A manual on Chemical Immobilization of wild animals

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Chemical Immobilization of Wild Animals

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Central Zoo Authority
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Laboratory for the Conservation of Endangered Species (LaCONES)
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Chemical Immobilization of Wild Animals

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1. INTRODUCTION

Severe threat of extinction of several wildlife species in the recent past has alarmed wildlife biologists and conservationists. Many conservation efforts are being attempted focusing on wild animals including mammals and their ecosystems. Such conservation and management programs often rely on research methodologies that require the handling of animals ranging from the radio-collaring, procurement of biomedical samples for research purposes to the translocation of the animals to another area, or even for management purposes in captivity. Further, restraining is often required in case of most of the manipulating and handling procedures on wild animals. It could be for routine health checkup (veterinary care, surgical intervention, vaccination, hormonal implantation or sterilization), research purpose (assisted reproductive techniques, blood collection for genetic health analysis, radio-collaring), or for conservation and management purposes (capture of problematic animals, translocation and reintroduction). Thus, capture and handling of zoo wild animals plays an important role in wildlife conservation and management. Although physical restraint is easy to operate and do not pose much risk to the animals, it has several limitations and many times it is unachievable. Chemical restraint is one of the most reliable alternative to restraining wildlife species as and when required and thus it has become a valuable tool in wildlife conservation research and management.

Historically, chemical restraint can be traced when South American tribes used curare-coated arrows to

immobilize animals for hunting for food. Although this method was effective for many years, an actual beginning of the chemical immobilization procedures dates back to the late 1950's by rangers in South Africa. Great care has to be taken while anaesthetizing wildlife species so as to keep it within the safety margin of anaesthetics, either by using neuromuscular blockers, or sometimes combined with tranquilizers. However, with the advancement of science, chemical restraint of zoo and wildlife species has improved rapidly over a few decades with safer and efficient drugs, portable monitoring equipment, and precise methods of drug delivery. Modern immobilizing techniques are more humane methods for handling of wild animals that has drastically reduced side-effects of drugs and causalities. Further, the use of antagonist/antidotes of anaesthesia is being preferred to avoid undesirable and harmful effects of drugs and for speedy recovery of highly precious wildlife species. Thus, chemical restraint has been successfully employed by the wildlife Veterinarians to relocate or treat animals in the captivity as well as in the wild resulting in the rescue of many rare and critically endangered species. These advanced procedures have become increasingly more popular and are slowly being adopted by zoos in India for safer handling of wild animals. However, the modern capture methods require a high degree of expertise and experience, as well as basic knowledge of anatomy, physiology and behaviour of the animals to be captured. Chemical capture of wild animals is a huge responsibility and can be very expensive, especially when there are losses caused by injuries, capture myopathy, and the incorrect use of tranquillizing and immobilizing drugs. There can also be deaths due to mal-adaptation to the new habitat. Many zoo veterinarians and

forest managers lack such expertise and experience. The ultimate success of the wildlife capture, transport and re-establishment of animals is determined not merely by the success in capture of the animals but more often evaluated in terms of how the animals are handled, transported and kept after capture and whether they adapt and breed successfully in their new environment. Unfortunately recent advancement in chemical capture techniques has not effectively reached to the end users, wildlife Veterinarians and conservation biologists working in the remote places of India. The majority of them do not have easy access to the updated veterinary literature for use in the field.

In this manual, an attempt has been made to present a comprehensive ready reckoner for zoo veterinarians and forest rangers on wildlife capture and very practical information with a systematic documentation of immobilizing drugs, their properties, usage, and availability. Each drug is described individually with its advantages and disadvantages under separate headings. The manual also provides information on variety of anaesthetic equipment, its usage, darting techniques and precautions while capturing wildlife species. The discussion is based on extensive experience of authors spanning over more than a decade in handling and care of anaesthetized animals. Based on this wildlife experience, several anaesthetic drug combinations in wild felids (Lion (*Panthera leo*) , Tiger (*Panthera tigris*) and Leopard (*Panthera pardus*), ungulates (Deer and Blackbuck (*Antilope cervicapra*)) and other zoo animals has been optimised using large sample size for achieving safer, efficient and reliable anaesthesia. The physiological values of cardio-pulmonary and thermal systems

during the anaesthesia are also provided in a tabular form. More importantly, based on the experience over the years, the safe, effective and precise dosage of antagonists/antidotes in variety of wildlife species in India has also been developed. This information is exclusively important during handling of valuable endangered animals as many times anaesthetic recovery would be dangerous and may prove fatal. Finally, this manual also presents anaesthesia regimes of other zoo animals such as Elephant (*Elephas maximus*), Giraffe (*Giraffa camelopardalis*), Rhinoceros (*Rhinoceros unicornis*) and other ungulates. It is hoped that this manual would be useful for zoo veterinarians and forest managers in India for safe use of chemical capture methods in case of precious wildlife species for their clinical health management, experimentation and translocation etc.

2. CAPTURE METHODS

The capture and handling of wild animals plays a prominent role in wildlife conservation and management. On a regular basis, zoo veterinarian has to deal with animal handling for various purposes. It could be for routine health check-up (veterinary care, surgical intervention, vaccination, hormonal implantation, or sterilization), research purpose (assisted reproductive techniques, blood collection for genetic health analysis, radio-collaring), or for conservation and management purposes (capture of problematic animals, translocation and reintroduction) and marking of animals.

2.1 Type of Methods

Animal capture and translocation have become specialized and well-organized procedures in wildlife conservation and management. Animal capture can be carried out using traps, nets or snares (known as *Physical restraint*), or by using chemical agents/drugs that are injected into the body to control wild animals (known as Chemical restraint/immobilization).

2.1.1. Physical (manual) restraint

Simple procedures such as brief examination, injection or venipuncture can be carried out using physical restraint alone for captive animals. Most of the zoos has squeeze cages where animal is allowed to feed and restrained its movements for veterinary care

(**Fig. 1**).

Other devices of physical restraint are:

Traps- Traps are routinely used to capture mass population of wild animals that are laid at places where the animals frequently visit such as water holes. The traps are laid in a funnel shape where the animals are driven from large area leading it into the trap. Sometimes, food or live bait (e.g. goat for carnivore sp. or large felids) is kept near traps to attract animals for capture. Even the opposite sex animal can also be used to attract the counterpart. In case of animals in zoos, the traps are used in their feeding cell or night shelter.

Nets- Variety of nets such as mist net, drive net, projection or cannon net or bait net can be used to capture aggressive or injured animals.

Snares- Snares can also be used to capture problematic animal but the snares needs to be monitored for long hours so that as soon as the animal is trapped in snares, it has to be relieved immediately from the snares to prevent strangulation.

Figure 1: Squeeze cage at LaCONES Animal Holding Facility for Physical Restraint of Wild Felids (Leopard) housed at LaCONES-CCMB.

These physical (manual) restraint methods have several limitations. For instance, physical restraint needs long-term planning and it is very expensive to perform physical capture in the wild such as hiring of helicopters and other vehicles for driving/chasing animals. Individual subject animal (such as aggressive animal) from a group of animals cannot be tracked and anaesthetized independently using physical restraint. Also, physical method cannot be applied in captive animals especially while dealing examining and offering veterinary care to the sick and injured animals. It leads to serious stress in the animals kept in captivity and sometimes, it may prove fatal. Thus, in such instances, chemical capture and handling would be an ideal capture method for immobilizing zoo captive animals.

2.1.2. Chemical immobilization or restraint

Chemical restraint is a form of animal restraint technique in which a drug or a chemical is used to restrict the movement (walking, running, aggression) of an animal or sometimes just to sedate or to calm down the animal. Chemical restraint is a safe and effective capture method when applied correctly and with due precaution. Chemical restraint is advantageous over physical capture because it allows examining and treating sick and injured animals or animals caught in snares or traps in the wild by poachers. It enables restraint of selected aggressive animals within a group of animals, and the equipment required for chemical restraint is easy to transport from one place to

another in the field. However, chemical capture may have disadvantages such as occasional failure of the equipment on site, undesirable side effects of drug in unknown excited or diseased animal, improper darting of an animal due to occasional operator's mistakes. Further, chemical capture method cannot be applied for mass capture of animals within a group. Nonetheless, chemical restraint has become a valuable tool in wildlife health, research and management since it facilitates the handling of animals as and when required for medical procedures and experimentation. However, the state of chemical restraint may vary from immobilization (restricting animal movements), to tranquilization (calmness), to complete anaesthesia (complete loss of consciousness).

Various modern capture methods require a high degree of expertise and experience, as well as knowledge of physiology and behavior of an animal to be captured. However, one of the biggest challenges facing Wildlife Veterinarians in India is the lack of expertise and experience in wildlife handling and also knowledge of basic physiology of various species. Therefore, wildlife veterinarians need to be fully conversant with a wide array of environmental and biological variables while using chemical restraint on wild animals. In order to minimize risks of anaesthesia to subject animals, Veterinarians also need to be able to react appropriately using the correct equipment with sufficient skill to deal with anything that may go wrong during the capture.

Anaesthesia: (from Greek **an**-"without" and ***aesthesis***-"sensation"), a state of total loss of sensation in a body, induced by a drug that depresses activity of nervous tissue

peripherally (local and regional anaesthesia) or centrally (general anaesthesia).

Analgesia: The loss of sensibility to pain (relief pain) without loss of consciousness.

Narcosis: State of sleep accompanied by analgesia.

Hypnosis: Artificially-induced sleep like state from which the animal can be aroused by stimuli.

Sedation: Calming due to mild degree of depression of central nervous system, most sedative cause drowsiness.

Tranquilization: A state of behavioural changes in which the animal is relaxed and unconcerned by his surroundings.

Local analgesia (anaesthesia): It is a loss of sensation in a defined area of the body.

Regional analgesia: Loss of sensation in a larger but limited body area.

Balanced anaesthesia: General anaesthesia produced by a combination of two or more anaesthetic drugs or techniques to achieve optimum hypnosis, analgesia and muscular relaxation.

General anaesthesia: It is complete unconsciousness produced by a process of controlled, reversible intoxication of central nervous system in which there is muscle relaxation and diminished response to external stimuli.

2.2 Factors affecting anaesthesia response

- ***Age:*** Young and much older animals are more sensitive to anesthesia in comparison to an adult animal. Young animals require more and older animals usually require less doses.
- ***Size and body weight:*** The small size animals with higher metabolic rate need higher doses of anaesthesia.
- ***Sex:*** Sex of the animal may influence drug dose response. Males require higher doses than the females.
- ***Species:*** There are species-specificity and variation in drug response. Choice of drug, doses and animal response vary between species. Therefore, it is essential to know the species of interest, feeding habit, seasonality in reproduction and response to particular drugs if known.
- ***Physical condition:*** A sick, malnourished or debilitated animals require lower dose of anaesthesia than a healthy, well-fed animal. Such compromised animals are at high-risk of anesthesia and thus needs to be handled very carefully.
- ***Pregnancy:*** Pregnant animals are more susceptible to anaesthesia due to high metabolic rate. However, animals in late pregnancy require more doses for anaesthesia. The pregnant ungulates (Spotted deer (*Axis axis*) and Blackbuck (*Antilope cervicapra*)) has been anaesthetized for artificial insemination and for ultrasound pregnancy diagnosis but no pregnancy loss

due to Ketamine - Xylazine anaesthesia has been observed.

- ***Season:*** The time of year may have a profound effect on response to specific drugs such as Succinylcholine.

3. ANAESTHETIC DRUGS

A variety of drugs have been used for chemical restraint of zoo and wild animals. As such, there is no perfect drug or an anaesthetic that will suit to variety of animal species. However, the characteristics of an ideal drug may serve as a guide for evaluating available immobilizing drugs. An ideal drug should have the following properties:

- Readily available and economical
- Readily soluble in water, stable in solution with long self-life.
- High therapeutic index
- Potent (required dose delivered in small volume) and suitable for most species
- Fast-acting with smooth onset of induction
- Minimum excitement
- Non-irritating upon administration via intravenous or intramuscular route
- Short induction period
- Good muscle relaxation
- Minimum depression of physiological variables (heart rates and breathing)
- Sufficient analgesia at subanaesthetic or lower doses
- Retention of reflexes such as swallowing
- Effective antidote having minimum side effects
- Rapid degradation to inactive, non-toxic metabolites
- Safe to use in pregnant animals
- Safe for humans on accidental exposure

"There is no such thing as safe anesthetic or safe anaesthetic procedure, just a safe Anaesthetist" **– Robert Smith**

Anesthesia procedures are quite safe but should be accomplished by a trained Veterinarian only.

3.1 Drug

Due to restrictions on import licensing in India, several immobilization drugs are not available in India. Therefore, an Indian Veterinarian has a challenge to optimize different drug combinations within the limited availability of drugs for use in wildlife.

3.1.1 Neuromuscular blocking drugs (Succinylcholine, Tubocurarine, Nicotine)

Neuromuscular blocking drugs act at the neuromuscular junction and paralyse muscle from functioning. These are some of the first drugs used for chemical immobilization of wildlife. There are three classes of neuromuscular blocking drugs: depolarizing, competitive (nondepolarising) and ganglionic. Due to narrow safety margin and the risk of respiratory failure due to paralysis of diaphragmatic muscles, these drugs are not suitable in wild animals.

3.1.2 Central Nervous System (CNS) Depressants

These drugs have an effect predominantly on the CNS. The effects range from calmness (tranquilization), depression (sedation), loss of pain (analgesia) to a complete loss of

consciousness (anaesthesia). In this category of drugs, some drugs (for example diazepam) which act as tranquilizer at a lower dose may work as an anaesthetic, although it is not recommended.

Tranquillizers/Sedatives (Acepromazine, Diazepam, Xylazine, Medetomidine, Azaperone)

Tranquilizers produce calmness, loss of aggression and loss of alertness which is generally required during transportation. Animals do not get immobilized fully with tranquilizers and can be aroused by slight disturbances. Therefore, they are used primarily as adjuncts to dissociative anaesthetics for hastening smoother induction and to reduce the quantity of anaesthetic for achieving more effective immobilization. This combined synergistic effect of tranquilizer and anaesthetic is far greater than the individual effect of either of the two drugs with respect to smooth induction, good muscle relaxation and smoother recovery.

Dissociative Anaesthetics (Ketamine hydrochloride, Tiletamine, Etorphine) They are also termed as Cyclohexanes. Anaesthetics are used when an animal needs to be unconscious and unaware for an extended period of time, such as for surgery or performing assisted reproductive techniques. When used singly, they usually cause rough inductions and recoveries and convulsions may be experienced. Therefore, they are usually used in combination with sedatives or tranquilizer that produces synergistic effect to yield good induction and smooth recovery.

3.1.3 Commonly used drugs for immobilization in Indian wild animals

- **Acepromazine**

  Trade names: Aceprom, Atravet, PromAce

  Route of administration: Intramuscular, Intravenous, Subcutaneous

  Advantages:

  - It is relatively a safe drug
  - It induces smooth anaesthetic induction and recovery
  - It potentiates anesthetic property of other dissociative anaesthetic
  - It is antiemetic (decreases vomiting)
  - It has high therapeutic index

  Disadvantages:

  - It causes hypotension with tachycardia
  - It can cause respiratory as well as cardiovascular depressant effects.

- **Xylazine hydrochloride**

  Trade names: Ilium, Rompun, Gemini

  Route of administration: Intramuscular, Intravenous, Subcutaneous

Advantages:

- It is a very safe sedative and potent muscle relaxant
- It is commonly used in combination with ketamine or etorphine to immobilize cervids and felids with synergistic effects
- It is potent analgesic
- The effects of xylazine can be completely antagonized by alpha 2- adrenergic antagonists such as yohimbine or tolazoline
- It is very compatible with other anaesthetics

Disadvantages:

- It does not cause complete immobilization in cervids
- Is respiratory depressant and can cause hypotension and bradycardia
- It can cause ataxia
- Causes vomition in felids and canids
- Long standing effects result in bloat in cervids

➢ **<u>Medetomidine, Detomidine</u>**

Trade names: Domitor, Dormosedan

Route of administration: Intramuscular, Intravenous, Subcutaneous

Advantages:

- Medetomidine and Detomidine are alpha-2 agonists with sedative, analgesic and muscle relaxation properties
- In comparison to xylazine, Medetomidine reduces the dose of an anaesthetic such as ketamine when used in combination
- It can be completely antagonised by atipamezole

Disadvantages:

- Like xylazine, it doesnot cause complete immobilization in cervids
- Medetomindine, like xylazine has detrimental effects such as bradycardia, decreases cardiac output and may result in apnea

➢ **<u>Ketamine hydrochloride</u>**

Trade names: Ketamil, Ketaset, Vetalar

Route of administration: Intramuscular, Intravenous,Subcutaneous, Intraperitoneal

Advantages:

- Ketamine is one of the most widely used drugs for wildlife immobilization
- It has high therapeutic index and efficacy
- It is very safe
- It provides peripheral analgesia

- It shows minimal respiratory distress (can be depressant only at high doses
- Good cardiovascular support
- Excellent synergetic with many tranquilizers

Disadvantages:

- Rough induction and recoveries when used alone
- Poor muscle relaxation
- Sometimes it could be conversant with prolonged administration. Convulsions could be controlled pentobarbital sodium at 0.5 to 1 mg/kg IV is advocated
- Cause increased salivation
- Rapid administration of ketamine by IV route causes sudden respiratory failure
- There is no known antidote for ketamine

4. ANAESTHETIC ANTAGONISTS

Antagonists are some of the notable pharmacological developments to wildlife immobilization that are useful to reverse the anaesthetic effects of tranquilizers such as xylazine, detomidine and Medetomidine after completion of procedures on wild ungulates (Kholkute and Umapathy, 2007, Sontakke et al. 2007, 2009a) and also wild felids (Sontakke et al. 2009). The ability of drug to antagonize the anaesthetic effects and return the animal more quickly to physiological normalcy. Thus antagonists help to recover the animals from anaesthesia as and when required thereby preventing predation in the wild and also to overcome physiological complications such as bloat and cardio-respiratory distresses due to long period of immobilization. Sometimes, accidental higher doses may cause severe complications of physiological variables, in such instances; recovery of anaesthesia is greatly warranted using antagonists. It also decreases the personnel and equipment time for monitoring the immobilize animal till its recovery process.

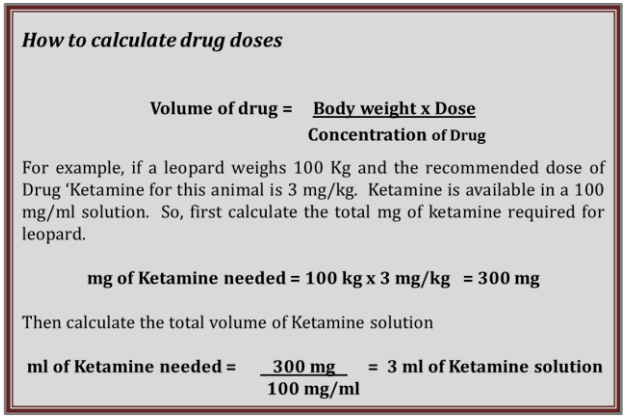
There are several antagonists but alpha 2–adrenergic antagonists such as Yohimbine hydrochloride, tolazoline hydrochloride and atipamezole are safe and are commonly used in wild animals. Intravenous injections of antagonists provide the most rapid recovery (as early as within 1 minute as observed in Spotted deer and Blackbuck using Yohimbine and Tolazoline respectively, Sontakke et al. 2007, 2009b). Tolazoline found to be more effective than yohimbine in some ungulates as was observed in Blackbuck (Sontakke et al. 2009b). It appears than tolazoline restore rumen motility faster

than yohimbine. Slower recoveries (generally 5 – 10 minutes) occur with antagonists when used via IM route. Therefore it is a common practice to give equal doses of the antagonist both IV and IM or IM and SC (Kreeger et al. 2002)

How to calculate drug doses

Accurate calculation of drug doses is very essential to reduce problems of over- or underdosing. The following information is required prior to calculating drug doses:

- Animal weight (either estimated or actual)
- Concentration of the drug
- Recommended dose



5. ANAESTHESIA EQUIPMENT

Anaesthetic drugs are generally administered by remote darting systems by means of a wide range of equipment such as aluminum or plastic syringes called 'Darts'. The darts are fired from a distance by a variety of dart guns or blow pipe for administering immobilizing and tranquillizing drugs intramuscularly into wild animals from a reasonable distance. Pole-syringes are used to inject animals that are in close proximity, such as animals in squeeze cages, crates or crush passageways. The drugs can also be injected with ordinary syringes after the animals have been captured in nets or by other mechanical means.

Various routes of drug administration –

- Oral – drugs can be mixed in water and food
- Hand-held syringes – Regular syringe, jab-stick
- Remotely projected syringes or darts – Blow-pipe, blow-gun, gun, pistol

5.1 Oral route – The immobilizing drugs can be mixed in the food or water as bait. However, it has limitations especially in free-ranging animals that the bait may be consumed by the non-targeted animals, or aggressive animal may consume more than the desired dose or if the drug gives undesirable smell, animal may reject the bait or regurgitate the food. This drug delivery will be applicable in captive or trapped animals.

5.2 Hand-held syringes – When the animal is held in the trap cage or in squeeze cage, regular or ordinary syringes made of

any metal/aluminium, plastic or glass with dart needle having sleeve can be used for delivering the drug.

5.2.1. Jab-stick is a modified syringe that allows operator to keep away from animal while injecting the drug. The stick will be attached with a syringe and attached needle. The drug will be administered using a pressure. Different types of jab-sticks, made of aluminum, plastic or fibre glass are available (**Figure 2**). An extendable jab-stick of 4.5 m is preferred for delivering anaesthetics in captive animals or partially anaesthetized animals. Even the repeated injections of desired doses can be injected using modern jab-sticks.

Figure 2: Pole syringe and Jab-stick for immobilization of captive animals (photo: Dist-Inject)

5.3 Projectile Dart Syringes – Most of the chemical immobilization procedures in wild animals are performed using dart syringes which are injected using either blow-pipe or dart gun or pistol. The dart has three components – needle with sleeve, barrel of syringe/dart for drug and rear side stabilizer which provides direction while darting as shown in the **Figure 3 and 4**. The preparation of dart is very important and needs much practice and experience. For filling a dart with a drug, first push the rubber plunger of the dart barrel back and fill the dart with the drug from the anterior opening. Then cover the

needle hole with a rubber sleeve and fix the needle on the syringe hub. The dart is then pressurized by filling the gas from the rear end of dart and finally the loaded dart is put in the blow-pipe ready for darting.

Figure 3: Dart syringes of varying capacity (1 ml to 5 ml) to be darted via blow-pipe (photo credit: Dist-Inject)

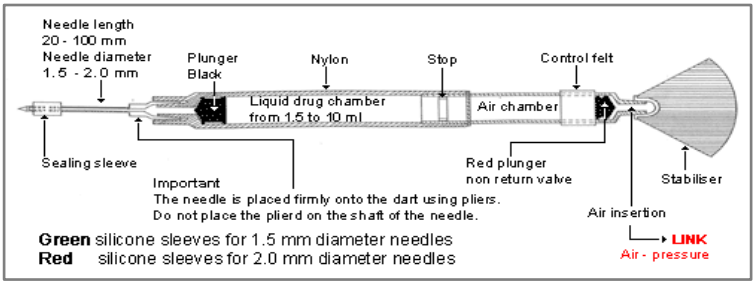


Figure 4. Cross section of dart syringe showing different parts (photo credit: Dist-Inject)

5.3.1 Blow-pipe – Blow-pipe is the commonest dart projector made of PVC or aluminum for darting (**Fig. 5 and 6**). The length of blow-pipe tube is generally 1-2 meters. It can propel a plastic dart of maximum of 5 ml capacity to over a short distance of 10 meters. It is mainly used for wild felids and

ungulates in captivity. The physiological results of immobilization drugs delivered by dart depend on dosages, the site of darting, success of dart placement and drug delivery in the muscle, as well as the physiological state of the animals prior to and during anaesthetic induction. The key to success in anaesthesia and analgesia in wildlife is being flexible and adapting to changes.

5.3.2 Air pressure dart Gun – It is commercially available as Tel-inject. The dart is similar to a blow-pipe but bigger in size. Some dart guns have interchangeable barrels and depending on the barrel diameter used, darts of 2 ml, 3 ml and 5 ml capacity can be used. There are four models with some variations of the Tel-Inject dart gun available:

• **Pistol:** It is the simplest of all the models. Pressure to fire the dart is built up by using either a foot pump or a carbon dioxide cartridge. The pistol has an effective range of 20 to 25 meters, but it does not have an accurate sight. It is recommended for darting animals in pens and at close range (**Fig. 7**).

Figure 5: Blow pipe used for darting and size varies from 1 to 2 meters.

Figure 6: Darting of a captive Tiger using a blow pipe that covers a range of approximately 5 meters.

Figure 7: Pistol for immobilization of wild animals
(Photo: Dist-Inject)

• **Rifle:** This model has a sight with two possible settings for accurate aiming up to 30 meters (**Fig. 8**). Pressure is supplied either by a foot pump or a carbon dioxide cartridge. Another Rifle model is a powerful dart gun having an effective range for firing darts over chamber by a 20 ml syringe fitted with a special adapter. The pressure in the rear air chamber is regulated by a blue valve. The pressure can be checked by gently probing the back of the valve with a blunt piece of thin wire that fits into the opening. The needles may be smooth or collared and have a solid, hard tip and two small holes on the sides above the tip. These holes are closed by a plastic cover that slips back when the needle penetrates the skin and muscles of the animal. In this way, the pressurized immobilizing drug is released. The firing mechanism used in Rifle is compressed air or carbon dioxide instead of a powder charge and is therefore silent. The advantage of this silence is that when an animal in a herd is darted, the others are not disturbed by the sound of the shot. The darted animal also does not become panic-stricken and run off because the impact of the dart is not associated with a loud noise. The darts are light and therefore do not damage the muscle tissue and injure the animal. The equipment is accurate at both close and long ranges when suitable allowances are made for wind velocity and direction. With special needles, elephants and rhinoceroses can also be darted. Special needles are available for animals of different sizes.

Figure 8: Rifle for immobilization of wild animals (Photo: Dis-Inject)

Figure 9: Captive Tiger was anaesthetized with a combination of ketamine-xylazine using a dart syringe projected via a Blow-pipe (Photo: Govindaraj Giridharan)

5.4 Darting sites

The preferred sites of darting are shoulder and hind quarter. The muscles of the shoulder, the biceps and triceps, are among the best places for remote injection in ungulates. It is better to avoid the upper part of the shoulder because the dart needle may become embedded in the cartilage or scapula. In skinny and emaciated animals, darts may strike the

spine of the scapula and result in fracture, hemorrhage or dart blockage. In such light muscled animals, the hindquarters may be a preferable site of darting. It is observed that darting on shoulder region gives shorter induction than the darting on the hind quarter. Large herbivores such as elephant, rhinoceros or hippopotamus, have well developed muscles in the withers or hump, which provides a suitable darting site. In Giraffe or buffalo, the brisket (pectoral area) can be a suitable dart site when no alternative sites are available, but fat portion interferes with the absorption of drug thereby delaying the induction. The well-muscled area is a commonly selected dart site. It is possible to dart most ungulates from any angle into the hind leg but the dart must hit perpendicular to the surface to prevent deflection and to ensure deep IM injection (Pic. 2). The mid-lateral part of the hind leg should be avoided due to the proximity of the femur (and a large bony protuberance, notably in Rhino). Placement of a dart high up on the hind leg from behind and to the side should be avoided as the bony prominences of the pelvis may deflect the dart.

Figure 10: Marked areas on the Axis deer (*Axis axis*) are the preferred sites of intramuscular injection by darting. The preferred areas are the large muscular region on the hindquarters and shoulder (Photo: Sadanand Sontakke).

Table 1: Recommended sizes of dart needles for use in wild animals

Species	Needle Size (diameter x length in mm)
Lion, leopard, tiger, cheetah, wild dog	1.5 x 35
Axis deer, Sambar, Nilgai, Eld's deer, Barasingha	1.5 x 35
Blackbuck, Chousinga, Chinkara, Barking deer	1.5 x 25
Elephant, rhinoceros, giraffe	3 x 60

Avoid using needles with a narrow bore. Needles with smaller diameters have thinner walls and tend to bend more easily on impact; the pressure within the dart chamber will be

greater and the force of injection will be more likely to result in the dart being forced back (Table 1). The dart contents sprayed into the air may be dangerous to humans so be cautious. Needles fitted with a bulb or a barb on the shaft can be used to prevent the dart from being forced backwards and out of the animal as the drug is injected. Using a barbed needle will help to retain the dart on the animal body for some time but these needles can cause excessive soft-tissue damage as the needle moves up and down in the tissue when the animal is running.

ANIMAL IMMOBILZATION FORM

DATE: _____ ANIMAL NUMBER: _____

NAME OF INVESTIGATOR(S): _____

SPECIES: _____ SEX: M/F/UN (TICK) _____

AGE: _____ Month Yr (ESTIMATED OR ACTUAL)

WEIGHT: _____Kg (ESTIMATED OR ACTUAL)

PURPOSE/EXPERIMENT OF CAPTURE: _____

LOCATION OF CAPTURE: _____

AMBIENT TEMPERATURE: _____ F°/ C° WEATHER CONDITIONS: _____

TIME	DRUG	DOSE (mg OR ml)	METHOD	LOCATION

TIME ANIMAL IMMOBILIZED: _____ TIME ANIMAL RECOVERED: _____

VITAL SIGNS:

TIME	TEMPERATURE	PULSE	RESPIRATION

CONDITION OF ANIMAL INDICATE: EXCELLENT GOOD FAIR POOR

INJURIES OR ABNORMALITIES NOTED: _____

SAMPLE(S) TAKEN:

TIME TYPE (INDICATE BLOOD, TISSUE, TOOTH, ETC.)

RADIO COLLAR FREQUENCY RADIO SIGNAL CHECKED:

TRANSPONDER NUMBER TRANSPONDER CHECKED

EAR TAG NUMBER(S) AND COLOUR (S)

OTHER MEASUREMENT:

BODY LENGTH: CM TAIL LENGTH: CM

SHOULDER HEIGHT: CM GIRTH: CM

COMMENTS:

SIGNATURE OF VETERINARIAN

(Adapted from Kreeger et al. 2002)

6. ANAESTHESIA IN WILD FELIDS

(Lion, Tiger, Leopard, etc.)

Immobilization of wild felids is challenging and requires experience and expertise while approaching a wild cat. Wild felids either in captivity or in the wild need to be immobilized for various reasons- for veterinary medication, surgical procedures, blood collection, sterilization, for carrying out assisted reproductive procedures or even capture and translocation of injured animal or man-eater from the wild. Nowadays, wild leopards are straying in the human premises in search of food thereby creating havoc in the public. Such situations need to be quickly attended by capture of strayed animal using the available anaesthetics. The recommended anaesthetic combinations and doses for wild felids are given below (**Table 2**).

Table 2: Recommended anaesthetic combinations reported earlier for common Wild felids

Animal	Recommended Drug (mg/kg)	Total drug Content mg/kg)	Total drug volume (ml)	References
Lion (*Panthera leo*) Body weight: 100-250 kg	Ketamine 2.2 + Xylazine 1.1	250 125	2.5 1.25	Sontakke et al. 2009, M. Naveen Kumar (*Personal comm*.)
	Ketamine 7.5 + Xylazine 3.5	750 350	7.5 3.5	Rodgers 1992

	Ketamine 2.5 + Medetomidine 0.07	250 14	2.5 1.4	Jalanka and Roeken 1990
Tiger (*Panthera tigris*) Body weight: 150-250 kg	Ketamine 2.2 + Xylazine 1.1	300 150	3.0 1.5	Sontakke et al. 2009 M. Naveen Kumar (*Personal comm*.)
	Ketamine 2.5 + Xylazine 2.5	300 375	3 3.75	Kotwal 1985
	Ketamine 2.5 + Medetomidine 0.07	250 14	2.5 1.4	Jalanka and Roeken 1990
Leopard (*Panthera pardalis*) Body weight: 50 -100 kg	Ketamine 2.2 + Xylazine 1.1	200 100	2.0 1.0	Sontakke et al. 2009 M. Naveen Kumar (*Personal comm*.)
	Ketamine 2.5	910	9.1	Smuts et al. 1973
	Ketamine 3.0 + Medetomidine 0.07	150 10	3.0 1.0	Jalanka and Roeken 1990
Snow leopard (*Panthera uncia*) Body weight:	Ketamine 2.2 + Xylazine 1.1	200 100	2.0 1.0	M. Naveen Kumar (*Personal comm*.)
	Ketamine 3.0 + Medetomidine	300 10	3.0 1.0	Jalanka and Roeken 1990

50 -100 kg	0.08			
Jaguar (*Panthera onca*) Body weight: 50 -100 kg	Ketamine 2.2 + Xylazine 1.1	200 100	2.0 1.0	M. Naveen Kumar (*Personal comm*.) Sontakke SD and Umapathy G (*Personal comm*.)
	Telazol 5.0	500	5.0	Seal et al. 1970 Jalanka and Roeken 1990

Anaesthetic events during immobilization of wild felids

Table 3: Time to onset of anaesthesia, lateral recumbency and anaesthesia (minutes) in the captive Asiatic lions, leopards and tigers anaesthetized with ketamine and xylazine (Adapted from Sontakke et al. 2009)

Species	Sex	Number of animals	Onset of anaesthesia	Lateral recumbency	Induction time
Lion	Male	22	9.7 ± 3.1	15.7 ± 4.9	18.0 ± 5.6
	Female	30	10.7 ± 3.1	17.1 ± 4.9	19.8 ± 5.2
Leopard	Male	32	7.9 ± 2.5	12.4 ± 3.4[a]	13.7 ± 3.7[a]
	Female	23	8.3 ± 1.3	14.3 ± 3.2[b]	16.1 ± 3.7[b]
Tiger	Male	16	8.5 ± 1.9	15.5 ± 3.2	17.8 ± 3.8

Values are represented as mean ± SD. Different superscripts in a column within a species differ significantly at $p < 0.05$.

Physiological variables during anaesthesia in wild felids

Immediately after complete anaesthesia, animals need to be monitored for various physiological parameters such as body temperature, respiration, heart rate and blood ocygene saturation throughout the anaesthesia period and as and when required corrective measures need to be taken (**Fig. 11; Table 3 and 4**).

Table 4: Physiological variables in captive Asiatic lions, leopards and tigers anaesthetized with ketamine (2.32 ± 1.1 mg/kg) and xylazine (1.16 ± 0.5 mg/kg) (Adapted from Sontakke et al. 2009)

Species	Gender	Number of animals	Respiratory rate (breaths minute^{-1})	Heart rate (beats minute^{-1})	Rectal temperature (^{0}C)
Lion	Male	22	21 ± 3 (16–28)	68 ± 6 (57–80)	39.1 ± 0.5 (38–40.2)
	Female	30	19 ± 4 (12–27)	67 ± 5 (56–75)	38.9 ± 0.6 (38–41)
Leopard	Male	32	23 ± 3 (18–30)	72 ± 7 (55–84)	39.9 ± 1.3 (38–42.5)
	Female	23	21 ± 3 (15–27)	71 ± 5 (59–80)	39.3 ± 0.9 (38–41.5)
Tiger	Male	16	19 ± 3 (12–24)	66 ± 5 (58–73)	40.4 ± 1.2 (38.5–42.5)

Recovery of Anaesthesia in wild felids

Uncontrollable recoveries because of prolonged sedation are a serious concern in wildlife research since the sedated free-ranging animals could be easily preyed upon. A few deaths have also been recorded in tigers because of profound respiratory depression following ketamine–xylazine anaesthesia (Seal et al. 1987). It is therefore very important to determine a suitable antagonist for the speedy recovery of anaesthetized endangered wild felids. Alpha-two adrenergic antagonists such as yohimbine, tolazoline and atipamezole have been used effectively in ungulates for antagonizing the anaesthetic effects of ketamine–xylazine (Kreeger et al. 1986; Sontakke et al. 2007, Sontakke et al. 2009b). Although common in ungulates, there are hardly any reports on reversal of anaesthetic effects by administering suitable antagonists. It

has been observed, for the first time in wild felids, yohimbine as an effective reversal of ketamine-xylazine anaesthesia in three wild felids that hastens the recovery of anaesthesia within 5-10 minutes of IV administration of yohimbine. Over the years, more than 300 anaesthetic procedures were carried out in Lion, Tiger and Leopard and well optimized yohimbine as a reversal of ketamine-xylazine anaesthesia in these endangered wild cats (Table 4).

Table 5: Stages of yohimbine-induced recovery of ketamine (2.32 ± 1.1 mg/kg) and xylazine (1.16 ± 0.5 mg/kg) induced anaesthesia in the captive Asiatic lions, Leopards and Tigers (n = 125 anaesthetic events; adapted from Sontakke et al. 2009a)

			Stages of yohimbine-induced recovery		
Species	Yohimbine (mg kg$^{)1}$ body weight)	Number of animals	Onset of arousal (minutes)	Sternal recumbency (minutes)	Standing/recovery time (minutes)
Lion	Saline	15	58.5 ± 7.4	62.28.8 ±	85.4 ± 15.5^{a}
	0.1	16	2.1 ± 0.6	4.10.8 ±	5.9 ± 1.0^{b}
	0.15	21	2.0 ± 0.4	3.70.5 ±	4.7 ± 1.0^{c}
Leopard	Saline	15	75.4 ± 10.4	79.28.9 ±	112.0 ± 12.5^{a}
	0.1	17	4.6 ± 1.9	8.33.0 ±	11.6 ± 3.2^{b}
	0.15	23	4.2 ± 1.6	7.82.8 ±	10.8 ± 3.5^{b}
Tiger	Saline	5	72.8 ± 5.1	83.54.4 ±	93.4 ± 2.2^{a}
	0.1	5	2.9 ± 0.6	7.31.0 ±	10.3 ± 1.5^{c}
	0.15	6	3.5 ± 1.5	5.71.8	7.7 ± 1.6^{d}

Values are represented as mean ± SD. Different superscripts in a column within a species differ significantly at $^{b,c}p < 0.01$ and $^{c,d}p < 0.05$.

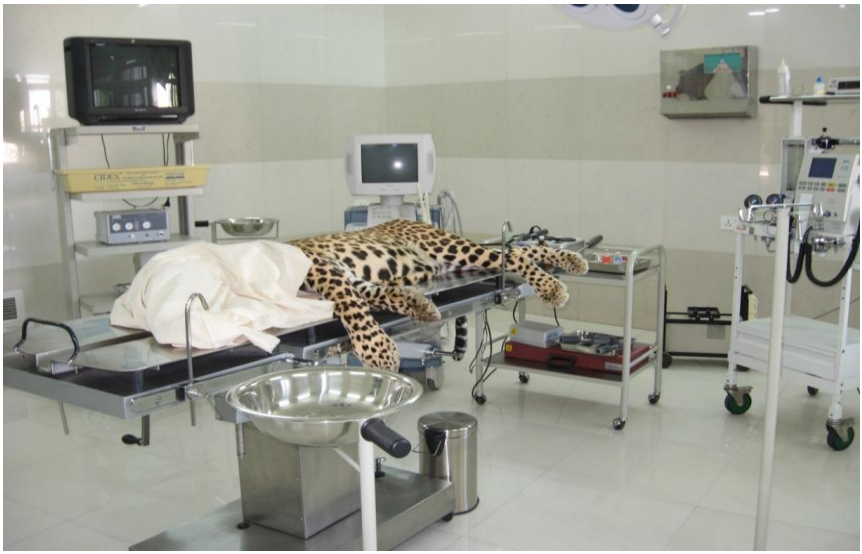


Figure 11: A State-of-art Operation Theatre at LaCONES equipped with modern instruments required for anaesthesia monitoring in wild animals. An anaesthetized Leopard is seen on the operation table before performing electroejaculation procedure (Photo- Sadanand Sontakke)

7. ANAESTHESIA IN WILD UNGULATES

Wild ungulates are very nervous and temperamental animals and therefore, chemical immobilization in wild ungulates may be associated with a high percentage of complications and fatalities. Several drugs, such as ketamine hydrochloride, xylazine hydrochloride, tiletamine, zolazepam, and medetomidine, have been routinely used to immobilize a number of wild animals. Of these, ketamine and xylazine are the most commonly used drugs that are readily available in India. Some of the recommended drugs in common wild ungulates are given in **Table 6 and 7**.

Table 6: Immobilization of large and small ungulates - Drug dosage for Sambar (*Rusa unicolor*), Barasingha (*Rucervus duvaucelii*) and Nilgai (*Boselaphus tragocamelus*)

Animal	Generic Name	Total content (mg/kg)	Total volume (ml)	Reference source
Sambar Deer (*Cervus unicolor*) and Barasingha	Etorphine + Xylazine	5- 8 500	5- 8 5	Seal 1976
Barasingha	Ketamine + Xylazine	200-250 250-312	2-2.5	Kotwal 1985
Sambar	Ketamine + Xylazine	80-160 100-200	0.8-1.6	Kotwal 1985
Sambar Male	Ketamine	210	2.1	WII

	+ Xylazine	 262	 2.6	Manual
Nilgai	Etorphine + Acepromazine	4.90-7.35 20- 30	2-3	WII Manual
Nilgai	Ketamine + Xylazine	100-180 125 - 225	1.0-1.8 1.2-2.2	Kotwal 1985
Nilgai Male	Ketamine + Xylazine	200 125	2.0 1.25	Sontakke SD (*personal comm*.)

Table 7: Immobilization of small wild ungulates

Animal	Generic Name	Total content (mg)	Total volume (ml)	Reference source
Spotted Deer (*Axis axis*) Adult male	Ketamine + Xylazine	100 20	1.0 0.2	Sontakke et al. 2007
Spotted Deer (*Axis axis*) Adult female	Ketamine + Xylazine	60 40	0.6 0.4	Sontakke et al. 2007
Spotted Deer (*Axis axis*) Adult female	Xylazine	350	3.5	Arnemo et al. 1993
Spotted Deer (*Axis axis*)	Ketamine + Xylazine	100 – 150 125 – 187	1.0 - 1.5 1.25 - 1.8	Kotwal 1985

Spotted Deer (*Axis axis*) Sub adult	Ketamine + Xylazine	30 39	0.30	Arora 1988
Spotted Deer (*Axis axis*) Adult	Ketamine + Xylazine	60 – 100 76 – 125	0.60 - 1.0 0.7 – 1.2	Arora 1988
Blackbuck (*Antilope cervicapra*)	Ketamine + Xylazine	50 25	0.5 0.2	Sontakke et al. 2009b
Blackbuck (*Antilope cervicapra*)	Ketamine + Xylazine	30 – 40 37 – 49	0.3 – 0.4	Arora 1988
Blackbuck (*Antilope cervicapra*)	Telazol	60	0.6	Kreeger et al. 2002
Blackbuck (*Antilope cervicapra*)	Ketamine + Xylazine	30 37	0.3	Kotwal 1985

Reversal of anaesthesia in wild ungulates

Wild ungulates are very sensitive and are easily prone to fatalities due to capture shock. Identifying a suitable antagonist for immediate recovery of the anaesthetic effect is equally important in wild ungulates so as to avoid hazards of regurgitation, aspiratory pneumonia, and distention of rumen in ungulates. Moreover, it is also important in free-ranging animals to avoid predation in the wild. For more than a decade, the authors from Laboratory for the Conservation of Endangered Species (LaCONES)-CCMB, Hyderabad, have

been working on Spotted deer (*Axis axis*) and Blackbuck (*Antelope cervicapra*) as models for critically endangered deer species and antelopes in India to develop various assisted reproductive technologies such as semen collection, ultrasonography for monitoring ovarian follicular response to oestrus synchronization regimes, they have optimized anaesthetic combinations as well as reversals in these species for easy handling and speedy recovery to avoid any distress and effect on their research experiments (**Table 8**).

Table 8: Recovery time of anesthetized Spotted deer after IV administration of yohimbine (n= 169 anaesthetic events; Adapted from Sontakke et al. 2007).

	Male		Female	
Duration of Anesthesia (Min)	No. of reversal attempts	Recovery time (min)	No of reversal attempts	Recovery time (min)
10 to 20	10	0.7 ± 0.1	22	0.7 ± 0.1
21 to 30	18	0.6 ± 0.1	10	0.6 ± 0.1
31 to 40	12	0.6 ± 0.1	8	0.6 ± 0.1

* Anesthetized by IM administration of a combination of 0.5 mg of xylazine/kg and 2.5 mg of ketamine/kg. †Anesthetized by IM administration of a combination of 1.0 mg of xylazine/kg and 1.5 mg of ketamine/kg.

However, we have also observed that yohimbine, which was suitable recovery of ketamine-xylazine anaesthesia in Spotted deer (*Axis axis*) (Sontakke et al. 2007) and also in Lion (*Panthera leo*.), Tiger (*Panthera tigris*) and Leopard (*Panthera pardus*) (Sontakke et al. 2009a), was found ineffective in Blackbuck. On the contrary, tolazoline, another alpha-2-adrenergic antagonist was found suitable for ketamine-xylazine anaesthesia in blackbuck and recovery was achieved within 1 minute of IV administration of tolazoline (Sontakke et al. 2009a **Table 9**)

Table 9: Comparative effectiveness of two alpha2-adrenergic antagonists on recovery of ketamine-xylazine induced anaesthesia in captive Blackbucks (adapted from Sontakke et al. 2009a)

Antagonists	Number of trials	Dose (mg kg^{-1})	Onset of arousal (min)	Recovery time (min)
Control	10	Saline	135.50 ± 0.20	157.30 ± 0.20
Yohimbine	9	0.15	130.60 ± 0.50	160.20 ± 0.70
	11	0.30	125.50 ± 0.40	155.90 ± 0.30
Tolazoline	19	1.00	0.62 ± 0.04	1.22 ± 0.04
	28	2.00	0.22 ± 0.02**	0.42 ± 0.03**

Both the antagonists and saline were administered intravenously by venipucture directly in to the Jugular vein. ** - indicates $P < 0.001$ (within the column)

Anaesthesia in other large herbivores

Immobilization in Large herbivores such as Elephant (*Elephas maximus*), Rhinoceros (*Rhinoceros unicornis*), Wild buffalo (*Bubalus arnee*) and Giraffe (*Giraffa camelopardalis*) etc. requires wide experience of handling these animals before undertaking any of these procedures. Some of the recommended doses of anaesthetics in these animals are given in the table below.

Table 10: Immobilization of large herbivores such as Elephant, Rhinoceros, Giraffe etc. in captivity or in free-ranging.

Species	Drugs	Total Content (mg)	Total volume (ml)	Reference
Elephant Male	Etorphine + Acepromazine	8 - 8.9 32 – 35	3.25 – 3.50	Sale et al. 1981) WII Manual
Elephant Female	Etorphine + Acepromazine	7.3 – 8.0 30 – 32	3.0 – 3.25	Sale et al. 1981) WII Manual
Rhinoceros	Etorphine + Acepromazine	2.45 – 4.90* 10 – 20	1.0 – 2.0	Sale et al. 1986) WII Manual
Rhinoceros	Etorphine	1.5 – 2.5	1.5 – 2.5	Seal 1976
Wild	Etorphine	5	5	Seal 1976

buffalo	+ Acepromazine	10	1	
Gaur	Etorphine + Acepromazine	8.0 – 10.0 10.0 – 25.0	8.0 – 10.0 1.0 – 2.5	Seal 1976
Giraffe	Etorphine	11	11	Snyder et al. 1992

8. HANDLING OF IMMOBILIZED ANIMALS

Once the animal is darted, immobilized animal should be under the expert care of an experienced wildlife veterinarian. The veterinarian needs to monitor the complete immobilization process and should know what to do if something goes wrong. Keep the darted animal in sight and allow the drug to act completely which may generally take 5-25 minutes depending on the species, sex, drug used, and body condition of animal. Any noise or excitement may cause immobilized animal to wake up or take flight which may make animal search difficult. Following lateral recumbency, check the animal for pedal and tail reflexes by prodding it lightly with a bamboo stick from the rear. Once confirmed of complete anaesthesia, approach the animal. The dart should be carefully removed from the site of injection, and intramammary preparations of antibiotics should be used for the treatment of mastitis which can be squeezed into the dart wound to counter infection and the possible formation of an abscess at the dart site. Animal body should also be thoroughly checked for any wound or abrasions that may have occurred during capture procedure and such wounds should be cleaned with antiseptic solution (e.g. povidone solution) and an antibiotic ointment should be applied.

Ruminants (ungulates) always suffer from bloat when immobilized for a long time. Therefore, they must always be rested on their sternum, with their limbs folded under their bodies and their head and neck held higher than their chest to avoid bloat. The head of the animal must be held upright and

usually one person is needed just for this task. The mouth must be lower than the rest of the head with tongue kept out of mouth so that any excess saliva can drain away, because the animal cannot swallow when immobilized. Immobilized animals should never be left in the sun for too long. When it is hot, shade should be provided or the animal must be carried to a shady tree. Large animals should be carried on a stretcher. In cold weather, blankets or sacks should be used to cover the body of the animal to prevent it from losing too much heat. Although animals should never be captured in hot weather, this sometimes happens in emergencies. This involves the danger that the immobilized animal may overheat. In such situation, the animal can be sprayed lightly with water to cause evaporation and cooling. Some animals do not close their eyes and cannot blink when they are immobilized. An eye ointment should be applied in the eyes to lubricate them and prevent them from drying out. A dark, soft blindfold over the eyes must be tied to prevent damage from dust and also the damage to the cornea. When an immobilized animal is transported over dusty roads, the eyes must also be protected by a blindfold. It is advisable not to make much noise near the immobilized animal as the animals can hear well while they are immobilized. As a precautionary measure against secondary bacterial infection, a dose of long-acting (LA) antibiotic such as Teramycin LA or Penicilin LA should be injected subcutaneously or intramuscularly after capture.

8.1 Physiological Monitoring of immobilized animals

Monitoring of immobilized animal is essential to determine changes in the physiological variables so as to

correct irreversible injury, ensure adequate anesthetic depth, and assess the effectiveness of supportive care, if required. Anesthetic monitoring requires solid understanding of normal and comparative physiology and anatomy, as well as the effects of immobilization and anaesthetic drugs. The techniques used in humans and domestic animals can also be applied to wildlife species. However, more research is necessary to validate the accuracy, sensitivity, and reliability of monitoring equipment in nondomestic species. The portable monitoring systems (e.g., pulse oximeter, blood gas and electrolyte analyzers) and technology to measure physiological variables offer opportunities to improve monitoring procedures in wild animals. Each anaesthetic event for individual animal should have a permanent record. Minimally, it includes examination and history findings, recent or estimated body weight, drugs used, start and finish of anaesthesia, endo-tracheal tube size, and problems encountered. Ideally, the anaesthetic record includes systematic recording of physiological variables throughout the anaesthetic procedure. The frequency of measurement or assessment is determined by the variable. For example, heart rate is assessed around every 5 minutes.

Anaesthetic depth: Depth is determined by the drugs, dosage, species, and physiological status. The presence of adequate muscle relaxation does not necessarily imply unconsciousness or analgesia (e.g., muscle relaxants). Corneal reflex and anal tone are usually present at surgical anaesthetic levels. In mammals, eye position often changes with anaesthetic level. This change can be validated as anaesthesia is deepened and lightened. A fixed dilated pupil,

unresponsive to light and with no corneal reflex is an indication of excessive anaesthetic depth or brainstem ischemia.

Body temperature: Measurement of body temperature using rectal thermometers is a standard procedure during all anaesthetic episodes. Thermometers made of glass should be avoided as it poses risk of breakage and rectal injury to animal. Digital thermometers are useful if they have a short measurement time. Thermometers should be able to read over a wide temperature range. Hypothermia is common in small animals because of the large surface area-to-volume ratio. Some of the drugs may suppress normal thermoregulatory mechanisms thereby causing hypothermia. On the other hand, hyperthermia is also common immediately after immobilization of both captive and free-living mammals because of excitement and struggling while darting.

Dehydration: Determination of relative hydration is difficult to interpret in wild animals because of the wide range of skin types and pattern in variety of wildlife species. Gently grasping a fold of skin and rolling it between fingers is a more reliable technique. Normally a hydrated skin moves easily, whereas in dehydrated animals, a “sticky” feeling exists. Dehydration also produces dry mucous membranes, sunken eyes, and decreased tear production. In dehydrated animals, the urine production usually decreases and specific gravity of urine is increased.

Respiration: Auscultation of lungs along with cardiac auscultation for evaluation of the respiratory system requires a good-quality stethoscope with appropriate head and length of

tubing. Usually during anaesthesia, respiratory rates lower down, although it depends on the anaesthetic used.

Cardiac function: The main function of the cardiovascular system is oxygen and nutrient delivery to tissues, and the removal of carbon dioxide and waste (e.g., lactate). Adequate cardiovascular function implies sufficient capillary flow to fulfill these functions. Unfortunately, no reliable, accurate, and effective way to measure capillary flow exists. Although cardiac output can be measured, it is not feasible for routine monitoring in Veterinary practice. Heart rate is an important determinant of cardiac output. Marked tachycardias, bradycardias, and arrhythmias can decrease blood flow.

Pulse Oximetry: Pulse oximetry is indicated for monitoring oxygen saturation (SpO_2) in the blood and for controlling external oxygen administration (**Fig. 12**). The latter allows for administration of the lowest concentration of inspired oxygen compatible with safe levels of arterial oxygenation. Commercial pulse oximeters also measure pulse rate. Pulse oximeters estimate arterial hemoglobin oxygen saturation by measuring pulsatile signals across (transmission) or by reflectance (reflection) from perfused tissue. Potential sites for placement of transmission pulse oximeter sensors include the ear, tongue, buccal mucosa, paw, vulva and tail. The oxygen saturation range is measured between 0 to 100% and level below 80% in the blood in considered as alarming. Accordingly the external oxygen needs to be supplied. Pulse oximeters require adequate plethysmographic pulsations to allow them to distinguish arterial light absorption; therefore, they are inaccurate in the presence of decreased blood pressure,

decreased pulse pressure, and vasoconstriction. The presence or absence of a pulse is quickly detected, but the presence of a pulse does not ensure adequate blood flow.

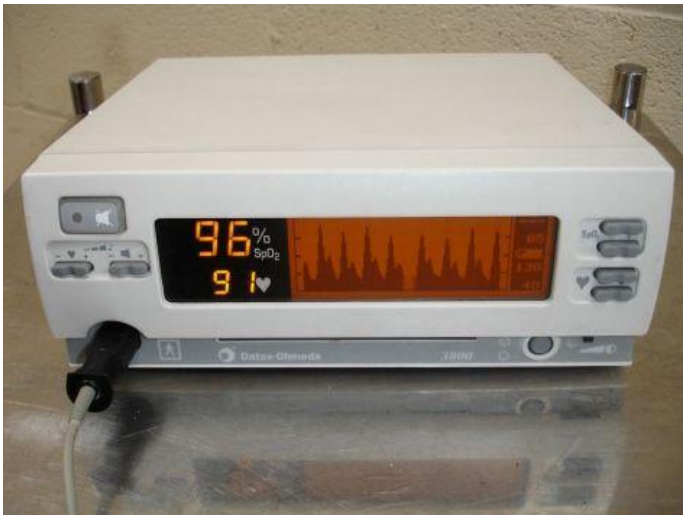


Figure 12: Pulse oximeter displaying oxygen saturation (SpO_2) in the blood and the pulse rate

Electrocardiography (ECG) monitoring: ECG is indicated for routine monitoring of cardiac function and whenever an abnormal pulse or arrhythmia is detected. The ECG monitor for human medicine can also be used for wildlife species. The ECG should have a multichannel oscilloscope with nonfade tracing and freeze capabilities. Also, it must be able to record at speeds of 100 mm/s and amplify the signal to at least 1 mV equal to 1 cm. The ECG of mammals resemble each other in general form, with clearly defined P, QRS, and T components. Standard lead positions described in cats and dogs can also be applied for wild animals. To improve signal detection,

stainless steel suture is passed through the skin and attached to the electrodes.

8.2 Safety precautions during immobilization

There is always an inherent risk to the animal as well as to the Veterinarian and associates during capture and handling of wild animals. Knowledge on safety and how to deal with accidents is an important part of animal capture. Following precautionary measures need to be taken to prevent drug accidents:

- Ensure that you are thoroughly trained in the use of capture drugs.
- Know basic first-aid techniques, including cardiopulmonary resuscitation.
- Before a capture operation, check your communications and transport infrastructure to ensure that you can respond quickly in an emergency.
- Use capture drugs only in the presence of a second person who is trained in their use and in the management of accidents.
- Respect the potency of these drugs – never take chances and never underestimate a potentially dangerous situation.
- Always concentrate on what you are doing, and work in an orderly fashion.
- Never eat, drink, smoke, or rub your eyes when working with capture drugs.
- If you have cuts or abrasions on your hands, put a plaster on the affected area or wear gloves.

- Be careful never to inhale drugs that are in powder or aerosol form.
- Never work with opioid drugs in a moving vehicle; exercise extreme care in a helicopter.
- Never work with opioid drugs without having the human antidote at hand in the first-aid kit or emergency kit.
- Take extreme care with loaded darts. Carry them in a container. Darts that work with compressed air or gas, or with a spring, should only be armed immediately before use.
- Always keep basic notes on capture drugs and emergency treatment, as well as emergency telephone numbers, in your drug box, first-aid kit and emergency kit.
- Sufficient quantities of water should always be available to wash off spilt or splashed drugs.

First-Aid Kit during immobilization procedures

Equipment:

- Record book and history sheet, if available
- Stethoscope
- Digital Thermometer
- Tourniquet
- Oxygen cylinder with face mask and connector
- Disposable syringes of varying sizes
- Hypodermic needles – 18G (1,2 mm) and 21G (0,8 mm)
- IV drip sets and catheter
- Sterile IV cannulas – 21G (0.8 mm)
- Sterile Normal saline solution and Ringer's lactate solution for IV use
- Elastoplast and scissors

Drugs:

- A bottle of naltrexone (50 mg/ml)
- 250 mg hydrocortisone
- 40 mg diazepam
- 5 mg atropine
- 20 mg adrenaline
- 10 mg neostigmine if working with gallamine
- Doxapram hydrochloride

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