CHEMICAL IMMOBILIZATION OF THE BLACK RHINOCEROS (*Diceros bicornis*)

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Abstract: Details are provided of the equipment and techniques necessary for the chemical immobilization of free-ranging and captive black rhinoceros *Diceros bicornis*. Emphasis is placed on the practical aspects of immobilization and post-capture management. A basic dose of 4 mg etotphine plus 100 mg xylazine or 250 mg azaperone plus 1500 IU hyaluronidase is recommended for an adult black rhino in good condition.

INTRODUCTION

Black rhino *Diceros bicornis* belong to the Rhinocerotidae, one of the three surviving families of the order Perissodactyla (odd-toed ungulates)[36]. The other two surviving families are the Equidae (horses and asses) and the Tapiridae (tapirs). Black rhino once ranged widely through the savannas of sub-Saharan Africa but hunting and habitat destruction have pushed the species to the brink of extinction - less than 2 500 black rhino remain in Africa. Black rhino are browsers. They are usually solitary and generally hostile when disturbed. Adult black rhino weight up to 1 300 kg, stand about 1,6m at the shoulder and have a thick skin (up to 32mm)[28]. In common with the equids they are hindgut fermenters and sweat after heavy exertion[23].

Chemical immobilization is an essential tool for the management of this endangered species, especially for translocation, treatment of injuries, marking and dehorning. Until the early 1960's black rhino were still physically caught with ropes from a pursuing vehicle[29]. Chemical capture was first attempted with the dissociative anaesthetic, phencyclidine[21], and the curariform muscle relaxant, gallamine triethiodide[2,11]. In 1960, during Operation Noah, many black rhino were saved from the rising waters of the newly built Lake Kariba, between Zambia and Zimbabwe, with these new chemical capture techniques[2,3,11]. Phencyclidine and gallamine were succeeded by the opioids which were considerably safer and easily reversed. The opioids Themalon (diethylthiambutene) and morphine were used initially[3] but were soon replaced by the considerably more powerful drugs; etorphine (M99)[2,14,16,19,21,22], fentanyl[8] and carfentanil[16,17,18].

Black rhino are good candidates for chemical immobilization[23,34]. If darted correctly, with the right drugs, at the right dose, induction is quick and predictable, excitement is minimal, and the vital functions are well maintained. Nevertheless, for a number of reasons including their large size, aggressive nature, tendency to frequent thick bush in often rough terrain, thick skin and their inclination to run into obstacles while semi-narcotized, immobilizing black rhino is not without problems and should only be done by people with suitable experience.

TECHNIQUE

Besides the drugs and darting equipment it is prudent to have the following before immobilizing a black rhino:

- at least 6 people to move/roll the immobilized rhino if necessary.
- at least 25ℓ of water
- 10 meters of strong nylon rope
- a towel or suitable dark cloth to cover the eyes.

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* axe, pangas, saws etc. to clear obstructing vegetation.

Darting

Darting free-ranging black rhino on foot is slower than darting from a helicopter and poses greater risks to the rhino[26] and the person darting the rhino. When darting black rhino on foot, the first opportunity to dart the animal is inevitably the best[7] for once a black rhino is frightened by an unsuccessful darting attempt it is alert and difficult to approach. Although rhino have relatively poor eyesight their sense of smell and hearing is acute and care must be taken when stalking them. Oxpeckers (*Buphagus* spp) are often associated with rhino and are quick to alert the animal to human presence. When darting on foot the shoulder or hindquarters offer the best targets - do not dart too high on the rump or the dart will tend to be deflected. The dart should be placed squarely for deep intramuscular injection[22] (the thick skin of a rhino often makes and angled shot ineffective). Black rhino usually run off after being hit by a dart.

Nowadays most black rhino are immobilized from a helicopter. The advantages of using a helicopter are:

* rhino can be easily located
* rhino can be driven to better terrain before darting
* darting is quick and easy
* there is some control over the rhino during induction[14]
* it is easy to get to an immobilized rhino quickly
* the recovery crew can be directed to the recumbent rhino from the helicopter[20]

When guiding a rhino to better terrain with the helicopter before darting, care should be taken not to push the animal too hard.

Ambient temperature

Immobilizing rhino at high ambient temperatures usually results in elevated body temperatures and increased physiological stress. For this reason most rhino capture is done the early morning or late afternoon in the winter months[27] when temperatures are less than 25°C and humidity is low. If working in the afternoon don't dart a rhino unless there is at least an hour of light left. If a rhino is dark with sweat it's temperature will be above 39°C and such an animal should not be darted (or, if already darted, it must be doused with water and processed quickly).

Cow and calf

When darting a cow with a young calf (to be avoided if possible, especially if the calf is unweaned) it is best to dart the cow first. The calf will usually stay close to its immobilized mother. If approached carefully on foot (when working from a helicopter land some distance away) the calf can be darted and will usually go down close to its mother (black rhino calves are skittish and run off more easily than white rhino calves). The other option is to dart the calf from the helicopter once the cow is recumbent. In this case the disturbance caused by the helicopter will usually result in the calf going down some distance away from its mother.

Darting equipment

A robust and reliable darting system (eg Cap-Chur™) must be used when darting free-ranging black rhino. The projector must have sufficient power to project a relatively heavy dart with a straight trajectory but the dart must not hit with excessive force. There are numerous suitable projectors on the market which work with powder or compressed gas. In a captive situation a lighter darting system (eg Dan-inject™) can be used with success. A spare dart gun and a push rod (to remove a dart from the barrel) must always be available. The dart must be robust enough to withstand the force of impact[26]. The dart needle should be 6-7cm long for adult rhino. Rhino skin easily plugs the lumen of a dart needle[12] and to prevent this the needle tip must be bent over (as done with the Fauncap darts) or the needle point must be sealed and side ports provided or the needle must have a relatively thick wall and narrow lumen (as with the Cap-Chur NCL needles). The needle must be provided with a bead, low barb or small collar 25mm from the needle base to hold the dart in the thick skin.

Dart placement

When darting from the helicopter the muscles of the rump or the upper part of the hind leg offer the best target. In the boma any large muscle mass can be used for dart placement although the neck is preferable. Occasionally in open country black rhino can be darted from a chase vehicle and in this situation the upper part of hind leg presents the best dart site.

Choice and dose of immobilizing drugs

It is best to make up a dart once you have seen the rhino and you can tailor the dose for that specific animal. Four milligrams of etorphine M99) + 100 mg xylazine (Rompun®) or 250 mg azaperone, is a good standard dose for an adult black rhino bull or cow in good condition. Young animals must be given a scaled down dose. For example a half size calf about 2,5 years old can be given 2 mg etorphine and 50 mg xylazine or 125 mg azaperone. Very young calves (2 - 3 months) can be immobilized with as little as 0.2 mg etorphine either alone or with a small amount of tranquillizer. The addition of 1500 IU of the spreading agent hyaluronidase will improve drug absorption and shorten the induction time[26 32]. Xylazine in mixture results in a slightly quicker induction and more salivation (not a problem) than azaperone. Azaperone should be used in preference to xylazine when immobilizing black rhino in bomas as xylazine tends to have too profound an effect on these animals. The dose given above will result in quick induction and is useful when working in rugged terrain or in hot conditions. A lower dose may be used for rhino which are in bomas, debilitated, old or in situations where you can not get to the immobilized animal quickly (when darting on foot). There appears to be a slight difference in the dose needed for the various sub-species. The larger South-Western sub-species *Diceros bicornis bicornis* needs a slightly higher dose than the other sub-species. While 4,5 or even 5 mg etorphine may be necessary for an adult *D.b.bicornis* bull in good condition, 4 mg is usually adequate for a similar response in a comparable animal of the *D.b.minor* or *D.b.michaeli* sub-species.

Induction time

With the above dose, and with good dart placement, induction should be between 2,5 and 6 minutes. With the recommended combinations induction is smooth and muscle relaxation good. Induction is quicker in young rhino and may be longer in large bulls and heavily pregnant cows. If there are no effects at eight minutes the rhino should be darted again. Extremely quick induction times of less than 2 min 30 sec may indicate of an overdose and it is important to get to such an animal quickly so that the respiration and other vital functions can be monitored (and nalorphine and doxapram given if necessary).

Effects of immobilizing drugs & recumbent position

As a rhino becomes affected by etorphine its pace shortens, the feet are lifted higher ("Hackney gait"), and the head is elevated. The rhino then starts to blunder through bushes and slows down (may circle) before going down into lateral or sternal recumbency. They are often stopped by an obstacle, eg. bush or a fork of a tree etc. In rough terrain rhino have a tendency to run downhill once they are heavily affected and easily injure themselves by running into a gully, river etc[5 16 18 19]. With a quick induction rhino tend to go down in sternal recumbency. This is the safest position for an immobilized rhino. Occasionally the forelegs collapse first and the hind quarters remain elevated. In this situation the full weight of the abdominal organs press on the diaphragm and respiration can be seriously affected. The rhino must immediately be pushed to its side and then back onto its sternum. If it is necessary to draw blood do it from the medical carpal vein on the inside of the fore leg[31] while the rhino is in lateral recumbency, and then roll the animal onto its sternum.

Monitoring

It is essential to work quickly while the rhino is recumbent and it helps to have a prioritized check list. A thorough clinical examination must be done as soon as you get to the rhino and the vital functions (respiration, temperature, heart rate, capillary refill) evaluated, and re-evaluated, as long as the rhino is recumbent. The first 10 minutes of recumbency, until the rhino has stabilized, are the most critical. Concentrate on respiration, temperature and heart rate in that order. These functions are very much a function of the degree of exertion and excitement before and during induction and this must be kept in mind during your evaluation of them. Careful monitoring is especially important in old debilitated, very young and heavily pregnant animals. Additional people can be used to help with monitoring - especially respiration. If it was necessary to use more than one dart check if all the dart contents were injected. This is important for monitoring the animal and for deciding on how much antidote to give. Pulse oximetry is a valuable new tool to help monitor blood oxygenation and pulse in a recumbent rhino. The sensor can be attached to the rhino's ear.

Eyes and ears

Cover the eyes of the recumbent rhino with a suitable cloth to prevent damage to the retina from direct sunlight and to keep dirt out of the eyes[8 13]. Saline can be used to wash any dirt out of the eyes and artificial tears or a bland eye ointment can be applied to keep the eyes moist. If a noisy procedure is to be done eg. dehorning with a chain saw, it helps to block the ears with a cloth (remember to remove the cloth!).

Respiration

Respiratory rate and depth is the most important function to be monitored in the immobilized rhino. Respiration is best monitored by watching the chest movement or, in the case of an immobilized rhino being transported on a sledge where it is difficult to watch chest movement, a hand close to the nostrils can sense the warm exhaled air. Breathing must be deep and regular. Monitor respiration for at least 30 seconds to get an accurate picture as an immobilized rhino often gives two or three quick breaths and then holds its breath for a short time. Respiratory rate is about 10-15 breaths/minute on induction, going down to 4-8 breaths/minute about 10 minutes post induction (may increase again slightly). Nalorphine given intravenously at 10-15 mg results in a marked and sustained improvement in the quality of respiration. 5-10 mℓ doxapram (Dopram[R]) IV will also give an improvement in respiratory rate and depth but it only lasts for 10-15 minutes and may result in some muscle tremor. A healthy pink colour of the mucus membranes is an indicator of good blood oxygenation.

Body temperature

Body temperature is an important parameter to be monitored in the immobilized black rhino and the best indicator of the degree of exertion before and during induction. It is important to remember that rhino are thermolabile and their body temperature varies slightly during the day as the ambient temperature changes[28]. Black rhino immobilized without excessive exertion have a rectal temperature of between 36 and 39°C. A black rhino immobilized with minimal exertion (eg in a boma) on a cold winters morning may have a temperature as low as 35,5-36°C, while a rhino immobilized with moderate exertion on a hot afternoon can have a temperature of 39,5°C. Young rhino tend to have a higher body temperature than adult rhino after running a comparable distance. There is usually a slight increase (0,3-0,5°C) in rectal temperature a few minutes after induction as the heat moves from the musculature to the general circulation. An animal with a body temperature of greater than 38,5°C must be doused with water to cool it down. Dousing with water is important but there is considerable thermal inertia in an animal as big as a rhino and dousing with water will not have a dramatic effect in lowering the body temperature. Making shade for a recumbent rhino will also help to keep the temperature down. A rhino with a temperature over 39,5° must be processed as quickly as possible (consider only doing the priority tasks). A body temperature of greater than 41°C indicates marked exertion and immediate antagonism should be considered.

Heart rate

Heart rate is best obtained using a stethoscope, by feeling the artery under the base of the tail (caudal artery) or on the inside of the ear (medical auricular artery), or by putting a flat hand on the chest over the heart. The heart rate is usually 55-80 beats/minute although it will be higher in rhino which have undergone marked exertion especially in young animals (as much as 140/minute). The capillary refill time (indicator or peripheral perfusion) must be checked on the gums and should not be more than 2 seconds.

Dart wound

Darts are best removed by twisting (stick to one direction) and pulling at the same time. The dart wound must be treated with an antiseptic or broad spectrum antibiotic - a mastitis ointment or 5 mℓ of a 200mg/mℓ oxytetracycline solution injected into the dart wound. The rhino should also receive a medium and long acting penicillin combination eg. Compropen[R 16].

Drawing blood

The medial carpal vein on the inside of the fore leg is the best place to draw blood[31]. This vein is easily accessible in rhino in lateral recumbency especially if a tourniquet is used. With a rhino in sternal recumbency this vein can also be found with practice or otherwise use one of the ear veins. Note the colour of the venous blood drawn as it is an excellent indicator of blood oxygenation.

Additional tasks

While the rhino is recumbent numerous other tasks must often be done, eg. giving azaperone for tranquillization during transport (best to give at least 10 min before waking up), ear notching, implanting transponders (under skin and in horn), applying an acaricide, injecting long acting neuroleptics and mineral and vitamin preps, horn tipping, collecting parasites and faecal samples, taking measurements etc. It is important to prioritize these tasks and to delegate wherever possible. Detailed records of every immobilization must also be kept to evaluate and improve techniques.

Antidote

Diprenorphine (M5050) is the antidote of choice for etorphine and must be given intravenously at 2-2,5 times the dose of etorphine used. Nalorphine is rarely used any more to provide complete antagonism of the black rhino although it remains a useful drug to partially antagonize the effects of etorphine either to improve respiration (10-15mg) or walk a black rhino (30-40 mg). Preliminary work with the mixed agonist-antagonist opioid nalbuphine (Nubain[R]) has shown that it too is useful for improving respiration (at about 20mg IV). Naltrexone (50mg/1mg etorphine) can also be used to antagonize the effects of etorphine, fentanyl (5mg/1mg fentanyl) and carfentanil (100mg/1mg carfentanil). Because of the problems with the antagonism of carfentanil, naltrexone is the antagonist of choice for this drug. Antidotes are best given intravenously in rhino as response after intramuscular injection is often slow and incomplete. After receiving the antidote intravenously the rhino will stand up after about 60-80 seconds. Response to the antidote is first seen as an increase in the depth and rate of respiration and movement of the ears and eyes. Black rhino get to their feet fast and are immediately strong and aggressive[12 33]. Black rhino appear to be even more lively and aggressive after being antidoted with naltrexone. A rhino should be placed in sternal recumbency before giving the antidote or it will bash its head on the ground as it attempts to get up. Re-narcotization is not usually a problem in black rhino.

Other drugs and doses for immobilization

Black rhino can also be immobilized with carfentanil, fentanyl and fentanyl + etorphine. The following are doses of these drugs for adult free-ranging black rhino in good condition:

- 2,5-3 mg carfentanil[17 18]
- 1,8mg etorphine + 30mg fentanyl + 100mg xylazine[26] or 250mg azaperone.
- 60mg fentanyl + 200mg azaperone[8] or 100mg xylazine.

Carfentanil gives a quick induction and it is not necessary to add azaperone or xylazine. Carfentanil must be reversed with naltrexone at 100mg/1mg carfentanil. 10mg detomidine (Domesedan[R]) can be used instead of 100mg xylazine or 250mg azaperone. I have found no advantages in using detomidine and neither have I found any advantage in using an etorphine + fentanyl combination.

DISCUSSION

A relatively high dose of etorphine, combined with azaperone or xylazine, and hyaluronidase ensures a quick induction with minimal exertion and stress[26]. A quick induction shortens the period the rhino is moving in a semi-narocotized state and thereby lessens the chance that the rhino will injure itself by running into a gully, river etc.[5 15 16 19]. This is especially useful when immobilizing black rhino in rough terrain. A quick induction also limits the amount of exertion and thereby the physiological stress associated with hyperthermia, tachycardia, increased oxygen consumption[5 8 23 26] etc. The negative side is that respiratory depression increases with the dose of opioid used. However, at the doses of etorphine recommended respiratory depression is not excessive and blood oxygenation remains good in healthy animals. I think these doses are a good compromise between the problems of using too little and too much etorphine.

Pulse oximetry has shown that blood oxygenation is better when an immobilized rhino is kept in sternal rather than in lateral recumbency[33]. Loss of ventilated lung volume, ventilation perfusion mismatching and pulmonary vascular shunting are known problems with anaesthetized animals in lateral recumbency[9 30]. Be this as it may, the fact remains that hundreds of black rhino have been transported in lateral recumbency with remarkably few problems[1 2 8 11 21 22 25]. Transient and permanent radial paralysis of the fore legs has however occurred in a few rhino kept in lateral recumbency for a number of hours 21. Being hindgut fermenters bloat is not a problem and regurgitation of stomach contents is rare. Rhino kept in sternal recumbency for more than 30 minutes often stand up with some lameness (poor circulation to the legs especially the hind leg carrying most of the recumbent rhino's weight) and in this position rhino should be shifted from the one side to the other every half hour.

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