Sumu Wildlife Park.

3. To evaluate the outcome of these methods viz: morbidity and mortality rates, in order to provide standardized protocols for chemical immobilization.

4. Assess the physical effects of the drugs on wildlife capture, restrain and transportation.

5. Make recommendations to improve the safety of capture, restrain and transportation of the wildlife as well as human personnel.

CHAPTER TWO

LITERATURE REVIEW

2.1 Importance of Wildlife

The value of wildlife has been widely ignored or under-rated in the past by the international community (Chardonnet *et al.*, 2002). At most, wildlife was considered from the limited aesthetic and touristic aspects. This situation has changed somewhat. In the majority of the veterinary profession, which is largely livestock-oriented, wildlife is increasingly considered in terms of wild animal production and occupies just as relevant a position as domestic animal production. Some economists are now trying to quantify the informal nature of a large portion of the wildlife sector. The importance of wildlife to local communities is now globally recognised in community-based or participatory natural resources management programmes (Chardonnet *et al.*, 2002). The World Charter for Nature, adopted and solemnly proclaimed by the General Assembly of the United Nations in 1982, addressed the concern of wildlife conservation without referring to the concept of wildlife value. It was only in 1992 at the International Convention on Biodiversity in Rio de Janeiro that a clear declaration of intent to secure the 'value' of the biodiversity of the Earth was made, in particular as follows:– in the range of 'actions' planned by the Convention (158); a number of these nominally refers to the value of biodiversity (i.e.: actions 24 and 36) – the final objective of Chapter X is 'to improve assessment and awareness of the value and importance of biodiversity'. Several classifications are used for the values of biological resources. As a classic approach, McNeely *et al.* (1990) split the values of wildlife into direct and indirect value categories thus:

2.1.1 Direct Values

Direct values were considered thus:

1. Consumptive use value: such as non-market value of firewood and game.

2. Productive use value: such as commercial value of timber and fish.

2.1.2 Indirect values

The indirect values were classified as follows:

1. Non-consumptive use value: such as scientific research, bird watching.

2. Option value: such as value of maintaining options available for the future

3. Existence value: such as value of ethical feelings of existence of wildlife.

2.2 Capture of Wildlife

Studies of free ranging wildlife often involve animal capture and handling. Researchers use mixtures of anaesthetic drugs and tranquilizers to facilitate handling of free-ranging animals and to reduce stress (Arnemo *et al*., 2006; Kreeger and Arnemo 2007). Irrespective of methodology, capture is a potential stressful event for free ranging wildlife (Koch, 1987; Haulton *et al*., 2001; Fahlman *et al*., 2008). Capture procedure impacts not only on animals physiological and physical parameters, but may also result in behavioral alterations following capture and handling, which calls for an assessment of the potential short-term and long-term disturbance effects on study animals and research results (Laurenson and caro, 1997; Cote *et al*., 1998; Cattet *et al*., 2008; Morellet *et al.*, 2009).

2.3 Physical Capture Methods of Wild Herbivores

2.3.1 Capture by means of spotlight

This method can be used successfully for the capture of wild herbivores at night, most especially impalas (*Aepyceros melampus*). Basically the method involves using two open trucks on a search mission at night when the moon is not shinning. Impalas (*Aepyceros melampus*) are usually noticed when their eyes reflected the light rays from the truck headlamb. Thereafter the intensity of the light rays will be lowered and the truck moves towards the back of the animal, approaching them as close as possible. At this time a powerful quartz-oxide or sealed-beam searchlight operated by a member of the capture team on the back of a truck, is switched on and the animals are "blinded" in the glare of the crossed searchlight beams. As the animals stand rooted to the ground or attempt to duck away from the bright beam of light, a group of men in dark colored overalls , stalk the animals from the shadow side of the vehicles, rush in and grabs the hind limb (just above the hock) of each animal. The disadvantage of this method is that it is not equally effective for other species of antelope and gazelle, as these are better able to dodge the "blinding" effect of the search light (Pienaar,1999).

2.3.2 Capture by means of pole- lassos

This is the method of choice for the capture of free-roaming wild animals, especially black wildebeest (*Connochaetes gnou*). The success of this method is largely dependent on availability of an open terrain, without too many obstacles, and skilful driving by the capture team's drivers. This method requires the use of two light open trucks or jeeps of suitable maneuverability. At the back of each truck two assistants are equipped with light pole-lassos of about 2.5-3.0 meters in length and with the hanging noose some 50-70 cm in diameter (Pienaar, 1999). The vehicles converge on the herd of animals and

one or the other spurts ahead suddenly and cut into the herd to divide it. The beast to be captured is selected and cut out of the herd as soon as possible. Once this is done, and the selected animal is separated from the rest, the two vehicles converge on the victim from behind and on both sides and attempt to head it off. This calls for tricky driving and considerable skill is required to bring the vehicle into such a position that the men on the back can slip their lassos over the horns of the animal (Pienaar, 1999). The pursued beast will attempt to break away only once or twice when head off and will then come to bay and attempt to gore its tormentors. It is then a relatively simple procedure to slip the noose of the lassos around its horns from two sides and render it helpless. It is then walked around for a while to calm down after the chase and then can be crated (Pienaar, 1999).

2.3.3 Capture by means of drop nets

This method can be used to capture a considerable variety of wild herbivores, ranging in size from the tiny reedbuck (*Redunca arundinum*) to the huge and formidable eland (*Taurotragus oryx* or *T. derbainus*). This is the method of choice for the capture of small antelope species e.g. reedbuck, Grimmia duiker (*Sylvicapra grimmia*) and even bushbuck (*Tragelaphus scriptus*) and also used with considerable success for the capture of larger species such as waterbuck (*Kobus ellipsiprymnus*), eland, kudu (*Tragelaphus strepsiceros*) and roan antelope (*Hippotragus equinus*). The nets used for this purpose are usually manufactured from nylon rope with breaking strain varying from 150 kg- 300 kg for the small and medium sized antelope to 1000 kg for the larger species. Nets for the smaller species have a 10 cm mesh while those for larger species have 15-20 cm mesh (Ramsey, 1968; and Conner *et al.*, 1987). The nets are usually set in lengths of 25-50 meters depending on the terrain and the heights of nets vary from 3-

4 meters. Each section of the net is provided with a supporting cable or rope from which it hangs, but which is attached at the anchor points to pieces of twine of low breaking strain. The purpose of these weak attachments is that they will break in the event that an animal hitting the net on the run will cause the entire net to drop and trap the fleeing animal (Ramsey, 1968; Conner *et al.*, 1987). The nets are rigged with a portion of their depth lying flat on the ground to prevent the animals from ducking under the net and provide an additional means of tripping up the animal running into the net. In the case of smaller antelope species the portion of the net lying on the ground can be as much as half its entire depth that is 1.5 meters. To stabilize the net, supports of light bamboo or other poles are spaced along its length at varying intervals. The success of the drop net technique is very much dependent on the selection of the capture site. Prior knowledge of the normal flight- routes of the animals to be captured and the direction of the prevailing wind are important factors for successful wildlife capture. Many animals flee upwind and it will be difficult to drive them downwind as they can scent the capture team hidden behind the net and will refuse to approach the capture site (Ramsey, 1968; Conner *et al.*, 1987).

2.3.4. Capture of herds by means of funnel traps and net-and –plastic corrals

This technique was developed by Oelofse. It is a refinement of the old funnel trap used for many years to capture species such as bushbuck (*Tragelophus scriptus*), springbuck (*Antidorcas marsupialis*) and black wildebeest (*Connocheatus gnou*) on the Transvaal Highveld of South Africa (Riney and Kettilitz, 1964). Oelofse's method differs mainly from conventional funnel trap in that this method utilizes nylon netting covered with plastic sheets, instead of wire mesh or poles, for the walls of the corrals and loading pens, and sheets for the legs of the funnel instead of wire mesh or brushwood. The

choice of site for this method is the same as that of drop-net but requires more extensive vegetation cover than drop-net. The funnel trap consists of a wide funnel, the legs of which can be anything from 400-800 meters long (depending on availability of cover camouflaging the 2 ½ meters high plastic walls of the funnel), with a mouth of 200-400 meters wide, which can be closed rapidly by means of a number of concealed plastic curtains sliding on an overhead cable.

The funnel tapers down to an opening 25-30 meters wide, which leads into the holding corral. The mouth of the corral can be closed off in an instant by a drop-gate made of nylon netting and plastic sheets, or a similar structure buried in a shallow trench and which is pulled into position by means of a cable running over a pulley and tied to the back of a vehicle. The sides of the 50-100 meters in diameter corral are constructed of nylon-netting of 15-20 cm mesh and1000 kg breaking strain. The netting is suspended from an overhead cable of 1cm thickness and secured at ground-level to a similar cable. The walls are at least 2.5 meters high and are also covered on the inside by same woven plastic material which is used for the legs of the funnel (Riney and Kettilitz, 1964).

2.3.5. Capture by means of chemical immobilization

2.3.5.1 Darting equipment

There are various types of equipment available: the Palmer Cap- Chur from USA; the Paxarms from New Zealand; Dist Inject from Switzerland; Tel Inject and Dan-inject from Germany, and others from Zimbabwe and South Africa. Design improvement has been rapid; therefore users should only contemplate modern darting equipment (Cornfield 1993). Palmer now uses powder-charged cartridges. The syringe plunger is activated by a small explosive charge detonated on impact when the dart hits. Drug

contents of the syringe are injected with great force and so these detonator type dart syringes are not ideally suited for smaller animals because of the tissue damages caused and the fracture on impact. Pressurized CO_2 to activate the plunger in Dan inject produces a slower but more gently injection, better suited for small and caged animals (Cornfield 1993).

Several firms produce pistol type equipment for use at short range. The dart is propelled by compressed air or CO_2. These are suitable for animals in enclosures. For caged animals a blowpipe works best. Paxarm equipment is designed for deer sized animals but not for thick skinned African mammals or for smaller species. Modified shotguns as well as crossbows are used to some extent to propel syringes. No matter what equipment is used the operator should make himself thoroughly familiar with it, especially its trajectory and hitting power (Cornfield 1993). In thin skinned and light boned animals, powerful propellants and heavy projectiles must be avoided. While a dart rarely breaks the skin of elephant (*Loxodonta africana*), rhino (*Diceros bicornis*) and buffalo (*Cyncerus caffer*), it happens only too often in smaller animals when inexperienced operators use propellants other than the weakest. Wound treatment with antibiotics is essential after darting, particularly in small animals (Cornfield 1993). Needle length and thickness for darts should be chosen according to size and species to be injected. The needle should be sharp, clean and have sufficient length to inject into the muscles below the skin. Barbs should be positioned along the shaft of the needle so that they become anchored in the skin, not deep below. On thick skinned animals, e.g. rhino, elephant, giraffe (*Giraffa camelopardalis*), buffalo and other large animals, do not use barb on needle, otherwise it is extremely difficult to extract (Cornfield 1993).

2.4 Drugs used for Wildlife Capture or Immobilization

2.4.1 Tranquilizers/neuroleptics

Neuroleptics or tranquillizers are psychotropic agents that result in the suppression of behavioural responses without affecting spinal and other reflexes **(**Baldessarini, 1990**)**. Many other terms have been used, one of the most widely used being ataractic (meaning perfect peace, calmness of mind, not disturbed). A characteristic of these drugs is that neuroleptic effects are generally observed at low doses, and that higher doses induce characteristic cataleptic immobility. Arousal from CNS depression effects is easily accomplished, and even at very high doses most tranquillizers do not induce coma **(**Baldessarini, 1990). A large number of neuroleptic drugs are available, of which only three groups, that is phenothiazines, butyrophenones, and thioxanthenes, are used in wild animals **(**Baldessarini, 1990). Thioxanthenes include zuclopenthixol and flupenthixol. The antipsychotic action of dopamine antagonists is achieved by blocking dopamine receptors and increasing turnover of dopamine in the limbic system of the brain, producing a state of "ataraxia" or behavioral quieting that is characterized by decreased emotional reactivity and aggression, and relative indifference to stressful situations (Brewer *et al*., 1990; Simpson and Simpson, 1996). Tranquilizers do not cause profound cortical depression (unconsciousness), but will suppress spontaneous movements while sparing spinal reflexes and unconditioned pain reflexes (Swan, 1993; Simpson and Simpson, 1996). Tranquilizers can be categorized according to their potency (minor or major, based on the incidence of side-effects), structural similarities (phenothiazine, benzodiazepine, or butyrophenone) and duration of action (short-acting or long acting). Minor phenothiazine tranquilizers are familiar to most practitioners and include the agents (i.e., promazine, acepromazine) that have historically been used for

sedation and anesthesia in domestic species. Typically, the minor tranquilizers produce a greater degree of sedation, while having a higher incidence of anticholinergic and cardiovascular side effects, and fewer extrapyramidal side-effects (Simpson and Simpson, 1996). The different neuroleptics that have been evaluated in animals have all been developed for use in people and are not licensed for veterinary use. These formulations were developed with the specific goal of achieving prolonged tranquilization of the patient, without the need for frequent, repeated injections that would be required with the traditional agents (Ebedes, 1993). Prolonged duration of drug action can be accomplished through several mechanisms, including: slow release of active drug from the site of injection, slow absorption of active drug or metabolite(s) into the blood, slow metabolism of active drug once absorbed, or slow elimination of the active drug or metabolite(s) from the body (Swan, 1993; Ebedes, 1993).

Successful anaesthesia of ranging mammals involves the use of safe, effective, potent anesthetics that are reversible, have a small injection volume, are rapid in onset of action, produce minimal undesirable side effect and are affordable. Potent opoid/α_2 agonist, opoid/α_2 agonist/dissociative anesthetics and opoid/α_2 agonist/neuroleptic tranquilizer combinations have been used to provide rapid onset of anesthesia in both captive and free ranging mammals (Wilson *et al*., 1996a, b; Tsuruga *et al.,* 1999; Caulkett *et al*., 2000; Janovsky *et al.,* 2000; Murray *et al.,* 2000; Moresco *et al.,* 2001; Miller *et al.,* 2003; Wolf *et al.,* 2004; Arnemo *et al.,* 2005; Walter *et al.,* 2005; Storms *et al.,* 2005; Smith *et al.,* 2006). Reported disadvantages of these combinations include human risk associated with handling potent opoids, unpredictable inductions, apnea/respiratory depression, hyperthermia, lactic acidosis, muscle rigidity, altered arterial blood pressure, excitement, regurgitation, decreased gastrointestinal motility,

incomplete reversibility and prolonged recovery times (Tsuruga *et al.*, 1999; Caulkett *et al*., 2000; Janovsky *et al.*, 2000; Moresco 2001; Miller *et al*., 2003, 2004; Wolf *et al*., 2004; Storms *et al.*, 2005; Smith *et al.*, 2006). Medetomidine and other alpha-2 agonist are known to reduce stress and to have an anxiolytic effect (Jalanka, 1993; Thurmon *et al*., 1996). Such drugs might therefore be beneficial in wild ruminants are susceptible to severe stress, fright, hyperthermia, struggling and muscular exertion and can develop capture/exertional myopathy, a fatal syndrome in free-living animals (Spraker, 1993; Williams and Thorne,1996). Medetomidine alone might not induce reliable and complete immobilization and should therefore be combined with a general anesthetic such as ketamine in non-domestic animals (Jalanka, 1993; Kreeger *et al*., 2002). The capture and immobilization of wild deer is likely to be one of the most stressful events in their life as is clearly indicated by capture-induced changes in the hematological and biochemical blood parameters (Marco and Lavin, 1999; Gupta *et al*., 2007). Appropriate chemical immobilization can be employed to safely capture any species minimizing stress and the risk of injuries associated with other methods (Janicki *et al*., 2006). Numerous reports have described the use of xylazine (and ketamine) or tiletamine/zolazepam for anesthetizing cervids (Tsuruga *et al*., 1999; Galka *et al*., 1999; Murray *et al*., 2000; Fernandez-Moran *et al*., 2000; Janovsky *et al*., 2000; Miller and Adams, 2003; Miller *et al*., 2004). Xylazine has a wide safety margin but has been associated with prolonged induction, unreliable immobilization and at high dosages apnea and bradycardia when used alone (Murray *et al*., 2000; Wallingford *et al*., 1996). Ketamine can be used as a sole anesthetic agent in numerous species but volume restrictions often preclude its use for darting procedures. It can also induce excessive muscle rigidity and violent recoveries as side effects (DelGuidice *et al*., 1989; Tsuruga *et al*., 1999; Ryeng *et al*., 2002; Arnemo *et al*., 2005). Despite the limitation of these

drugs as anesthetic agents alone, their use in combination can provide satisfactory anesthesia (Janovsky *et al*., 2000; Caulkett and Haigh, 2004).

2.4.2 Opioid analgesics

Opioid is a term used to designate a group of drugs that are, to varying degrees, opium- or morphine-like in their properties. Previously, these drugs were referred to as narcotics. Since the term in a legal context now refers to any drug that can cause dependence it is no longer useful in a pharmacological context (Jaffe and Martin, 1990). Opiates are drugs derived from opium, such as morphine, codeine, and the many semi-synthetic congeners of morphine, e.g., etorphine. Entirely synthetic substances with morphine-like activity are referred to as opiate or morphine substitutes.

Opioids interact with several closely related groups of receptors (mu, kappa, delta and sigma) (Akil *et al*., 1984; Jaffe and Martin, 1990) collectively known as the endorphin receptors. These receptors occur in the brain, spinal cord, autonomic nervous system, myenteric plexus of the gastrointestinal (GI) tract, heart and kidney as well as in other organs (Booth and McDonald, 1988). They are important in neuromodulation of pain, moods, emotional response, behaviour, voluntary muscle tone, and GI motility. The occurrence and distribution patterns of the various endorphin receptors in the body, and the consequences of their activation, may vary significantly within an animal and between species (Simon, 1977). It is also possible that receptor population changes could occur as result of external factors (such as when animals are kept in captivity) and as a consequence of stress.

The effect of opioid drugs on the endorphin receptors differs in terms of affinity and intrinsic activity. A given opioid drug may interact to a variable extent with all or some of the endorphin receptors, and may act as either an agonist, partial agonist, or as an

antagonist. It is also possible that a drug may be agonistic on certain receptors, but only partially agonistic or even antagonistic on others (Jaffe and Martin, 1990). A great variation in the pharmacological effects of opioid drugs, both between species and under different physiological conditions, can therefore be expected.

Opioids have a broad range of pharmacological effects (Booth and McDonald, 1988). They are extremely potent analgesic drugs, and have variable psychotropic effects in different animal species. For example, CNS depression is observed in the dog, monkey, human, and in many wild animal species, while in feline, porcine, and equine species excitatory effects are observed. The reasons for these differences are not well understood: they have been ascribed to a number of factors, including alteration in the functioning of the brain dopaminergic or noradrenergic systems (Kania, 1985) and to differences in the distribution pattern of the opiate binding sites in the brain (Simon, 1977). Excitatory effects, including convulsions and extrapyramidal signs such as myoclonic twitches, catalepsy, and muscular rigidity, have largely been attributed to overdosage (Booth and McDonald, 1988). Respiratory depression, hypertension or occasionally hypotension, inhibition of the thermoregulatory mechanism, inhibition of gastro-intestinal motility and other important effects need to be considered when using these drugs.

Opioids, being dangerous, habit-forming drugs, are listed under Schedule I of the single convention of dangerous-dependence producing substances in South Africa and are named in part II of the schedule of the abuse of Dependence-producing substances and rehabilitation centres Act, 41 of 1971 (Meuleman *et al.,* 1984). As such, the veterinarian and pharmacist shall keep a register or permanent record of the following: The quantity of any such drugs possessed, imported or acquired. The date of acquisition, the name of

the person from whom and the place from which the same were imported or acquired and the quantity that has been disposed of and whether this was by sale or by use in the ordinary course of practice.

Every register shall be retained and preserved for at least three years, and must be balanced every three months on the last day of March, June, September, and December of each year. The register is open to inspection by any person authorized thereto in writing by the Registrar of Medicines and Related Substances. A prescription for a Schedule 1of the single convention of dangerous- dependable producing substances in South Africa and are named in part II of the schedule of the Abuse of Dependable-producing substances and rehabilitation centres Act, 41 of 1971 **(**Meuleman *et al.,* 1984) drug may not be repeated and is only valid for 30 days from the day of issue. Furthermore, the amount prescribed may not exceed that which is required by a person for 30 days.

Currently the most common opioids used for the immobilization of wild animals are etorphine, fentanyl, and carfentanil. Etorphine is the only opioid registered for use in South Africa. Fentanyl has been exempted from registration and is available directly from the manufacturer. Sufentanil and A3080 are newer opioids currently being investigated for use in wild animals (Haigh, 1990). Butorphanol (Torbugesic®, Ayerst Laboratories), meperidine (Pethidine®, Glaxo) and diethylthiambutene (Themalon®) are other opioids occasionally used for the immobilization of captive wild animals (Haigh, 1990).

2.4.2.1 Morphine derivatives

Etorphine Hcl:

Chemical and physical characteristics*:* Etorphine hydrochloride a neuroleptamnalgesic powder which is readily soluble in slightly acidified water (Harthoorn, 1973). Solutions of up to 10 mg/ml may be made in dimethyl sulphoxide (DMSO). The solutions are clear and colourless.

Etorphine hydrochloride (6,14-endoetheno-7α-(2-hydroxy-2-pentyl)-tetrahydro-oripavine hydrochloride): is a semi-synthetic opioid derived from thebaine. Etorphine is available in Africa as M99® from Krüger-Med Pharmaceuticals (Pty.) Ltd, South Africa in 4.9 mg/ml and 9.8 mg/ml concentrations. M99® is supplied in preformed polystyrene containers containing a 10 ml rubber-stoppered vial of M99® and a similar vial of its analogue M5050® (diprenorphine). Both vials contain 5 ml of solution.

Pharmacological action*:* The pharmacological effects of etorphine hydrochloride are typical of the opioids, but may vary significantly between species. Its analgesic potency is given as 500 to 10000 times more than that of morphine sulphate, depending on the nature of the test (Alford *et al.*, 1974; Harthoorn, 1971; Haigh, 1982; Fowler, 1986; Booth and McDonald, 1988).

Given alone, etorphine hydrochloride causes areflexia without total loss of consciousness (Harthoorn, 1973). The initial reaction of a wild animal following administration of etorphine varies with the method of approach: this may range from panic flight with a helicopter to passive squatting in a net or trap (Haigh, 1982). Changes in gait or walking pattern occur in most terrestrial species: these progress steadily as the animal loses awareness of obstacles and terrain. In most ruminants this

ataxia is accompanied by the characteristic 'hackney gait'. The more gregarious animals, such as the roan antelope (*H. equinus*), eland (*T. oryx*), kudu (*Tregelaphus strepsiceros*), and waterbuck (*K. ellipsiprymus*), continue to run for extended periods, especially if etorphine hydrochloride is given alone. During this period, ruminants can often be approached and guided while on their feet. Apart from gait changes, an early sign of induction in elephants (*L. africana*) is relaxation of the trunk.

As immobilization progresses, animals either suddenly collapse into sternal or lateral recumbency or stop, often unimpeded, and sway before going down. The onset of action following standard doses is about 2-4 minutes, up to eight minutes in some individuals (Harthoorn, 1973, Haigh, 1982). Peak effects differ according to the rate of absorption but usually follow in 15-30 minutes, the duration being about one hour. The drug is excreted mainly through the liver and intestine. Re-cycling of etorphine hydrochloride, either from enterohepatic circulation or redistribution from adipose depots occurs, occasionally leading to renarcotization of the animal (Harthoorn, 1973, Haigh, 1982).

Indications*:* Etorphine hydrochloride is used for the immobilization and capture of all African ungulates, but in particular for the very large ungulates and sub-ungulates such as elephant (*L. africana*), rhinoceros (*Diceros bicornis*), giraffe (*Giraffa camelopardalis*), zebra (*Equus zebra hartmannae*), wildebeest (*Connochaetes gnou*), and hippopotamus (*Hippopotamus amphibius*) (when on land) (Harthoorn, 1973). It is generally not suitable for use in carnivores, but has been used in spotted hyaenas (*Crocuta crocuta*) and bears (*Ursus arctos*) (Van Jaarsveld *et al.*, 1984).

Dosage: The dosage of etorphine hydrochloride varies from 0.5µg/kg in the rhinoceros (*D. bicornis*) to 5µg/kg in camels (*Camelus dromedari*) (Ebedes, 1989). Young, old, sick, or debilitated individuals generally need lower doses than those recommended for

adults. Females of any species also require a slightly lower dose relative to males. Pregnant animals appear to be more resistant to the effects of etorphine hydrochloride than non-pregnant ones (Ebedes, 1989). It is important to emphasize the difference in sensitivity of free-living animals, captive wild animals, and domestic animals to immobilizing drugs (Haigh, 1982): tamer animals generally require much lower doses.

The most important side-effects are respiratory depression, rumen stasis and a decrease in gastro-intestinal motility, changes in heart rate and blood pressure, decrease in urine output, and excitement. Of these, excitement has caused most problems, but has been overcome by the judicious use of sedatives or tranquillizers (Harthoorn, 1973). Depression of respiratory rate and minute volume (Harthoorn, 1976) may result in a severe hypoxia, hypercapnoea, and progressive acidosis (Booth and McDonald, 1988). Alterations in cardiovascular function have been fatal in equids (Kock and Pearce, 1985). Hypertension has been reported in a number of domestic ungulates (LeBlanc *et al*., 1987), and presumed in non-domestic ungulates based on cardiovascular responses (Lumb and Jones, 1984**)**. Recently, hypertension following etorphine administration in rhinoceros has been reported (LeBlanc, 1987). Passive regurgitation of rumen contents, which may result in fatal aspiration, is not uncommon (Severinghaus, 1950; Booth and McDonald, 1988).

Spontaneous recovery from etorphine-induced immobilization is slow (Fowler, 1986). Opiate antidotes, including diprenorphine, nalorphine, and naloxone, have been used with success to reverse the depressant effects of etorphine. It is recommended at 3-5 times the M99® dose in elephants, rhinos, and giraffes, and at 2-3 times the M99® dose in other species. Most frequently it is used at between 2:1 diprenorphine to etorphine ratio (w/w) (Jalanka, 1991**)**.

Naloxone is a pure opioid antagonist, in contrast to the other previously mentioned antidotes which have both antagonistic and some agonistic properties (Booth and McDonald, 1988). Naloxone has a short half-life, and high doses are required to prevent renarcotization. This drug is of particular importance in emergency situations (due to its rapid effect). The low concentration (0.4 mg/ml) of the naloxone formulation available limits its use in the wildlife field. The effects are dose dependent, and larger species may require two injections because of the short half-life (Haigh, 1982). The first dose is administered subcutaneously at 0.04-0.07 mg/kg followed by an intravenous or occasionally an intramuscular injection at 0.1-0.25 mg/kg.

Toxic effects of opioids are principally related to respiratory depression. Certain species or individuals may be particularly sensitive (Haigh, 1982). No supportive treatment is required under normal conditions (Harthoorn, 1973). Overdosage is readily treated with an appropriate antagonist and, if necessary, with analeptics, e.g., doxapram (Dopram®, Continental Ethicals).

Humans are particularly sensitive to the toxic effects of etorphine. The rapid onset of toxic effects makes it extremely dangerous, the effects being evident within two minutes of injection and reaching a peak in 5-10 minutes (Harthoorn, 1973). Symptoms and signs of a toxic dose include loss of consciousness, slow, shallow respiration, cyanosis, pin-point pupils, weak pulse and fall in blood pressure, and twitching of the muscles. Death occurs in deep coma by respiratory failure.

In the event of accidental poisoning, 1 ml of naloxone 0.4 mg/ml (Narcan®, Boots) must be administered immediately intramuscularly (IM) or preferably intravenously (IV). Repeat at 2-3 minute intervals until symptoms are reversed. Any one of the other

antidotes could also be used, but only if naloxone is not available. Care should be taken due to possible aggravation of respiratory depression by these mixed antagonists.

Stability and storage instructions: M99® solutions are stable if stored in a cool place (below 25°C) away from light. Keep the drugs in the container supplied. The container should be out of reach of people and should be labeled "poison" with the symbol of skull and bones.

2.4.3 Hypnotics and sedatives

Hypnotics are drugs used to moderately depress the central nervous system. They produce a physiological state of sleep from which a subject can easily be aroused. A sedative may be used to quieten an animal that is excited by unfamiliar handling procedures or by a change in its surroundings. Hypnotic and sedative effects are dose dependent, with only slight sedation at low doses, increasing sedation with increasing doses, until hypnotic effects are attained. Similarly, increasing intensity of hypnosis is achieved with still higher doses, until the animal becomes comatosed at excessively high doses. These drugs are seldom used alone in wild animals, but are extensively used in combination with immobilizing drugs, or immediately following restraint, for their anticonvulsant, muscle relaxant, or sedative activity. Some members of this group of drugs are able to produce general anaesthetic effects, and may be used on their own (Swan, 1993).

There are two main groups of drugs classified as hypnotics and sedatives (*viz.* diazepinones and alpha-2-adrenoceptor agonists) which are used in wild animals. Some of the most recently developed drugs (e.g., climazolam and medetomidine) used for the immobilization of wild animals belong to these groups. These drugs are administered by

intravenous or intramuscular injection. Diazepinones may also be administered orally (Swan, 1993).

2.4.4 Alpha-2-adrenoceptor agonists

Alpha-2-adrenoceptors can be found in different locations, both in neuronal and non-neuronal tissues (Scheinin and McDonald, 1989). At present, these receptors have been classified into at least three alpha-2-isoreceptors (α-2a, 2b & 2c) according to their affinity for alpha-2-adrenoceptor ligands (Byland, 1985; Murphy and Byland, 1988). These receptors act pre-synaptically (causing feedback inhibition of noradrenaline release in sympathetic nerve endings), by modulating the function of other neurons (such as those utilizing acetylcholine, dopamine, and serotonin, reducing the release rate of these neurotransmitters after neuronal activation), by post-synaptic mediation of constriction of vascular smooth muscle in the periphery (post synaptic alpha-2-adrenoceptors appear also to exist in the central nervous system), or on 'hormonal' receptors situated outside the nervous system (e.g., in platelets, pancreas, and adipose tissue) which are thought to respond primarily to adrenaline in the circulation (Vähä-Vähä, 1991).

These drugs have been used in a wide range of non-domestic herbivores and carnivores. They are used mainly as synergists: mixed with either opioids or cyclohexylamines, they result in reduction of the doses required, improvements in induction times, and better relaxation. Xylazine was the first drug of this group to be used. It has recently been followed by detomidine, with medetomidine in the process of registration in South Africa. Specific alpha-2-adrenoceptor antagonists such as yohimbine, tolazoline, atipamezole, and idazoxan are used to reverse the effects of these drugs (Byland, 1985; Murphy and Byland, 1988).

Detomidine

Chemical and physical characteristics*:* Detomidine (Domosedan®) (4-(2,3-dimethylphenyl)methyl-1H-imidazole hydrochloride) is available as a 10 mg/ml injectable solution. Detomidine is an almost white, crystalline powder that is readily soluble in water, ethanol, methanol and chloroform. The aqueous solution is clear and colourless, with a pH of 4-5 (Vähä-Vähä, 1991).

Pharmacological action: The pharmacological effects of detomidine are typical of those described for the group. However, detomidine is considerably more potent as an agonist of the alpha-2-adrenoceptors than xylazine (Vähä-Vähä, 1991). Only at high doses does the action on alpha-1-adrenoceptors occur. Xylazine appears to produce more of an alpha-1-adrenoceptor effect: this may explain the pharmacological differences between detomidine and xylazine. High doses of detomidine produce deep sedation, leading to loss of consciousness and a light plane of anaesthesia (Lees, 1991). In laboratory studies, higher doses have been found to lead to a decrease in sedation and an increase in sedative-analgesic activity, while hypnosis does not occur. Detomidine does not induce a loss of the righting reflex of animals at any dose level (Virtanen, 1986).

Detomidine is rapidly and completely absorbed after subcutaneous or intramuscular injection. It is highly lipid soluble, resulting in very rapid distribution to the brain. After extensive distribution the drug is metabolized in the liver and excreted, the majority of the metabolites passing into the urine with a small fraction excreted in the faeces (Salonen, 1986). The elimination half-life is one to two hours. The duration of action of detomidine in the horse is longer than that of xylazine, being up to six hours (Salonen, 1986).

Detomidine is indicated as a potent sedative and analgesic (somatic and visceral) in the horse, the sedative and analgesic effects being dose dependent in depth and duration. It can be used on its own in horses to facilitate handling, transportation, examination, and minor surgical procedures, or as a premedication to both injectable and inhalant anaesthesia. It has also been used in a 'cocktail' with various opioid drugs. In dogs detomidine has unpredictable (not dose-related) sedative effects (Vähä-Vähä, 1991).

Detomidine has been used successfully to sedate various species of wild animals, such as gemsbok (*Oryx gazelle*), black (*C. gnou*) and blue (*Connocheates taurinus*) wildebeest, eland, red hartebeest (*Alcelaphus buselaphus*), zebra, and giraffe, and for immobilization in combination with etorphine hydrochloride (Hyman, 1992).

Dosage: Detomidine can be administered by intramuscular or slow intravenous injection. The recommended dose rate is 20µg/kg, but may vary from 20-150 µg/kg depending on the depth and duration of sedation required. Individual animals appear to be tolerant to the effects of detomidine: this may, however, be due to underdosing. If needed, 1-15 times the initial dose may be repeated with no untoward effects. The desired effects usually develop in 2-10 minutes (Hyman, 1992).

Detomidine has been combined with opioids, such as morphine, pethidine, and butorphanol, to increase its sedative and analgesic effects (Hyman, 1992).

Side Effect: The side-effects of detomidine are similar to those described for xylazine. Rise in blood pressure is greater and longer lasting with higher doses. The incidence of arrhythmias appears to be lower after intramuscular injection than after intravenous administration. Other side-effects include sweating, snoring, and transient tremors.

Recovery: Any of the alpha-2-adrenoceptor antagonists can be used to reverse the effects of detomidine. Atipamezole (Antisedan®, Ciba Geigy) can be used at 4-6 times the preceding detomidine dose.

Respiratory and cardiac depressions are associated with overdosage. These effects are normally transient and reversible. Specific antagonists and analeptic drugs could be used for treatment.

Medetomidine

Chemical and physical characteristics*:* Medetomidine (Domitor®, Ciba Geigy) (±) 4-[1-(2, 3-dimethylphenyl) ethyl]-1H-imidazole hydrochloride) is available as a 1 mg/ml injectable solution in 10 ml multidose vials.

The chemical structure of medetomidine differs from that of detomidine by one methyl group in the CH_2-bridge. Its pharmacodynamic properties resemble those of detomidine, although it is more potent and its mechanism of action is more selective.

Pharmacological action: Medetomidine is a racemic mixture, the active isomer being predominantly the d-enantiomer (dexmedetomidine) (Jalanka, 1991). Characteristic effects of medetomidine in different laboratory animals include sedation, analgesia, relieve of anxiety, bradycardia, hypotension, and hypothermia **(**Jalanka and Roeken, 1990**)**. At high doses it has hypnotic or anaesthetic effects.

The pharmacokinetics of medetomidine, as determined in rats, cats and dogs, indicate rapid absorption and distribution of this highly lipophilic drug (Salonen, 1989). Peak concentrations are reached at 30 minutes after intramuscular injection. Medetomidine is metabolized in the liver, and the metabolites are excreted in the urine. In rats,

elimination is controlled by the extent of enterohepatic circulation. Significant presystemic elimination occurs following oral administration.

Indications: Medetomidine has been tested extensively in a large number of different non-domestic mammals (Jalanka, and Roeken, 1990, Van Heerden *et al.,* 1991). In combination with ketamine it has been used for immobilization, and alone it induces sedation in a dose-dependent manner. Complete immobilization has been achieved in semi-domesticated reindeer (*Rangifer tarandus tarandus*) and blue foxes (*Vulpes lagopus*) (Jalanka, and Roeken, 1990). In combination with ketamine, medetomidine doses are usually 60-100 µg/kg. Remarkably low doses of ketamine are given in these combinations.

Recovery: The alpha-2-adrenoceptor antagonist, atipamezole, is highly effective in reversing the immobilization induced by medetomidine and medetomidine-ketamine combinations. In ruminants, the atipamezole dose is 4-5 times the medetomidine dose used. An initial dose of 100-150 µg/kg is given intravenously and the remainder is given subcutaneously. Because the required ketamine doses are relatively high in carnivores, only half the ruminant dose of atipamezole is suggested in these species when medetomidine is used in combination with ketamine. Using this dose, reversals are calm, and animals show minimal 'residual ketamine effect'. The dose of atipamezole in dogs is 4-6 times and in cats 3-4 times the preceding dose of medetomidine, when medetomidine is given alone. Medetomidine effects are reversed in 5-10 minutes. Smaller doses of atipamezole are required the longer the interval becomes between medetomidine injection and the administration of the antagonist.

Increased future use of medetomidine and atipamezole in the immobilization, capture, and sedation of wild animals is anticipated.

2.5 Translocation

Translocation in both in-situ and ex-situ in wildlife conservation means capture, transport and release or introduction of species, habitats or other ecological material (such as soil) from one location to another. It contrasts with reintroduction, a term which is generally used to denote the introduction into the wild of species from captive stock (Griffith *et al.,* 1989).

Translocation is an effective management strategy and important topic in conservation of biodiversity. It decreases the risk of extinction by increasing the range of a species, augmenting the numbers in a critical population, or establishing new populations thus reducing the risk of extinction (Rout *et al.,* 2007). This improves the level of biodiversity in the ecosystem.

Translocation may be expensive and is often subject to public scrutiny (Griffith *et al.,* 1989), particularly when the species involved is charismatic or perceived as dangerous for example wolf reintroduction (Bath, 1989). Translocation as a tool is used to reduce the risk of a catastrophe to a species with a single population, to improve genetic heterogeneity of separated populations of a species, to aid the natural recovery of a species or re-establish a species where barriers might prevent it from doing so naturally (Shirey and Lamberti, 2010). It is also used to move ecological features out of the way of development.

2.5.1 Types of translocation

2.5.1.1 Introduction

Introduction is the deliberate or accidental translocation of a species into the wild in areas where it does not occur naturally. Introduction of non-native species occurs for a variety of reasons. Examples are economic gain, improvement of hunting and fishing,

pornamentation of roads or maintenance. In the past, translocation introduction of non-native species to ecosystems has far outweighed the benefits of them. This is because it causes instability in a balanced ecosystem (Holdgate, 1999).

2.5.1.2 Re-introduction

Re-introduction is the deliberate or accidental translocation of a species into the wild in areas where it was indigenous at some point, but no longer at the present (Griffith *et al.*, 1993). Re-introduction is used as a wildlife management tool for the restoration of an original habitat when it has become altered or species have become extinct due to over-collecting, over-harvesting, human persecution or habitat deterioration (Holdgate, 1999).

2.5.1.3 Re-stocking

Re-stocking is the translocation of an organism into the wild into an area where it is already present. It is considered as a conservation strategy where populations have dropped below critical levels and species recovery is questionable due to slow reproductive rates or inbreeding. The World Conservation Union recommends that re-stocking should be only when the causes of population decline have been removed, the area has the capacity to sustain the desired population, and individuals are of the same race as the population into which they are released but not from genetically impoverished or cloned stock (Holdgate, 1999).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Areas

The study area was the Yankari Game Reserve and Sumu Wildlife Park. The Sumu Park is a new wildlife Park established by the Bauchi State Government in 2000 (MTCB, 2004). The animals were translocated from Namibia to an old forest reserve in Kafin Madaki area of Ganjuwa Local Government Area in Bauchi State, Nigeria and geographically located between latitude 10^{o}. 2″N and longitude 16E (MTCB, 2004) .The Yankari Game Reserve is a forest situated under Alkaleri Local Government Area in Bauchi State, Nigeria and geographically located between latitude 9^{o}. 2″ N and longitude 16 E (MTCB, 2004).



Fig. 3.1: Map of Bauchi State, Nigeria

3.2 Materials

3.2.1 Study animals

Animals used for this study were free roaming wild ruminants Sumu Wildlife Park and Yankari Game Reserve.

3.2.2 Drugs and other materials

Drugs and other materials that were used during the course of the study are presented in Tables 3.1 and 3.2 respectively. The collapsible pole syringe, folded stretcher along with eartags and applicators used for numbering the captured wildlife are shown in Appendix VI to Appendix VIII. Similarly, the sample drugs used in the study; Etorphine Hcl (captivon$^{(R)}$) was sourced from Kruger-Med South Africa and is shown in Appendix IX, while the short acting tranquilizer used Azaperone (Stresnil$^{(R)}$) was sourced from Janssen Pharmaceuticals, South Africa and is shown in Appendix X. The long acting Tranquilizer Perphenazine (Trilafon-LA$^{(R)}$) was sourced from Kruger-Med South Africa and is shown in Appendix XI. The reversal agent, Naltrexone (Trexonil$^{(R)}$) was sourced from Kruger-Med South Africa and is shown in Appendix XII.

Table 3.1: Drugs utilized for the chemical immobilization and treatment of wildlife in Yankari Game Reserve and Sumu Wildlife Park, Nigeria

GENERIC NAME	TRADE NAME	MANUFACTURER
Etorphine HCL	M99®	Krüger-Med South Africa
Diprenophine	M5050®	Krüger-Med South Africa
Medetomidine	Domitor®	SmithKlime Beecham
Azaperone	Stresnil®	Janssen Pharmaceutica South Africa
Perphenazine	Trilafon-LA®	Krüger-Med South Africa
Penicillin- Streptomycin	PenStrept®	Alfasan Holland
Oxtetracyclin injectable	Oxycare®	Alfasan international Holland
Diminazine aceturate	Berenil®	Alfasan Holland
Ivermectin	Vectomec®	Kepro Holland
Cypermethrine pour-on	Cypermil®	Kepro Holland
Piroxicam	Geovin®	Greenfield China
Multivitamin	Multinor®	Juballi Agrotec Lebanon
Oxytetracycline spray	Oxytetra spray®	Pantex Holland

Table 3.2: Other Materials used for chemical immobilization and treatment of wildlife Yankari Game Reserve and Sumu Wildlife Park, Nigeria

S/NO	ITEMS
1	Empty 25litre gallon
2	Plastic bucket
3	Ear plug
4	Cloth for blind fold
5	Stretcher
6	Whistle
7	Ropes
8	Wooden crates
9	Thermometer
10	Portable pulse oximeter
11	Clock
12	Pole syringe
13	Ear tags and applicator
14	Holding pen (Boma)
15	Dart Gun (Dan inject)
16	Range finder

3.4 Methodology

3.4.1 Capture technique

The wild animals to be captured were cautiously approached in a motor vehicle and projection of the syringe using a dart gun containing immobilizing agents at about 50 metres maximum from where the vehicle was stationary with the aid of a range finder. Animals were immobilized using a combination of etorphine and medetomidine (Krüger-Med Pharmaceuticals Pty. Ltd. South Africa). Both drugs were administered simultaneously via a single dart injection (Hyman, 1992). Azaperone and Naltrexone (Krüger-Med Pharmaceuticals Pty. Ltd. South Africa) were administered using different syringes via intramuscular injections at the thigh muscles after capture for short tranquilization and reversal of etorphine respectively.

3.4.2 Parameters Assessment

Parameters were taken in line with the method used by Willott *et al*., (2009). These parameters included:

A: Physiologic disposition: Animal's disposition was assessed as active, calm and excited.

B: Dart administration time: time to locate animal (time until animal is found minus time when animal was darted),

C: Time to recumbency: time until animal is recumbent minus time animal was darted.

D: Time to data collection: time of initiation of data collection minus time animal was darted.

E: Lag time: time of initiation of data collection minus time until recumbency.

Once located, the animal's level of anaesthesia was assessed, and supplemental anaesthesia was administered if need be. Once the plane of heavy sedation to light anaesthesia was achieved, the time was noted as Time 0, and physiologic data collection initiated.

Physiologic data that were collected included respiratory rate (RR), rectal temperature (T), pulse rate and arterial blood oxygen (SpO_2).

(a) Respiratory rate was taken by counting costo-abdominal movement for a minute.

(b) Body temperature was determined by the use of digital rectal thermometer (GLA M700 digital thermometer, GLA Agriculture Electronics, San Luis Obispo, California, USA).

(c) Pulse and SpO_2 were obtained by the use of a pulse oximeter (Nellcor N-200, Inc., Pleasanton, California, USA) with the sensor placed on the tongue.

Upon securing the animal, it was blindfolded using a towel and then ears were plugged with athletic socks. Animals were then maintained on sternal recumbency with the head elevated above the level of the rumen. The dart syringe was removed using a plier and the site of penetration was also injected with penicillin and streptomycin combination (PenStrept® Alfassan, Holland). Physiologic monitoring was started once the animal was secured (Time 0), and continued at 5 minutes interval for a 20-minute period. Then the animal was taken to the holding pen (Plate 3.9) as soon as possible. The holding pens were designed to facilitate the easy movement of animals within the pen. The pen was lined internally with a thatch to prevent the animal from seeing beyond and thus prevent them from running into the edge of the boma when frightened. On getting to

the pen, the reversal agent (Naltrexone) and a tranquilizer (azaperone) were administered intramuscularly thereafter and the animals were treated based on clinical findings.

3.4.3 Translocation of captured animals

Animals captured were translocated after 10-14 days acclimatization in the holding pen situated at Sumu Wildlife Park (Plate 3.9). Animals were translocated to three locations namely; the Aso Rock Zoo, State House, Abuja, Zoological Garden, Gombe State University, Gombe State and Kano Zoo, Kano State. The animals were loaded into crates (Plate 3.10), which were locally constructed using angle irons to do the framing, then re-enforced using woods and flat bars. Each crate's width was 2.4m the height was 7m and the length 10m. These animals were loaded onto trucks using a crane (Plate 3.11) at different occassions. Three (3) Zebras each were translocated to Kano Zoo, Kano State and Zoological garden Gombe State University, Gombe State. Nine (9) Zebras, Five (5) Elands and Five (5) Waterbuck were translocated to Aso Rock zoo, State House Abuja at different occasions as well.



Plate 3.1 An Eland (*Hypotragus derbensinsis*) in a holding pen (boma) after capture



Plate 3.2 Locally constructed crates used for translocation of wildlife



Plate 3.3 Animals loaded in a crate being lifted with a crane onto a truck for translocation



Plate 3:4 Animals loaded on a truck ready for translocation

CHAPTER FOUR

RESULTS

4.1 Capture Records made in and out of Yankari Game Reserve and Sumu Wildlife Park

There were no written records in respect of captures made in and out of Yankari game reserve. However from verbal communication with some staff of the Park, I was made to know that, there were captures made in the early 80s for stocking of the Jos Zoo. The capture consisted basically of buffaloes from Yankari Game Reserve using immobilon for darting and revivon for reversal. This was carried out by a non-Veterinarian who claimed to have undergone training in Kenya (Anon, 2012). Before now, no capture was made from Sumu Wildlife Park, but the animals were translocated from Namibia to Bauchi State by air through Kano airport and then by road to the Park (MTCB, 2004).

4.2 Wildlife Species Captured

Twenty five animals were captured which consisted of 15 (60%) Zebra, 5 (20%) Waterbucks and 5 (20%) Elands. There were more male captures (52%) especially Zebras than females captures (48%) as shown on Fig. 4.1. There were also more captures at the Sumu wildlife park 20 (80%) than the Yankari game reserve 5 (20%).

4.3 The Physiological Activities

The physiological activities of individual species were also documented and as shown on Fig.4.2. The clinical finding were as shown on Fig.4.3, while the time the animal became recumbent after darting and the time it stood on its feet when the effect of the drugs was reversed were shown on Fig. 4.4 for individual specie. The live dead ratio was also considered. A total of 3 (10.7%) of the animals died while 25 (89.3%) were successfully darted as shown on Fig. 4.5.

4.4 Vital Parameters

4.4.1 Rectal temperature

The average mean rectal temperature mean values recorded at intervals of 5 minutes are presented in Figure 4.6. An increase in rectal temperature was observed in some animals during the first 5 minutes post-induction. Thereafter the rectal temperature fluctuated between 37.5^{o}C and 39.0^{o}C before declining and stabilizing to normal.

4.4.2 Pulse rate

The pulse rate values recorded at intervals of 5 minutes are presented in Figure 4.8. An increase in pulse rate (92 beats/minute-120 beats/minute) was observed in all the groups during the first 10 minutes post induction. The pulse rate then declined and stabilized returning to normal at the later time.

4.4.3 Respiratory rate

The respiratory rate values recorded at intervals of 5 minutes are presented in Figure 4.7 with an average of 12 cycles per minute for all the species. Though an increase in respiratory rate was observed in all the groups during the first 10 minutes post induction. The respiratory rate declined and stabilized after returning to normal.

4.4.4 Arterial blood oxygen (SpO2)

The arterial blood oxygen (SpO2) values recorded at intervals of 5 minute are presented in Figure 4.9. A decrease in SpO2 value was observed in all the groups during the first 10 minutes post induction. The value then increased when the animals were repositioned and then stabilized before returning to normal.

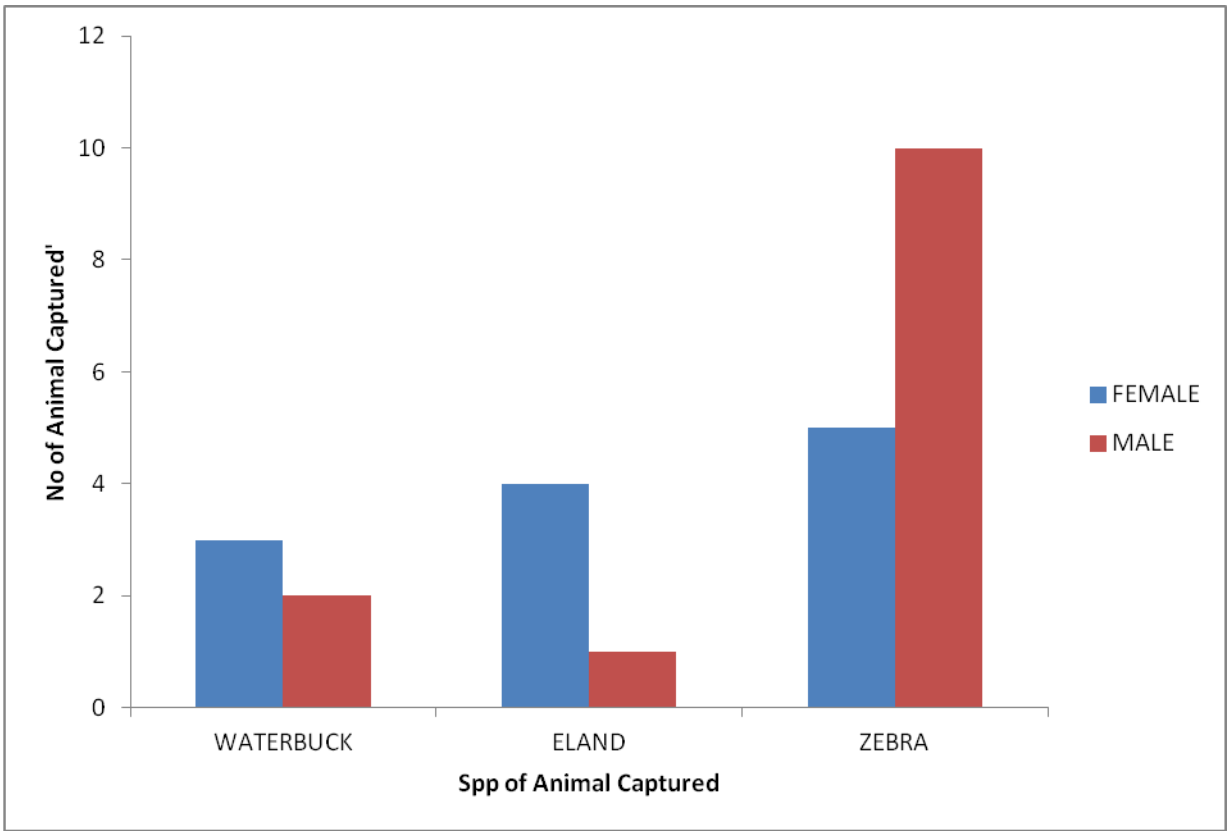


Fig. 4.1: Distribution of Captured Animals by Sex from the Yankari Game Reserve and Sumu wildlife Park, Nigeria

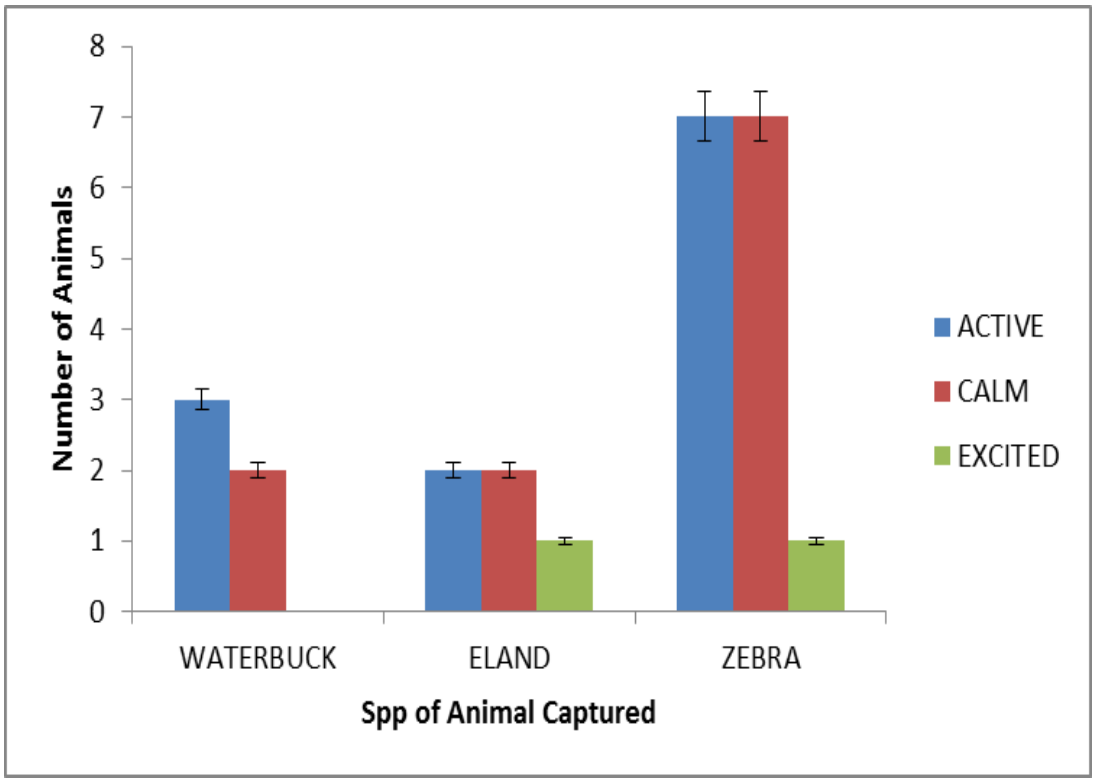


Fig. 4.2: Distribution of Captured Animals Activities in Yankari Game Reserve and Sumu wildlife Park, Nigeria.

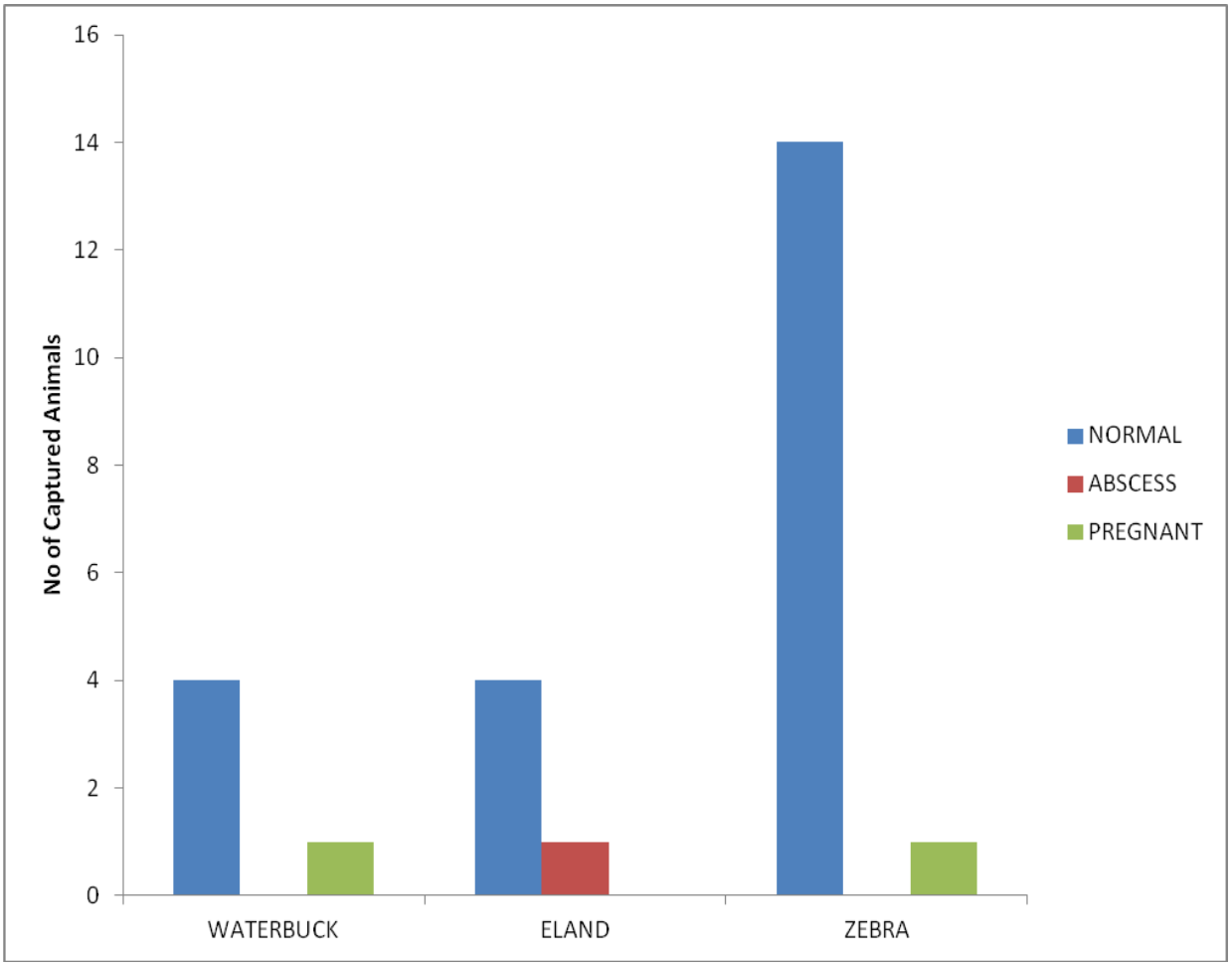


Fig. 4.3: Condition of Captured Animals at Yankari Game Reserve and Sumu Wildlife Park, Nigeria.

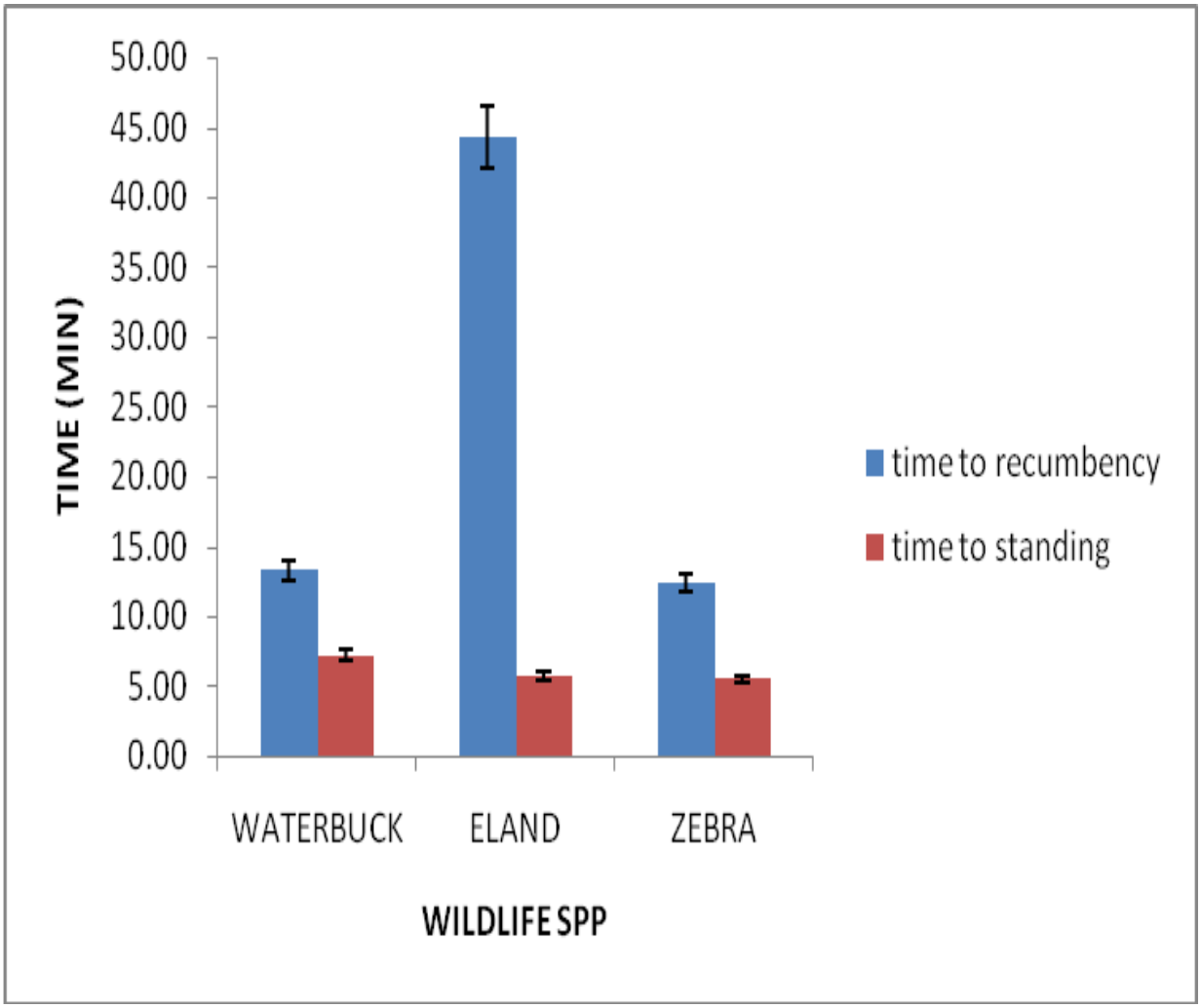


Fig. 4.4: Distribution of Captured Animals Drugs Effect and Reversal State.

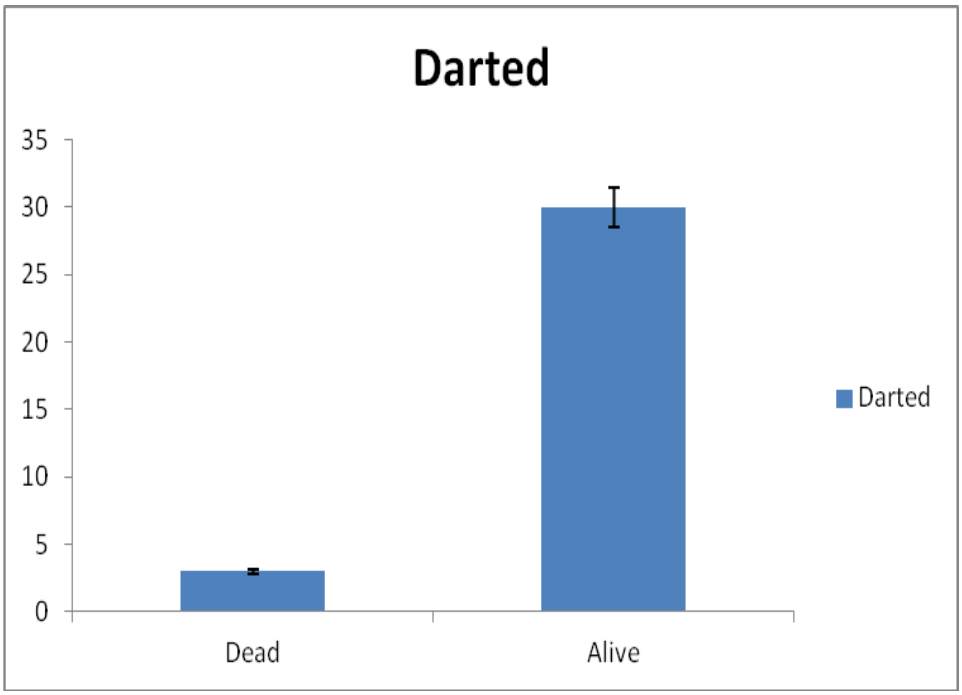


Fig. 4.5: Distribution of Captured Animals Mortality and Morbidity State

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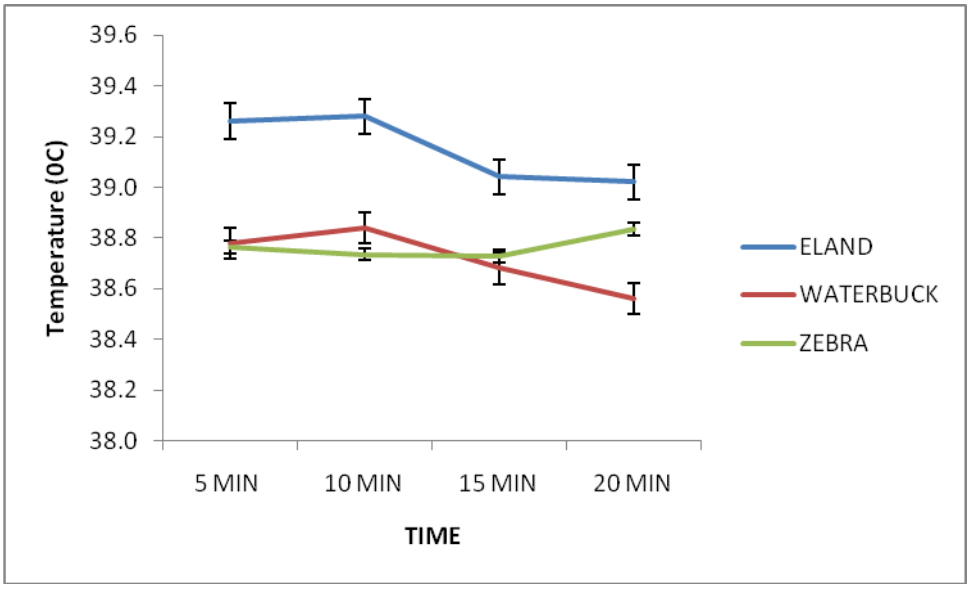


Fig. 4.6:Mean Temperature distribution of Captured Animals

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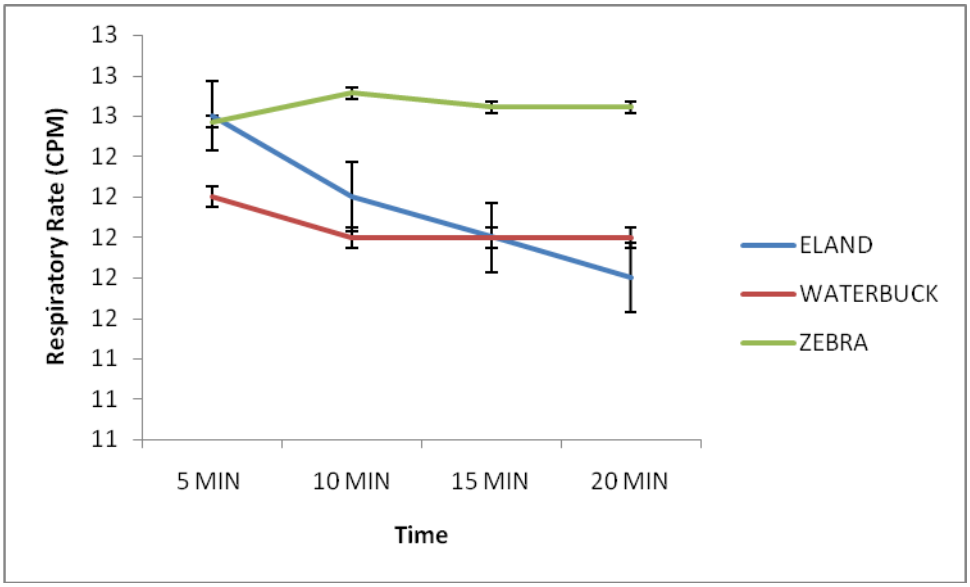


Fig. 4.7: Distribution of Respiratory rates of Captured Animals.

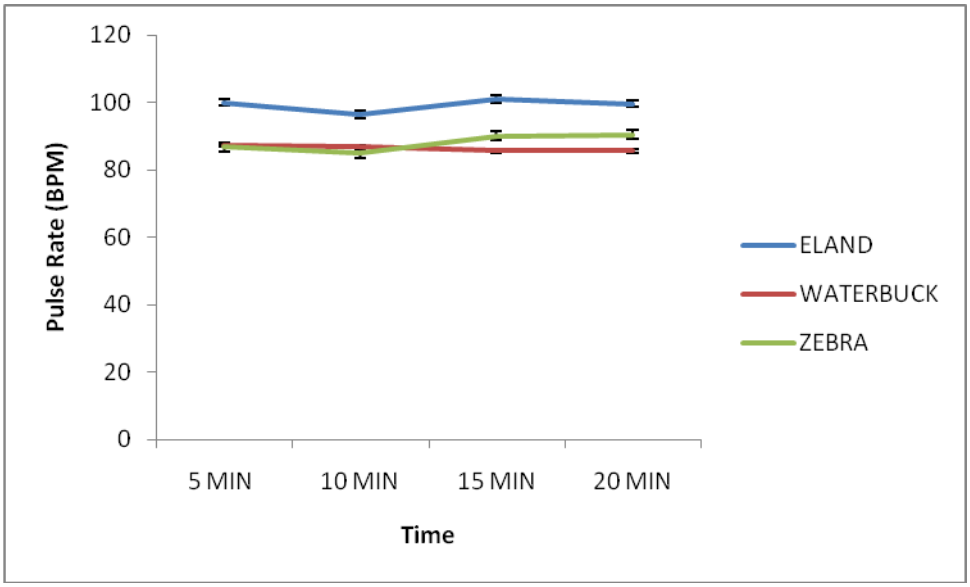


Fig. 4.8: Distribution of Pulse rates of Captured Animals.

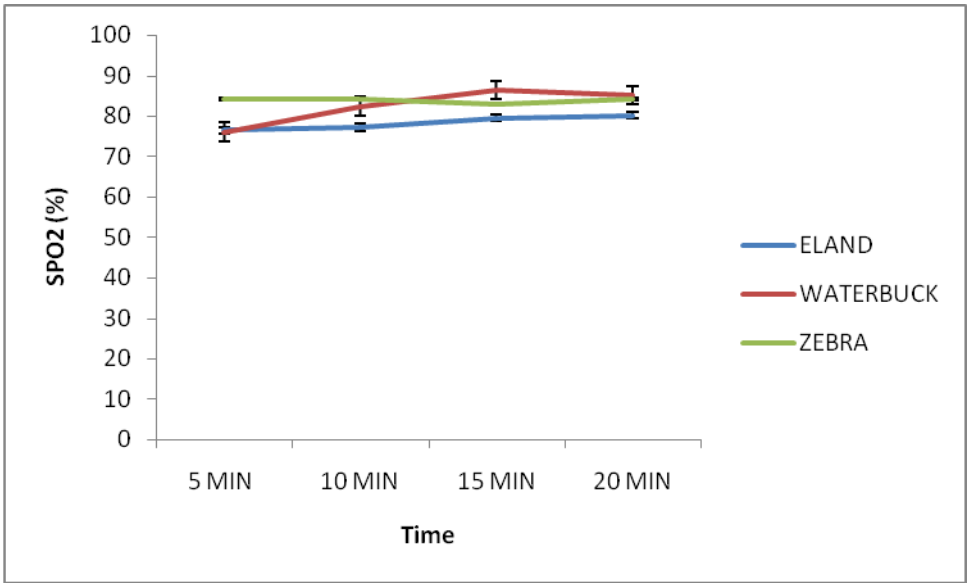


Fig. 4.9: Distribution of Captured Animals Arterial blood oxygen.

Table 4.1 Average doses of drug used for individual specie during chemical immobilization

Species	Etorph. (mg)	Medi. (mg)	Azap. (mg)	Perph. (mg)	Nal. (mg)
Waterbuck	7.8 ± 0.64	5.4 ± 0.48	96 ± 19.2	69 ± 37.2	80 ± 16
Eland	9 ± 1.5	6.5 ± 0.75	117.5 ± 37.5	75 ± 25	70 ± 17.5
Zebra	6.13 ± 0.73	5.2 ± 0.67	117.33 ± 4.98	86 ± 20.53	70 ± 0

Keys:

Etorph. For etorphine

Medi. For medetomidine

Azap. For azaperone

Perph. For perphenazine

Nal. For naltrezone

CHAPTER FIVE

DISCUSSION

In free-ranging mammals, chemical capture is an invaluable tool both for management and research. Since the pioneer days of the 1950s and 1960s, a large number of wild mammals has been chemically immobilized or anaesthesized for various purposes. Unfortunately however, no attempt has been made to evaluate the consequences of applying the stated protocols in the literature to wildlife captive practices in Nigeria. This informed the need for the study. This study has shown that free ranging wild herbivores can be successfully anaesthesized using an average combination of 6 – 9 mg etorphine and 5- 6.5 mg medetomidine for all the captures made. Anaesthesia was achieved using a combination of etorphine and medetomidine per dart, despite a wide range in weights. The wide weight range and various physiologic states of successfully anaesthesized animals without negative consequence imply a wide margin of safety for this anaesthetic combination. This is ideal for field anaesthesia, where animals weight are visually estimated before darting and animals are usually taken to the holding pen before given the reversal. The animals also recovered within approximately 7 minutes after the reversal administration.

Regular monitoring of temperature, respiratory rate, pulse and Spo2 at 5 minute revealed stable parameters that remain within physiologic limits throughout the anaesthetic period with no statistical significance changes over time. This agrees with the findings of (Caulkett *et al.*, 2000; Miller *et al*., 2003; Caulkett and Haigh, 2007). During the initial phase of chemical capture, mortality rates were often very high, ranging from 26-35% in several studies (Rausch and Ritcey, 1961; Fuller and Keith, 1981; Peterson *et al.*, 2003). Causes of mortality included respiratory depression,

cardiovascular collapse, hyperthermia, trauma (dart injuries), stress and exertional myopathy (Arnemo *et al*., 2006).

During the last two decades, effective drugs and antagonists have become available for reversible immobilization of a wide range of mammalian species. In addition, remote drug delivery systems and light weight darts were developed for no-traumatic administration of anaesthetic drugs. Access to portable and easy-to-use monitoring devices, such as pulse oximeters, has also improved animal safety during field anaesthesia. In spite of this progress, mortality rates routinely range from 2-10% and high capture mortality rates are still being reported in several mammalian species (Jessup, 1993).

By using drugs and doses with proven safety, proper remote drug delivery systems and established capture methods and techniques, a skilled and experienced capture team will reduce the risk of capture-related mortality to a minimum. This was especially evident in the little experience we acquired during this work. By improving capture protocols and adopting improvements in drugs and doses, we were able to reduce mortality rate to less than one tenth as reported by (Arnemo, 2006).

As a result of good team work and experience from the pilot study, there was a substantial reduction in mortalities during this captures. An important part of this process included establishment of a refined capture protocol for this species that allows incorporation of additional improvement to the process as they become necessary or apparent (Spraker, 1993).

Animal was secured and a blindfold placed, this is because most immobilized animals cannot close their eyes. Therefore they became exposed to deleterious effect of direct sunlight and the corneal surface can dry out. Prolonged direct exposure may result in

severe retinitis and drying of cornea. These can lead to ulceration and scarring both of which may result to blindness.

Supplemental drugs were not required, and muscle relaxation and immobilization remained stable. Intramuscular administration of the reversal agents resulted in consistently smooth, rapid, uneventful recoveries, with little variation in recovery times. First signs of recovery (ear twitch, head movement, standing) occurred within an average of 3.2 min of drug administration, and animals were fully ambulatory and alert within an average of 5.5 ± 1.5 min. this is comparable or superior to recovery times reported for opioid/α_2 agonist, α_2 agonist/ketamine, opioid/ α_2 agonist/neuroleptic tranquilizer, or tiletamine/zolazepam combination(Wilson *et al*.,1996b; Tsuruga *et al.*, 1999; Caulkett., *et al.,* 2000; Murray *et al*, 2000; Miller *et al.*, 2004; Arnemo *et al*., 2005; Storms *et al*., 2005; Walter *et al*., 2005; Mich *et al*., 2008). In a majority of cases animals not only stood within this time period but were alert with a steady, rapid gait. Alpha$_2$ agonists used with dissociative anaesthetics (i.e., tiletamine-zolazepam mixture, ketamine) have been associated with rapid onset of action but variable anaesthetic quality; respiratory, cardiovascular and/or gastrointestinal side effects; and incomplete reversibility (Caulkett, *et al.*, 2000; Murray *et al.*, 2000; Storms *et al*., 2005, 2006). The use of medetomidine, a potent, highly selective α_2 agonist, Regurgitation was not detected in any of the anaesthesized animal, despite immobilization at feeding stations, although rumination was noted during the anaesthetic period. Mild to moderate bloating noted and improved with animal repositioning. Cardiac arrhythmias were not detected during auscultation.

The mild hypoxemia in immobilized animal noticed during this study was likely due to perfusion mismatch resulting from poor body positioning (lateral recumbency), bloat, and drug effects because SpO2 values indicated adequate oxygenation, average

respiratory rates remained within normal limits, pulse oximetry values subjectively improved with animal repositioning. This agrees with findings of (Moresco *et al*., 2001; Read, 2003; Caulkett and Haigh, 2007; Mich *et al.*, 2008). Hypoxemia of healthy, nonsedate animals reportedly occur at SpO_2 values < 80%, whereas values < 60% in anaesthesized individuals warrants correction (Read, 2003). In this study, average SpO_2 of anesthetized animals remained above 70%. Increased respiratory acidosis (often seen with hypoventilation due to recumbency) was not evident, suggesting other processes, such as peripheral vasoconstriction, induced by the α_2 agonist were occurring as reported by (Tsuruga *et al.*, 1999; Janovsky *et al.*, 2000; Read, 2003).

Azaperone is a short-acting butyrophenone tranquilizer that has been used in translocation of cervids, and in anaesthetic combination (Wilson *et al.*, 1996a; Ebedes and Raath 1999; Read and McCorkell 2002; Caulkett and Haigh 2007). Use of azaperone in this study likely contributed to calmness of the animals, as well as decreased stress, excitement in recovery stages of anaesthesia, where factors such as human presence and release into a new environment (versus the location where darted) were present, this agrees with (Wilson *et al.*, 1996a). Tranquilization and stress reduction are important in species susceptible to capture myopathy and in free-ranging animals where long-term monitoring following anaesthetic recovery is not possible. Potential extrapyramidal side effects of azaperone could not be evaluated based on the current study design but were not detected in animals kept in the Boma for acclimatization, considering that these animals were anaesthesized with Etorphine and Medetomidine combination. Potential extrapyramidal effects of azaperone may be dependent on the specie or dose-dependent; few reports describe the use of azaperone in cervids, and further investigations are warranted (Wilson *et al.*, 1996a; Ebedes and Raath, 1999; Read and McCorkell, 2002; Mich *et al.*, 2008).

Administration of naltrexone allowed the reversal of etorphine. Although highly selective and preferred antagonist, relatively expensive and may not be feasible for all free-ranging wildlife anaesthetic procedures (Mich *et al.*, 2008).

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

In conclusion, the combination of etorphine and medetomidine for the purpose of immobilization was safe for the wild herbivores. While a combination of azaperone, perphenazine was safe for translocation purposes.

6.2 RECOMMENDATION

The study recommends that:

1. More studies should be conducted using radio-transmitter darts to aid in tracking the animals after darting.

2. More studies should be conducted using a newer immobilization drugs such as BAM (butorphanol, azaperone and medetomidine) combinations to compare with present study.

3. The National Parks should be provided with facilities for aerial darting, which should be under the custody of a Veterinarian.

4. Further research work involving the analysis of haematological indices are required.

5. Further research work should be conducted with more modern anaesthetic monitoring equipment in order to reduce human errors.

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APPENDIX

Appendix I. Average of vital parameters of all the animals captured

	WATERBUCK	ELAND	ZEBRA
Temperature	38.7	39.2	38.8
Resp. Rate	12	12	13
SPO2	83	78	84
Pulse Rate	86	99	88

Appendix II. Average time to recumbency and standing

	WATERBUCK	ELAND	ZEBRA
Time to recumbency	13.26	44.31	12.45
Time to standing	7.22	5.69	5.49

Appendix III. Sex of captured animals

	WATERBUCK	ELAND	ZEBRA
FEMALE	3	4	5
MALE	2	1	10

Appendix IV: Condition of captured animals

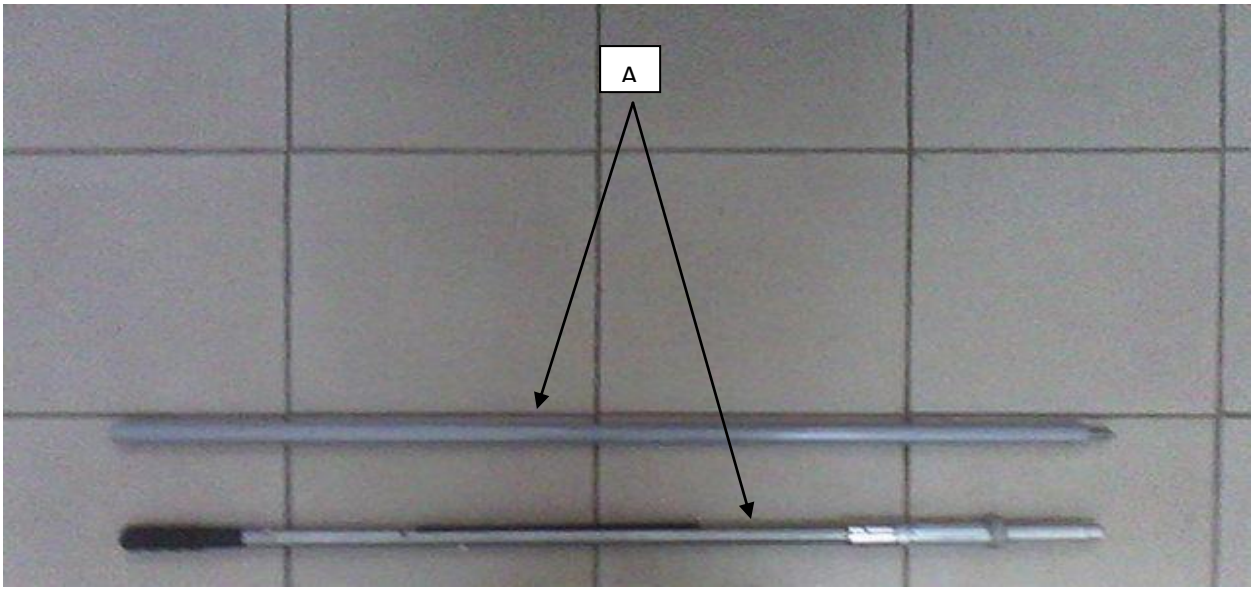
	WATERBUCK	ELAND	ZEBRA
NORMAL	4	4	14
ABSCESS	0	1	0
PREGNANT	1	0	1

Appendix V: Showing location and the level of activity before capture

S/NO	SPECIES	SEX	LOCATION	LEVEL OF ACTIVITY
1	WATERBUCK	FEMALE	YANKARI	ACTIVE
2	WATERBUCK	FEMALE	YANKARI	ACTIVE
3	WATERBUCK	MALE	YANKARI	ACTIVE
4	WATERBUCK	MALE	YANKARI	CALM
5	WATERBUCK	FEMALE	YANKARI	CALM
6	ELAND	FEMALE	SUMU	ACTIVE
7	ELAND	FEMALE	SUMU	ACTIVE
8	ELAND	MALE	SUMU	CALM
9	ELAND	FEMALE	SUMU	EXCITED
10	ELAND	FEMALE	SUMU	CALM
11	ZEBRA	MALE	SUMU	ACTIVE
12	ZEBRA	MALE	SUMU	ACTIVE
13	ZEBRA	FEMALE	SUMU	CALM
14	ZEBRA	MALE	SUMU	CALM
15	ZEBRA	FEMALE	SUMU	ACTIVE
16	ZEBRA	MALE	SUMU	ACTIVE
17	ZEBRA	MALE	SUMU	CALM
18	ZEBRA	MALE	SUMU	CALM
19	ZEBRA	MALE	SUMU	ACTIVE
20	ZEBRA	MALE	SUMU	CALM
21	ZEBRA	MALE	SUMU	CALM
22	ZEBRA	FEMALE	SUMU	CALM

23	ZEBRA	FEMALE	SUMU	ACTIVE
24	ZEBRA	FEMALE	SUMU	ACTIVE
25	ZEBRA	MALE	SUMU	EXCITED

Appendix VI*:* Collapsed pole syringe (Jab stick) A



Appendix VII: Folded stretcher



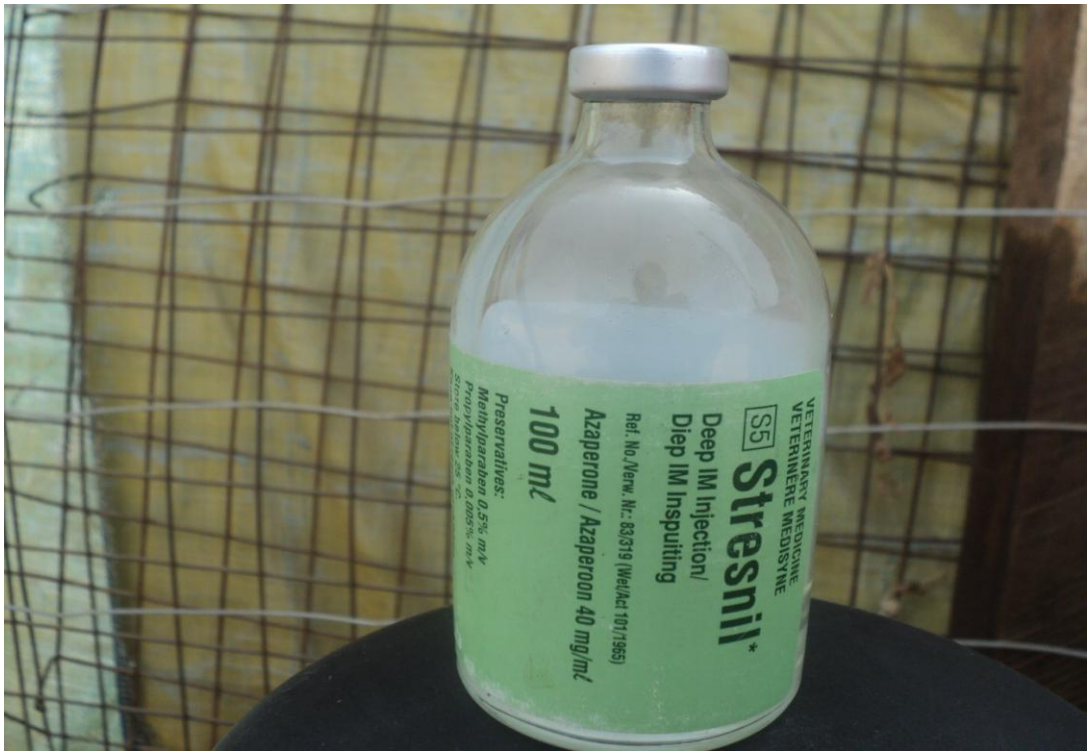
Appendix VIII: Ear tag applicator (A), with an ear tag (B)



Appendix IX*:* Immobilization drug Etorphine HCL (Captivon®)



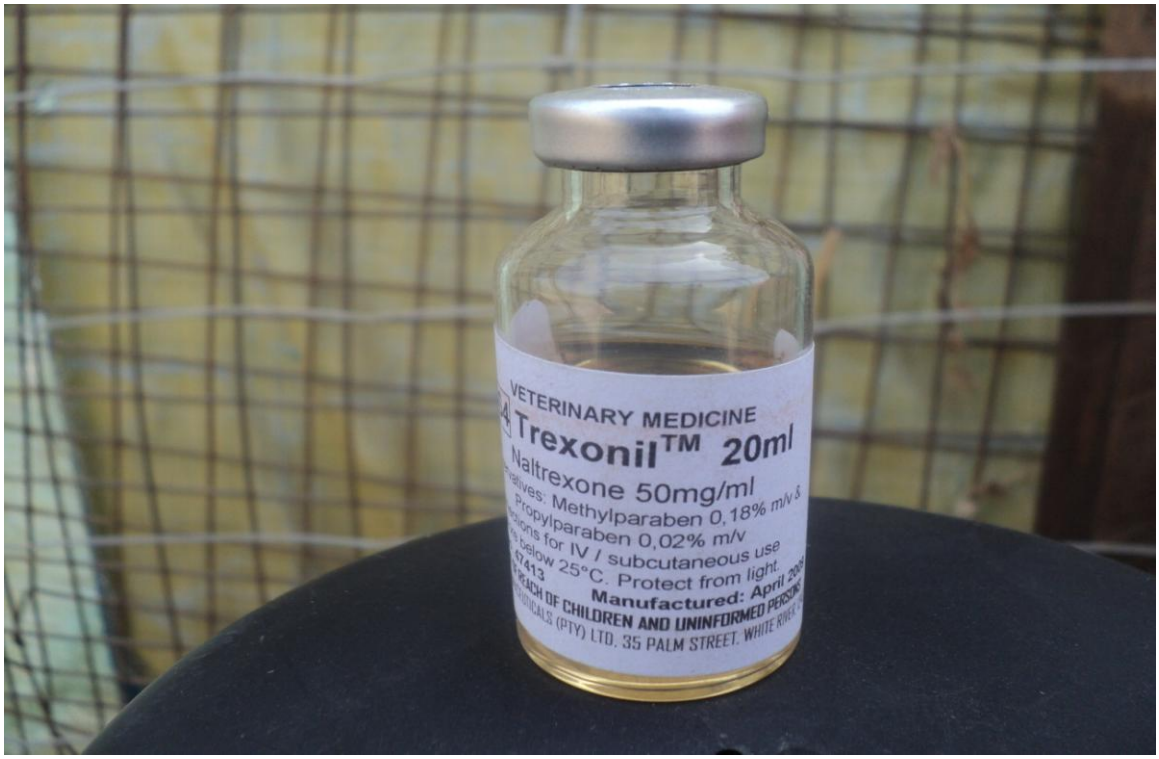
Appendix X*:* Short acting Tranquilizer Azaperone (Stresnil$^{(R)}$)



Appendix XI: Long acting Tranquilizer Perphenazine



Appendix XII: Reversal agent Naltrexone (Trexonil$^{(R)}$)



Appendix XIII: Darting of Zebra (a) at 50 metres from a stationary vehicle. A giraffe (b) in the background.

