ASSOCIATION OF VETERINARY ANAESTHETISTS

AUTUMN MEETING 2004 VIENNA

Training Day for Residents

Wild animal immobilisation

15. September 2004

Vienna, 15 September 2004

Dear friends and colleagues,

I am delighted to be able to welcome you as participants of the Training Day for Residents organised under the wings of the Association of Veterinary Anaesthetists. There are two meetings of the AVA a year, and as the European College of Veterinary Anaesthesia pointed out about five years ago these meetings offer an excellent and practical opportunity to organise in- depth continuing education for ECVA residents and other vets specialising in the field of veterinary anaesthesia. This initiative has now become tradition and always attracts a high number of delegates. Here in Vienna the Training Day is organized in collaboration with the Research Institute of Wildlife Ecology. We are proud to present an excellent team of experts in the field to make this for you a very informative and exciting day!

On behalf of all of the Viennese anaesthetic team

Yves Moens

Content

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The AVA would like to thank the following companies who have generously supported this Training day and without whom it could not have happened:

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2. Timetable

Research Institute of wildlife ecology Wilhelminenberg

07:30 – 08:30
Registration and Bustransfer

8:30 - 09:30
R. Korbel: Monitoring in bird anaesthesia, airsac perfusion anaesthesia

09:30 - 10:30
S. Wenger: Pharmacology in wild life immobilisation

10:30 - 11:00
Coffee break

11:00 - 12:00
W. Zenker: The procedure of wild animal immobilisation: in theory and practice

12:00 - 13:30
Lunch

13:30 - 14:00
Ch. Walzer: Anaesthesia in rhinoceros

14:00 - 15:00:
C. WalzerS. Wenger W. Zenker: Case reports

15:00 - 17:00
Practical training

Institut für Geflügelkrankheiten
Ludwig-Maximilians-Universität München

Clinic for Birds
University Ludwig-Maximilian Munich

AIRSAC PERFUSION ANAESTHESIA (APA) AND ANAESTHESIA MONITORING IN BIRDS

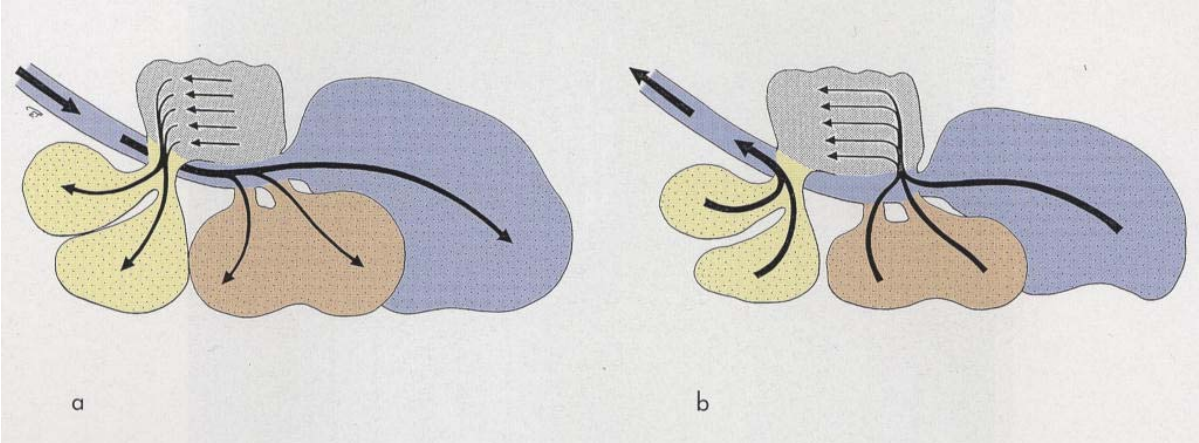
R. Korbel, Prof. Dr. habil, Dipl ECAMS

I. Air Sac Perfusion Anaesthesia (APA)

Air sac perfusion anaesthesia (APA) is an anaesthetic procedure that has been developed for surgery in the head area and for ophthalmological procedures in birds (KORBEL et al. 1993, 1995, 1996, 1997). In contrast to conventional head chamber inhalation anaesthesia, it ensures free surgical access to the head and neck, and is thus suitable for surgery in the head area, including the oral cavity the upper gastrointestinal tract. Furthermore, APA is an integral element of avian ophthalmological investigations for preventing excitation shock during protracted examination methods (e.g. Shirmer tear test, [KORBEL and LEITENSTORFER 1995] Electroretinography [KORBEL and STÜTZ 1997] gonioscopy [KORBEL et al. 1998]) and fluorescein angiography (KORBEL et al. 2000). It is also particularly suitable for anaesthetic induction of mydriasis as a preliminary to routine ophthalmoscopy (fundoscopy) because mydriatics commonly used in mammalian ophthalmology are ineffective in birds on account of the striated intraocular muscles(KORBEL in preparation) and as other invasive techniques using muscle relaxants (Murphy 1987) bear certain risks

APA is making use of the specific anatomical peculiarities in birds with the relatively small lungs but assisted by an airsac system (Korbel 2004).

Fig. 1: Air pathways in birds during inspiration (a) and expiration (b) in birds showing the lung, cranial thoracic airsac group with the cervical and claviculuar airsac (yellow), the cranial and coudal thoracic airsac (red) and abdomimal airsac (blue). In principal all of them may be used for airsac perfusion anaesthesia but causing varying efficacy.

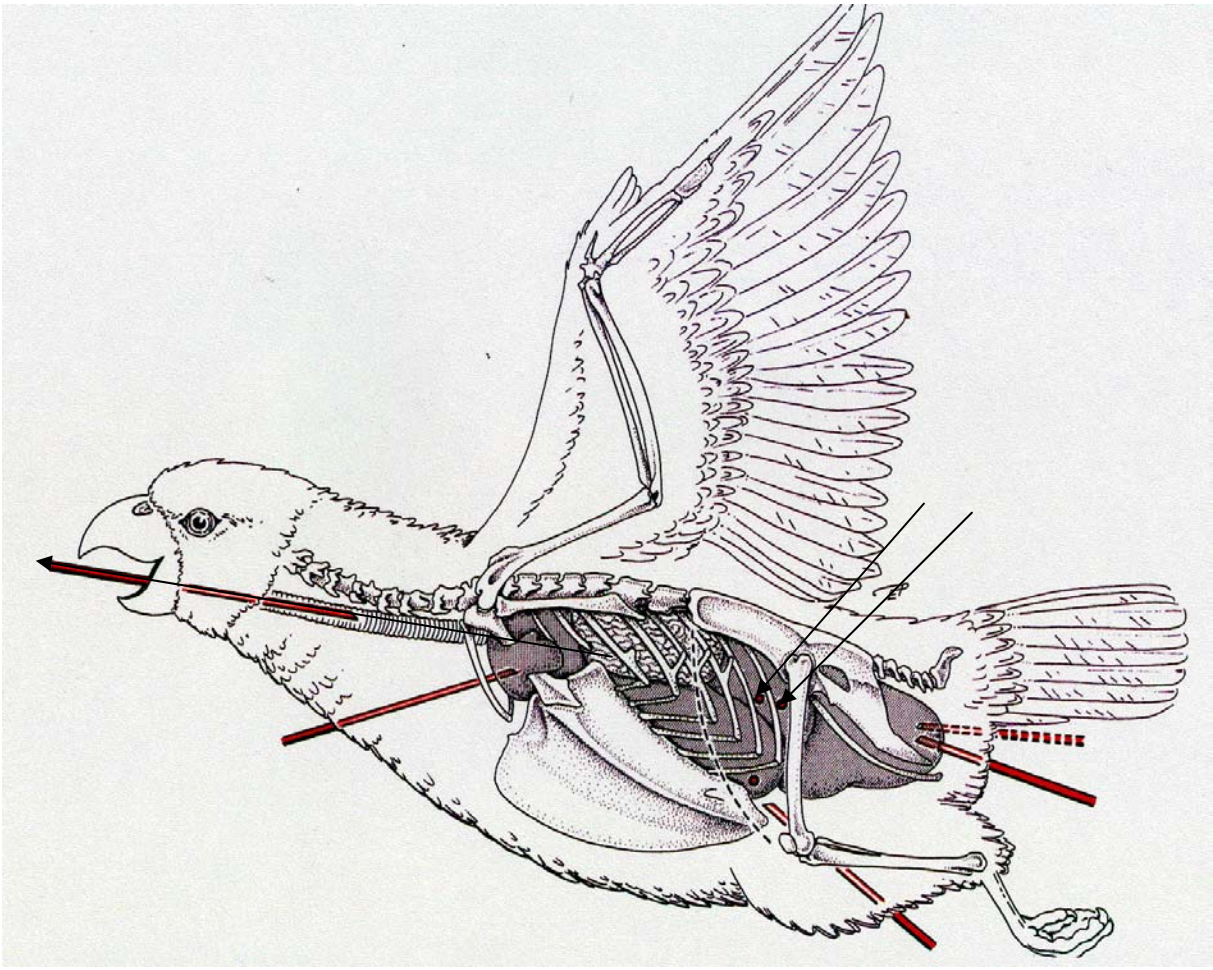


APA is conducted by retrograde perfusion of the lung-air sac system with an isoflurane-nitrous oxide mixture through a special air sac catheter which is introduced into the left caudal thoracic air sac. The required puncture of the airsac is performed under conventional head chamber inhalation anaesthesia analogously to the procedure for endoscopic sex determination. After having a skin incision of about 3 to 4 mm long along the cranial border of the thigh (sartorius muscle) on one side, and in the middle of the femoral shaft on the other, the left caudal airsac is punctured by blunt perforation of the intercostal muscles and fascia or of the last intercostal space, or behind the last rib using angled blunt forceps. The subsequently introduced sterilisable Korbel polyurethane airsac catheter (COOK Inc.), with an overall length of 100 cm and fitted with a standard Dräger connector for easy adaptation to standard respiratory gas tubing systems, has a diameter of 2 mm and a number of lateral openings at the tip to avoid obstruction by the airsac. In addition, the first 6 cm of the catheter are graduated (1 mark equal to 0.5 cm) to give the surgeon an indication of the penetration depth into the air sac. The tip of the catheter, which has an exactly defined flexibility, is rounded to prevent injury of the air sac walls and other internal organs. In contrast to other types of catheter, the Korbel air sac perfusion catheter is suitable for universal use in almost all fancy and predatory birds weighing from 30 to 5000 g treated in veterinary practices. The puncture site in the thoracic wall is sealed by drawing together a purse-string cutaneous suture inserted before the procedure. For switching from conventional head chamber administration to air sac perfusion anaesthesia, the carrier gas-perfusion volume (oxygen - nitrous oxide mixture 1:1) is reduced to 0.3 l/min/kg body weight to ensure a virtually

physiological blood pH. Higher perfusion volumes increase CO_2 wash-out and thus cause hypocapnic alkalosis with associated cardiac arrhythmias. After about 8 to 15 seconds APA induces APA-specific reversible apnoea which is attributable to perfusion-induced, subphysiological arterial CO_2 partial pressure ($PaCO_2$) with loss of stimulation of the respiratory centre. For example, the minimum $PaCO_2$ measurable by pulse oximetry for stimulating the respiratory centre in domestic pigeons (Columba livia var. domestica, Gmel., 1789) is 38 mmHg. By using a modified anaesthesia machine with integral low-flow measuring columns (minimal flow 0.01 l/min), APA can be used for birds with a body weight as low as 30 g (e.g. budgerigars). The low-flow flowmeter can be used as an exact measuring instrument for ensuring unimpeded perfusion of the lung-air sac system. Thus a slight or complete fall of the bobbin indicates partial or complete obstruction of perfusion which may be due to blockage of the catheter tip by massive adhesions with blood or inflammatory products or kinking due to inserting the catheter too deeply. Any subcutaneous emphysema that develops immediately after switching to air sac perfusion is generally due to malpositioning of the air sac catheter, excessive perfusion volume, or obstruction within the lung-air sac system.

Fig. 1:

Air sac perfusion anaesthesia (APA) with an isoflurane-oxygene-nitrous oxide-mixture using an isoflurane-oxygen-nitrous oxide-mixture applicated via a specially designed air sac catheter inserted into the left caudal thoracid air sac to archive a free surgical access to the head for head area and eye surgerey, to immobilisate of the patient and to induce a ophthalmoscopically useful (here: binocular indirect ophthalmoscopy) mydriasis in a domestic pigeon (Columba livia Gmel., 1789, var. dom.). Application site for airsac catheter as incicated with arrows between the last two ribs or alternatively behind the last rib. The entrance site is located by finding the dorsal third on a line between the hip and the knee joint of the caudally retracted left leg and finding the cranial conture of the sartorius muscle. Routine anaesthesia monitoring using pulsoximetry using pedriatical probes located above the M. gastrocnemius, electrocardiography and cloacal temperature probe. (Fig. taken from: Korbel R. Endoskopie bei Vögeln. In: König H, Liebich HG: Anatomie und Propädeutik des Geflügels. Stuttgart, New York: Schattauer 2000.)



The isoflurane concentration required for maintaining surgical tolerance is slightly higher than with conventional head chamber administration. Thus different species-specific isoflurane concentrations are required, ranging from 1.0 ± 0.2 (e.g. Alexandrine Parakeet (Psittaula eupatria L., 1766) to 2.4 ± 0.2 Vol.% (e.g. domestic pigeons (Columba livia L., 1789, var. domestica).

The carrier gas / anaesthetic mixture that escapes through the beak and nostrils should be scavenged by an extractor integrated in the operating table. The addition of nitrous oxide to the carrier gas (caution! danger of emphysema in birds with “air sacs” without open communication to the lung-air sac system, e.g. pelicans), potentiates isoflurane by around 11% (KORBEL et al. 1996).

APA is ended by interrupting the flow of isoflurane and nitrous oxide. However, the bird is perfused with pure oxygen for a further four minutes to shorten the recovery phase by rapidly washing isoflurane out of the airsac system and preventing nitrous oxide diffusion hypoxia. On average, spontaneous respiration restarts 3 to 3.5 minutes after ending O_2 perfusion once physiological CO_2 partial pressure is restored and stimulates the respiratory centre. Therefore, the patient is occasionally awake, but not breathing. Immediate induction of spontaneous respiration after ending APA is possible by adding 1% CO_2 to the respiratory gases, i.e. increasing the $PaCO_2$.

Due to the lack of spontaneous respiration and absent peripheral tendon and ocular reflexes (or local anaesthesia for eye surgery), pulse oximetry is obligatory for monitoring anaesthesia (KORBEL et al. 1997) during APA (sensors applied to the lower leg over the gastrocnemius muscle). In order to avoid an excessive infusion-induced drop in body temperature, a (heated) respiratory gas humidifier is used to avoid cooling by condensation off the large surface area of the airsacs (BENEDIKT et al. 1998) in addition to exogenous heat from a heated pad.

Besides its controllability and suitability for long-term anaesthesia, the special benefit of APA compared with conventional head chamber anaesthesia is free surgical access to the head and a reduction in the isoflurane consumption (and thus sparing the surgical team expired anaesthetic gases) by a factor of 5 to 7. The reversible apnoea achieves complete immobilisation of the patient - particularly beneficial for microsurgical procedures. Furthermore, a stable reduction in intraocular pressure (IOP) by a mean 20% (from 14.8 ± 2.1 mmHg [domestic pigeons] or from 16.0 ± 3.0 mmHg to 12.9 ± 2.1 or 11.6 ± 2.4 mmHg [common buzzards]) is achieved, which is essential for intraocular surgery.

II. Avian Anaesthesia Monitoring

Routine anaesthesia monitoring in birds includes:

- reflex status
- body temperature
- respiration
- pulsoximetry
- electrocardiography
- (blood gas analysis)

Routine reflex status asessment is performed using the standardised reflex score chart for birds (Korbel 1997, 2004). The Gudel scheme used in mammals may not be used for determinating the depth of anaesthesia in birds. For this purpose rather a standised reflex score chart has to be used. The score chart ranges from 0 points with a bird showing no reflexes (surgical status with the corneal reflexes missing due to topical anaesthesia for example in ophthalmological procedures) and 27 points in a fully awakened patient. Target score for surgical depth of anaesthesia (tolerance status) is 2 to 4 points, with a fully triggerable corneal reflex, 50 – 75 % mydriasis and slightly present papillary response to light stimulation (Nota bene: striated rather than smooth internal ocular musculature in the avian eye and thus reflexes under voluntary control).

Body temperature during anaesthesia should never exceed temperatures 1,5 °C below physiological body temperature, i. e. usually above 40 °C in pet birds. For evaluation used best a cloacal or better oesophageal temperature probe with 0.1 °C scale and short reading times. The Electrotherm TM 99 A (Vet. Speciality Prod./USA) is used is a well established unit in avian medicine. For body temperature support the carrier gas should be humidified using a “gas washing bottle” rising humidity of the carrier gas up to approx. 70 %. Exogen heating is provided using a heat cushion or even better a heated fluid or air system (for example Biar Hugger System/USA).

Using isoflurane inhalation anaesthesia in birds **endotracheal intubation and ventilation systems** should be used under all circumstances to ensure controlled respiration in situation of respiratory arrest. For controlled respiration pressure

controlled systems have to be used (Vetronics Ventilator Services/GB) with a maximum of 12 - 15 cm H_20 (Korbel 2004) rather than using volume controlled systems (as used in the Hallowell Anaesthesia unit), as these include the risk for severe problems following for airsac rupture.

Pulseoximetry and **electrocardiography** is used for routine purposes and is indispensable in air sac perfusion anaesthesia to monitor the patient, as under this condition performing ophthalmological procedures the reflex score is zero and as respiratory movements fade due to CO_2-washout effects. Pulsoximeter units for birds have to include the capacity detecting high heart rates frequencies above 300 to 500 beats/min (Nellcor NP 20 sytems and others). Pedriatric sensors may be used to be positioned above the gastrocnemius muscle. Cloacal probes are advantageous for avoiding movement induced artefacts.

Tab. 1: Standard reflex score chart for birds

REFLEXSTATUS (SCORE)	TRIGGERING AND EVALUATION OF REFLEXES
1. LID OPENING	
0 = Lid fissure closed 1 = Lid fissure partial closed 2 = Lid fissure open	Beurteilt wird der Zustand der Lidspalte. Mit zunehmender Narkosetiefe wird von einem Schluß der Lidspalte ausgegangen.
2. PALPEBRAL REFLEX	
0 = Reflex absent 1 = Reflex present, without head movment 2 = Reflex present; with head movements	Die Reflexauslösung erfolgt mit einem trockenen Wattetupfer durch Berühren des Lidrandes im medialen Augenwinkel.
3. PUPIL OPENING	
0 = Mydriasis 1 = pupillary opening 50 - 75 % 2 = Miosis	Beurteilt wird die relative Öffnung der Pupille. Mit zunehmender Narkosetiefe wird eine größere Pupillenöffnung erwartet. Cave: ggf. reverse Effekte
4. PUPILLARY REFLEX	
0 = Reflex absent 1 = Reflex delayed 2 = Reflex present	Beurteilt wird die Geschwindigkeit und das Ausmaß der Pupillenreaktion nach Beleuchten des Augens (Diaskleralkegel, Distanz 0,5 cm).
5. CORNEA REFLEX	
0 = Reflex absent 1= Reflex delayed; slow movement with complete nict. membrane prolaps 2 = Reflex delayed, complete nict. membr. prolaps 3 = Reflex physiol.	Die geschlossene Lidspalte wird geöffnet. Beurteilt wird die Reaktion der Nickhaut nach dezentraler (!) Touchierung der Hornhaut mit einem trockenen, sterilen Tupfer. Für die Gewichtung des Reflexes ist die Bewegungsgeschwindigkeit der Nickhaut und die Vollständigkeit des Reflexablaufes maßgeblich.
6. HEAD POSITIONING	
1 = down 2 = sligh raising 3 = raising	Beurteilt wird die Tiefensensiblität durch Lage des herabhängenden Kopfes ohne Einwirken eines speziellen Stimulus
7. NECK TONE	
0 = Not present 1 = Presend	Beurteilung der Tiefensensibilität anhand des Muskeltonus durch vorsichtiges Bewegen des Kopfes. Bei völliger Erschlaffung kein Widerstand.
8. LEG TONE	
0 = Absent 1 = Low tone 2 = Contraction 3 = Contraction and respiratory movement	Beurteilt wird die Tiefensensibilität anhand des Muskeltonus und von Reaktionen nach passiver Streckung der Gliedmaße (aktives Zurückziehen des Ständers, Maximalreaktion durch zusätzliche Abwehrbewegungen (Flügelschlagen) gekennzeichnet.
9. PECTORAL REFLEX	
0 = Reflex absent 1 = Slight wing movement 2 = Movement of legs/wings, head movem. opening of lid fissure 3 = Massive movements	Beurteilung von Reaktionen nach Kneifen der Haut zwischen den Ossa pubis mit reproduzierbarem Druck (spez. Kneifzange) von 0,9 kp/0,5 cm^2. Geringgradige Reaktionen: Flügelzittern, stärkere Reaktionen: uneinheitliche Bewegung verschiedener Körperteile, Maximalreaktion: Flügelschlagen, Kopf und Beinbewegungen.
10. PROPATAGIUM REFLEX	
0 = Reflex absent 1 = Sligh wing movements 2 = Movements of wings and legs, opening of lid fissure 3 = Massive movments	Beurteilt werden Reaktionen nach Kneifen des Propatagiums. Beurteilungskriterien s. o..
11. PEDAL REFLEX	

0 = Reflex absent 1 = Slight withdrawal movements 2 = Withdrawal of legs, opening of lid fissure	Beurteilt werden Reaktionen nach Kneifen der Zwischenzehenhaut. Beurteilungskriterien s. o..
12. CLOACAL REFLEX	
0 = Reflex absent 1 = Constriction of sphincter cloacae, withdrawal of legs 2 = Withdrawal of legs and wings, head movements, opening of lid fissure 3 = Massive movements of legs/wings	Beurteilt werden Reaktionen nach Kneifen der perikloakalen Haut. Beurteilungskriterien s. o..

Tab. 2: Target score during tolerance stadium (surgical depth of anaesthesia) in birds

Reflex	**Max. score (patient fully awakened)**	**Target score (Tolearance stadium)**
Lid opening	2 points	0 points
Palpebral reflex	2 points	0 points
Pupillary opening	3 points	0 – 1 points
Pupillary reflex	2 points	0 – 1 points
Corneal reflex	3 points	2 points
Head positioning	1 points	0 points
Neck tone	2 points	0 points
Leg tone	3 points	0 points
Pectoralis reflex	3 points	0 points
Propatagium reflex	3 points	0 points
Pedal reflex	2 points	0 points
Cloacal reflex	3 points	0 points
Reflex score total	**29 points**	**2 – 4 points**

III. Annotations on Anaesthesia in Ratites

Large ratites, including ostriches, emus, rheas and cassowaries are difficult to handle in terms of anaesthesia. In general praenteral of inhalation agents may be used with the latter to be preferred. For preanaesthetic restraint darkness with a darkened room or using methods to cover the eyes (head hooding with light opaque fabric) is the method of choice due to the fact that adult ostriches may reach a body weight up to 175 kg. Additionally gentle grasping of the head and abruptly lowering it to the ground is useful. Moving an ostrich, a handler should rasp the tail root with the lead handler at the head. Note the substantial risk for injuries for personel approaching the patient from the front and side. Fasting 12 to 24 h pre anaesthesia is recommended.

Various anaesthesia protocols are available for induction of anaesthesia in ratites. Intramuscular application includes use of Ketamine/Xylazine with as dosage of 5 / 1 mg/kg BW i. m. resp. 2.2 / 0.25 mg/kg i. v.or 2.2 – 3.3 i. v. 15 min after i. m. application of 2.2 mg/kg Xylacine i. m.. Administration of ketamine alone either by the im or iv route is unacceptable. Combinations of Ketamine and Xylacin is not recommended as an induction combination for inhalation anaesthia and is contraindicated in debilitated patients due to minimal cardorespiratory effects. For induction of inhalation anaesthesia i. m. application of a tranquilizer such as azaperone (0.5 – 2.0 mg/kg i. m.) or diazepam (0.1 – 0.3 mg/kg i. v. or 0.5 – 1.0 mg/kg BW i. m.) followed by an intravenous agent or combination may provide the most effective method of incduction. Use of opioids has been limited to the potent but potential hazardous agents, carfentanil and etorphine, alone or in combination for the immobilization of free-ranging ratites.

Using isoflurane as the method of choice for anaesthesia in ratites initially setting of 5 Vol. % followed a decrease to maintenance levels to facilitate a smooth and rapid induction should be used. Induction should be performed using a head chamber following endotracheal intubation. Intubation should be used in procedures requiring anaesthesia of more than 10 min in duration. Tube sizes for ratites are 4 – 6 for ratite chicks, 7 – 11 for ratite juveniles, 12 – 14 for adult rheas/emus and 14 – 18 for adult ostriches. Tubes should never forced in into the trachea and noncuffed tubes or noninflated cuffs should be used to avoid injuries of the mucosa because of the closed, complete rather than open, incomplete tracheal cartilaginous rings in birds. Maximum peak inspiratory pressure for assited ventilation is 12 to max. 15 cm H_20.

As a perianaesthetic support ratites have to be well padded to avoid neuropathy and myositis. Note the susceptible to peroneal nerve paralysis when placed in laeral recumbency for as little as 1 hour. For thermal support ideally a circulating warm water heating pad and iv

fluids should be warmed to body temperature. Monitoring must be performed as described above.

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DRUGS USED FOR THE IMMOBILIZATION OF WILD ANIMALS:

PHARMACOLOGICAL ASPECTS

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Introduction

Decisions made concerning the application of drugs for the immobilization, capture and translocation of wild animals depend on a thorough knowledge of the nature of the drugs being used. Criteria applicable to the choice of a drug include availability, safety for the animal and the users, previous results in the particular species, duration of effects required, the need for an antidote and the legislative implications of using the drug. Anesthetic agents, opioids, hypnotics, sedatives, tranquillizers and neuromuscular blocking agents are commonly used for the immobilization of wild animals. Some of the characteristics of an ideal immobilization drug include the following: small volume, suitable stability, quick absorption and onset of action, wide margin of safety, rapid elimination from the body, non-occurrence of tissue irritation, availability of an antidote, and minimum risk to personnel.

I) Opioids

Morphine and related μ-agonist opioids produce their major effects on the CNS and bowel by acting as agonists, particularly at μ-receptor sites. The effects are markedly diverse and dose dependant and include analgesia, drowsiness, changes in mood, respiratory depression, decreased gastrointestinal motility, nausea, vomiting, regurgitation, and alterations of the endocrine and autonomic nervous system. CNS depression is seen in the dog, monkey, human and many wild animal species, while in feline, porcine, and equine species excitatory effects are observed. Excitatory effects include convulsions, extrapyramidal signs, catalepsy, and muscular rigidity. The primary mechanism of respiratory depression by opioids involves a reduction in responsiveness of brainstem respiratory centres to CO_2. Other side-effects that may occur include hypotension or hypertension, tachycardia or bradycardia, bloat and inhibition of thermoregulatory mechanism. Under-dosing may result in excessive running and prolonged induction, which may lead to hyperthermia, exhaustion, and loss of the animal.

A major advantage of opioids is that their effect can be antagonised with full or mixed opioid antagonists. Reversal with opioid antagonists occurs within several minutes following intravenous injection. If the opioid is not reversed, the duration of immobilization is lengthy,

often several hours, leaving the animal at risk from drug-induced respiratory depression, self-injury, predation, or the effects of inclement weather. Diprenorphine and nalorphine are mixed antagonists that can be administered intravenously or intramuscularly. Diprenorphine is a potent morphine antagonist with an action similar to nalorphine. Its potency, however, was stated to be up to 35 times greater than nalorphine and to have a duration of action 2 - 3 times as long. In game animals it produced a rapid and complete reversal of the immobilisation produced by etorphine. Diprenorphine is available as M5050 or as Large Animal Revivon® in a 3.26 mg/ml concentration. Because of their agonistic properties, overdosing with diprenorphine or nalorphine may cause continued immobilization and exacerbate respiratory depression. Naloxone, naltrexone and nalmephene are pure opioid antagonists. Naloxone is available in a 0.4 mg/ml injectable solution. The standard naloxone dose for opioid reversal is 0.04 mg/kg. Naloxone has a short half-life – in some species, as short as 30 minutes. When used as an opioid antagonist, the short duration of naloxone may cause recycling and renarcotization in the treated animal within 15-30 minutes of administration. In those cases, repeated treatment with naloxone will be required to recover the animal. Naltrexone and nalmephene have a long half-life (more than 10 hours for naltrexone in many species). Naltrexone is reported to be 2.5 times as potent as naloxone and an active metabolite of naltrexone appears to play a role in the prolonged effect of the drug. In one study naltrexone was the only opioid antagonist that was fully effective in preventing recycling of carfentanil. Nalmephene is a naltrexone derivative that has only been tested a limited extent in wild animals. It appears that nalmephene is a more potent antagonist than naltrexone and longer lasting than naloxone.

1) Etorphine

Etorphine hydrochloride is a semisynthetic opioid from the opium alkaloid of thebaine. Etorphine is marketed as Immobilon® (mixed with acepromazine) and M99®. Etorphine is commonly used for the immobilization and capture of a range of African wildlife species. It is particularly useful in very large ungulates and sub-ungulates as African elephant, rhinoceros, hippopotamus, giraffe and African buffalo. Etorphine is also used in smaller ungulates as impalas or antelopes. It is generally not suitable for use in primates or felids. Its use for immobilising game animals results largely from its ability to cause catatonia at very low dose levels (for example, the total dose for a rhino may be as low as 5 mg).

The major metabolite of etorphine is glucuronide, which is hydrolyzed in the caecum by bacteria-derived glucuronidase. Most opioids are excreted by the kidney, but there is clear evidence that the major route for excretion of etorphine is in the faeces via the bile. Enterohepatic circulation of etorphine and its glucuronides occurs, which accounts for small amounts of etorphine in the faeces and in the urine for several days after the last dose.

The pharmacological effects of etorphine are typical of opioids, but may vary significantly between species. Its analgesic potency is given at 500 to 10'000 times that of morphine, depending on the nature of the test. The extreme potency of this drug is the result of a molecular structure with a greater affinity for the μ-receptor, as well as increased lipophilia, which amplifies its ability to cross the blood-brain barrier. At optimum doses, first effects are seen 2 - 10 minutes following intramuscular injection, with peak effect reached after 20 - 30 minutes. In the horse, etorphine consistently causes spastic rigidity of the limbs and muscle fasciculations over the entire body surface. In the hippopotamidae, etorphine has resulted in muscle hypertonicity. Reports of muscle tremors and opisthotonus were also seen in Giraffidae and Camelidae. Head pressing in rhinoceros has been noted. It is generally recommended to dose heavily and then reverse as soon as possible with diprenorphine, as insufficient dosage or under-dosing with etorphine may result in hyperexcitability. Respiratory depression has been reported as a common side-effect during capture of black rhinoceros and periods of apnea have been reported in horses and Grevy's zebra. In artiodactyls, depression of the respiratory rate is not usually observed. Etorphine has been found to cause pronounced tachycardia and increased blood pressure in both Grevy's zebra and African elephants. Hypertension is a common occurrence in African elephants and may lead to lung edema. In the equidae, it increases total peripheral resistance. Hypertension has also been reported in swine and a white rhinoceros. In artiodactyls, hypotension tends to result, and bradycardia is sometimes seen, especially in higher doses. In monkeys, cats, and dogs bradycardia and hypotension are reported. Etorphine can inhibit gastrointestinal motility and abolish ruminal movements. The eructation of gas, however, should be possible, provided the animal is kept in sternal recumbency. Regurgitation has been mentioned in dogs, cats, cattle, camel, and giraffe.

Safety Precautions

Because of the great risk involved to man and animal in handling etorphine, the possession and use of etorphine is strictly controlled by law in almost all countries. Keep etorphine and diprenorphine together and ensure that there is sufficient diprenorphine to reverse the effects

of etorphine. Load the diprenorphine syringe first and keep it to hand throughout the procedure. Load the etorphine syringe well clear of the patient or assisting persons and use a disposable syringe. Always ensure that a syringe loaded with an appropriate antidote like naloxone for human use is at hand. Wear gloves and eye protection and do not pressurise the contents of the vial. An eye and skin wash should be available. An assistant capable of giving an injection of the reversing agent should be present whenever etorphine is used. Although it appears that there may be some degree of species variation in the response, in practice it has been found that a dosage ratio diprenorphine to etorphine of 2:1 is perfectly satisfactory.

Accident Procedure

Etorphine is a very potent neuroleptanalgesic, which is highly toxic for humans. It causes dizziness, nausea and pinpoint pupils, followed by respiratory depression, lowered blood pressure, cyanosis and, in extreme cases, loss of consciousness and cardiac arrest. With accidental exposure to etorphine, inject 2 - 3 mls Narcan® (0.4mg/ml naloxone) preferably intravenously or alternatively intramuscularly, and repeat at intervals of 2 to 3 minutes until the symptoms are reversed. In the event of Narcan® being unavailable, or in a situation of extreme emergency, the following procedure has been suggested: Inject 0.1 ml diprenorphine, preferably intravenously or alternatively intramuscularly, but if the actual quantity of etorphine injected or absorbed is known, inject an equal quantity of diprenorphine. If respiratory depression is not reversed, repeat the dose after 2 or 3 minutes. Recurrence of morphine-like effects may occur due to enterohepatic recycling. (diprenorphine may also induce a hallucinatory state). IT IS VITAL THAT ADEQUATE RESPIRATION AND HEARTBEAT BE MAINTAINED, IF NECESSARY BY MEANS OF ARTIFICAL RESPIRATION AND EXTERNAL HEART MASSAGE, UNTIL MEDICAL HELP ARRIVES.

2) Carfentanil

Carfentanil is a congener of fentanyl and is approximately 10´000 times more potent than morphine. It can be used successfully at doses as low as 1 μg/kg and the usual dose ranges from 0.005 to 0.01 mg/kg IM. Carfentanil is fast-acting, with onset of effects in 2 - 10 minutes following intramuscular injection. It has a wide safety margin.

Even at high doses, respiratory depression is rare. Carfentanil, probably due to its high potency and long duration of action, has a major disadvantage of occasionally producing renarcotization following administration of an antagonist. Renarcotization can result in severe

metabolic problems and death. The drug has been widely used for a variety of African wildlife species. Carfentanil has also been given successfully orally to bears, monkeys, tapirs and chimpanzees for immobilization and sedation. Giraffes, which are usually caught standing or ambulatory, become recumbent without side effects. The recommended reversal dose for diprenorphine is 7 times the carfentanil dose; for naloxone, 80-100 times the carfentanil dose; and for naltrexone, 100 times the carfentanil dose.

Due to its high potency and toxicity in human beings, the same rules concerning safety precautions and accident procedures as with etorphine are applicable.

3) Fentanyl

Fentanyl has an analgesic potency of about 100 times that of morphine. It has a rapid onset of action (between 3 - 5 minutes) and a short duration of action (approximately 30 - 60 minutes). It is rapidly metabolised in the liver, and the metabolites are excreted in the urine. Fentanyl is effective for immobilizing most of the African antelopes as well as buffalo, giraffe, rhinoceros, and warthog. Zebras apparently are resistant to fentanyl and cannot be captured with this drug. In most instances, it is used in combination with either azaperone, α_2-agonists, or hyoscine. Fentanyl has been administered orally in orangutans, chimpanzees and gorillas.

One of the principal advantages of fentanyl is that many species remain standing and can be worked on in this state. Side effects are mainly respiratory depression, possible bradycardia, and allotriophagia. The recommended average reversal doses are 0.04 mg/kg for diprenorphine, 0.5 mg/kg for nalorphine, and 0.04 mg/kg for naloxone.

4) Thiafentanil (A-3080)

Compared with carfentanil, thiafentanil has a significantly shorter duration of action and appears to be about two-thirds as potent as carfentanil. Moreover, thiafentanil apparently offers a greater margin of safety than carfentanil. Thiafentanil has been used in elks, impala, pronghorn, kudu, buffalo, waterbuck, ferrets, and mule deers.

II) Cyclohexamines

Cyclohexamines are a group of drugs that produce a cataleptic state of immobility, referred to as "dissociative anesthesia". The state of dissociated anesthesia is produced by interruption of ascending transmission from the unconscious to the conscious parts of the brain, rather than by general central nervous system depression. Electroencephalographic tests have shown evidence of dissociation between the thalamus and the limbic system. They produce intense somatic analgesia of short duration. Muscle tremors, hypertonicity, mydriasis, nystagmus are characteristic of dissociative anesthetics. Pharnygeal and laryngeal reflexes are usually well maintained. Excessive salivation may occur. Respiratory and cardiovascular functions are usually well maintained. Ketamine, tiletamine and phencyclidine belong to this group of drugs, but only the former of the two are currently used. All three have been extensively used in a wide variety of mammalian, avian, and reptilian species. Cyclohexamines are particularly useful in bears, large carnivores and primates. The cyclohexamines can be used alone in some species, but they are usually combined with a sedative. This inclusion potentiates the primary drug, produces a smoother induction and recovery, and alleviates the undesirable side-effects often associated with the use of cyclohexamines. Cyclohexamines are usually administered either intravenously or intramuscularly. In captive animals, ketamine may also be administered orally by squirting it into an open mouth.

The eyes should be protected from direct sunlight and an ophthalmic ointment instilled to protect the cornea, as the eyes of anesthetized animals remain open. Noises and bright light should be avoided during induction and recovery. Hyperthermia frequently occurs as a result of the catatonic effects of these drugs, and body temperature should be monitored.

1) Ketamine

Ketamine is short-acting analogue of phencyclidine with a relative potency of 1/5 to 1/6 of phencyclidine. Onset of action is within 3 - 5 minutes and complete immobilization is produced within 5 - 10 minutes. The duration of effect varies with the species and the dose administered, but most animals are ambulatory within 1 - 2 hours. The recovery from ketamine is due mainly to redistribution of the drug from the brain to other peripheral tissues (adipose tissue, liver, and lung). Ketamine undergoes extensive hepatic metabolism in the dog, horse, and human. Clinically, animals with hepatic dysfunction do not metabolize

ketamine as rapidly as normal animals. The water-soluble glucuronide derivatives are excreted in the urine. The principal metabolite has some anesthetic activity: Very little hepatic metabolism occurs in the domestic cats, and the majority of the ketamine is eliminated unchanged via the kidney. Cats with renal dysfunction tend to stay longer anesthetized following ketamine induction than healthy cats. The low pH of the aqueous solution may cause pain upon injection.

Due to its relative lack of potency, it is used primarily in smaller animals like wild carnivores, subhuman primates, reptile and birds. A very large variation in dose of 2 - 50 mg/kg occurs between species, although most wild animals require only 10 - 20 mg/kg. Lower doses are generally required when used in combination with sedatives and neuroleptics. Ketamine has a wide margin of safety.

2) Tiletamine

Tiletamine is available as a 1:1 combination with zolazepam known as Telazol® or Zoletil®. The combination is available as a freeze-dried powder of 250/250 mg, which is reconstituted with a diluent. Tiletamine is 3 - 4 times more potent than ketamine. It produces similar pharmacological actions as those of ketamine, but it is faster-acting and the duration of action is three times longer. Due to its tendency to produce convulsions similar to phencyclidine, it is combined together with zolazepam, a benzodiazepine. This combination produces a potentiation of the anesthetic effects of ketamine, muscle relaxation, abolition of convulsions, and smoother recovery.

Tiletamine-zolazepam have been used extensively, and are especially indicated for the chemical immobilization of wild and exotic primates and carnivores. Doses of this combination are expressed in mg of the drug combination. Recommended dose rates vary widely from 1 - 30 mg/kg. Tiletamine-zolazepam are often combined with other drugs to reduce the necessary amount to be administered.

Because tiletamine and zolazepam are metabolized at different rates in some species, emergence and recovery are affected by which of the drugs may be metabolized first. Recovery is 3-5 hours in most cases. There is no known antagonist for tiletamine, but the effects of zolazepam may be reversed with flumazenil after the tiletamine part of the combination is metabolized. Tiletamine-zolazepam is primarily metabolized and excreted through the kidneys.

III) Steroid Anesthetics

Alphaxalone and alphadolone acetate are two steroids that are mixed and solubilized in saline with 20% castor oil into the final product. It is available as Saffan® from Janssen Pharmaceuticals as an injectable solution. The steroid mixture produces short-acting anesthesia with good muscle relaxation. Depth and duration of anesthesia are dose-dependent. Respiration is usually well maintained. Induction of anesthesia following intravenous administration is rapid and smooth. The duration of anesthesia is short: within 6 - 9 minutes, animals are able to stand. Complete recovery after intramuscular administration takes slightly longer.

The steroid components are biotransformed in the liver to polar metabolites that are excreted in the bile. The plasma half-life of alphaxalone in various animals is roughly seven minutes. Accumulation does not occur following repeated administration and termination does not depend on uptake by adipose tissue. The hormonal effects of alphaxalone and alphadolone are minimal.

Saffan® has been used in monkeys (6 - 9 mg/kg), cheetahs (2 - 3 mg/kg), birds and reptiles. It is compatible with commonly used inhalation and premedicant drugs. Another advantage is its wide margin of safety. In cheetahs, Saffan® induced a state of hypothermia and should be used with caution on hot and cold days.

In cats, sneezing on induction, flushing, and edema of the paws, ears and face are sometimes seen. These effects usually resolve within 1 – 3 hours. In dogs, the release of histamine caused by castor oil results in severe vasodilation and hypotension, and should therefore not be used in dogs and other canines.

There is no known antidote available.

IV) Barbiturates

Barbiturates are seldom used in wild animals. In the past, they have been used to treat the epileptiform convulsions induced by the cyclohexamines. They have also been used to prolong anesthesia following immobilization with other drugs. Higher doses of pentobarbital

have been used for euthanasia of smaller animals. Lions fed with meat from horses euthanatized with pentobarbital have become anesthetized. Thiopental must be administered intravenously due to perivascular necrosis following extravascular administration.

V) Inhalation anaesthetics

Inhalation anesthetics such as halothane, isoflurane or sevoflurane are not generally used in wild animals. They are used for research and, in the case of captive wild animals, to prolong or augment maintenance of anesthesia for lengthy surgical and diagnostic procedures. Inhalation anesthetics are also used to induce anesthesia in animals that can be manually restrained such as birds, reptiles, and young mammals.

Inhalation anesthetics have the advantage that the level of anesthesia can be controlled precisely. Uptake and removal of the drug are very rapid because these actions depend on respiration. Isoflurane and sevoflurane have the advantage that they are less arrhythmogenic than halothane. Due to their low blood/gas partition coefficients, sevoflurane and isoflurane have a more rapid uptake and elimination than halothane. Another advantage is the lower hepatic biotransformation of sevoflurane and isoflurane in comparison to halothane.

VI) α_2-agonists

The α_2-agonists are potent central nervous system depressants with sedative, muscle relaxant and analgesic properties. The sedative effect is dose dependant and ranges from mild sedation to deep sleep. Side effects include altered thermoregulation, vasoconstriction, bradycardia, hypertension and hypotension, respiratory depression, inhibition of insulin release, and diuresis. Because of the increased release of norephinephrine in stressed, agitated, or very excited animals, these drugs do not produce satisfactory immobilization when animals are in such states. Alpha-2-agonists have been used in a wide range of non-domestic herbivores and carnivores. They are usually mixed with either opioids or cyclohexamines due to their synergistic effects with these drugs. This results in reduction of doses required, improvement in induction times, and better relaxation. Due to their unpredictability concerning adequate sedation, they should not be used as sole agent in dangerous species.

Specific α_2-antagonists such as yohimbine, tolazoline, atipamezole and idazoxan are used to reverse the effects of these drugs. They block the effect of alpha-2-agonists at the synapse and permit resumption of neural transmission. Depending on the particular antagonist given, the species, and the dose administered, complete reversal may take place in 2 - 5 minutes. The α_2-antagonists should always be administered slowly. Severe hypotension, tachycardia, and subsequent death may result from too rapid intravenous injection. Tolazoline has the least specificity for α_2-adrenoreceptors of all the antagonists. It has been associated with tachycardia, cardiac arrhythmias, hypotension and gastrointestinal hypermotility, abdominal pain, nausea and diarrhea.

Xylazine, romifidine, detomidine and medetomidine have all been used in wild animals. Xylazine is available as 20 and 100 mg/ml aqueous solutions. In some countries it is also available in a 500 mg powder allotment. The powder can be dissolved with a special solvent or ketamine to make various concentrations. Xylazine is not rapid-acting. In calm animals, the initial effect may be seen after 10-15 minutes following intramuscular injection, with peak effect reached after 15-20 minutes. The analgesic effect lasts only for 15 - 30 minutes, and lengthy painful procedures or surgery should be avoided. Ruminants are particularly sensitive to xylazine and may remain depressed for as long as 24 hours. As well, ruminants should be maintained in sternal recumbency during the immobilization period. Because it may have a stimulating effect on the uterine muscle, xylazine can cause abortion in ruminants in the later stages of pregnancy. The effects of xylazine may be reversed by atipamezole (1 mg of atipamezole per 8 – 12 mg of xylazine given), tolazoline (0.4 - 4mg/kg) and yohimbine (0.125 mg/kg). Recommended antagonist dosages are given for intravenous injection.

Detomidine was initially developed as a sedative-analgesic in horses and cattle. It is available in a 10 mg/ml injectable solution. The action of detomidine is comparable to that of xylazine, but it is more potent. Detomidine is rapid-acting with induction time ranging from 2 - 20 minutes. The elimination half-life of the drug is 1 - 2 hours and the duration of action can be as long as 6 hours in horses. The effects of detomidine may be reversed by atipamezole (4 – 6 times the detomidine dose) and tolazoline (0.4 - 4mg/kg).

Medetomidine was developed primarily for use in dogs and cats, but has been used in a lot of different species. It is rapid-acting and quickly eliminated in treated animals. Medetomidine is available as a 1 mg/ml solution, as well as a 10 mg/ml solution from Orion Pharma (called Zalopine®). The effects of medetomidine may be reversed by giving atipamezole at 4 - 5 times the medetomidine dose.

VII) Benzodiazepines

Diazepam, midazolam, climazolam, and zolazepam have been used in wild animals for sedation and anxiolysis of wild animals during transportation. They have also been used for muscle relaxation and as an anticonvulsant following immobilization. They have little effect on the cardiopulmonary system. They can be administered intravenously, intramuscularly or orally. The effects of benzodiazepines can be antagonized with specific antagonists such as flumazenil or sarmazenil. Flumazenil acts competitively at CNS benzodiazepine receptors, and is indicated for reversal of the central effects of benzodiazepines. In wild animals, doses of 1 - 2 mg/kg intramuscularly have been used to antagonize benzodiazepines. Flumazenil has been described as devoid of side effects at recommended doses. At high doses, convulsions may occur.

Diazepam and midazolam have been used successfully in a number of zoo animals either alone or in combination with ketamine, α_2-agonists or other drugs. The dosage of diazepam varies from 0.5 to 10 mg/kg depending on the species, purpose and route of administration. The recommended dose for midazolam is 0.1 – 0.5 mg/kg. Paradoxical reactions such as hyperexcitement may occur. When high doses of zolazepam of 10 mg/kg were given intramuscularly to cats, a “fear reaction, extreme continuous territorial exploration, or a hysterical jumping-climbing behaviour occurred that was not unlike that often observed with high doses of midazolam administration. Respiratory depression occurs only at higher doses, but benzodiazepines may potentiate the respiratory depressant effects of other drugs like opioids.

VIII) Tranquillizers / neuroleptics

Tranquillizers comprise one of many groups of pharmacologically active agents whose primary effect is modulating neurotransmitter activity within the central nervous system. There are five main neurotransmitters that are involved in behaviour modification: acetylcholine, dopamine, norepinephrine, serotonin, and γ-aminobutyric acid (GABA). 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 behavioural quieting that is characterized by decreased emotional reactivity and aggression, and relative indifference to stressful situations. Tranquillizers do not cause

profound cortical depression (unconsciousness), but will suppress spontaneous movements while sparing spinal reflexes and unconditioned pain reflexes.

Typically, the minor tranquillizers (i.e., promazine, acepromazine) produce a greater degree of sedation, while having a higher incidence of anticholinergic and cardiovascular side-effects, and fewer extrapyramidal side-effects. Major tranquillizers produce less sedation and fewer anticholinergic effects, but have a higher incidence of extrapyramidal side-effects.

All neuroleptics have the potential to cause mild anticholinergic effects, peripheral alpha-adrenergic receptor blockade, and to impair thermoregulation. They may also interfere with several hormones, including increasing prolactin secretion, and inhibiting luteinizing hormone, anti-diuretic hormone, and oxytocin secretion.

1) Phenothiazines

Effects of phenothiazine derivates include: sedation, potentiation of other sedatives and anesthetics, anti-emetic, altered thermoregulation, vasodilation, and hypotension. Due to their cardiovascular side effects they should not be used in weak, debilitated or aged animals, and in animals with cardiac disease.

Acepromazine has been used extensively for tranquillization, neuroleptanalgesia, and as premedication for general anesthesia in wild animals. It is seldom used for immobilization on its own. In combination with opioids and cyclohexamines, it has synergistic activity and therefore reduces undesirable side effects, shortens induction time, and reduces the dose of the particular immobilizing drug with which it is combined. The recommended dosage range is 0.125 - 0.25 mg/kg for small animals and 0.05 - 0.1 mg/kg for large animals. There is no specific antidote to acepromazine, but doxapram has been found to reverse effects of phenothiazines effectively. Chlorpromazine and promazine were used for tranquillization and capture of exotic species in the past.

2) Butyrophenones

Butyrophenones produce their effects through central dopaminergic and peripheral adrenergic blockade, and have similar effects to phenothiazines. Azaperone, droperidol, and haloperidol have been used in wild animals. They can either be used alone or in combination with other anesthetic drugs.

Azaperone is active within 15 - 30 minutes, lasts for 2 - 3 hours, and is primarily metabolised in the liver. When used alone, it is effective at doses from 0.5 - 2 mg/kg; lower range for herbivores, and higher range for carnivores. When combined with opioids, the dose can usually be reduced. Haloperidol has a longer duration of action than azaperone. Depending on the dose and species, the effective duration varies from 8 - 18 hours. Onset of action is usually within 5 - 0 minutes. Haloperidol possesses some analgesic properties. Haloperidol has been shown to be particularly effective in the majority of small- and medium-sized antelope species. Recommended doses for free-ranging animals range from 0.05 - 0.5 mg/kg. For some species, it may be administered successfully by spraying it on the food. It is incompatible with opioids and cannot be included in combinations with these drugs. Droperidol used to be available in a combination with fentanyl.

3) Long-acting neuroleptic drugs

Long-acting neuroleptics have proven to be a valuable tool for use during wildlife management. Translocation operations frequently involve chemical capture, confinement, transport, relocation, and adaptation to a new environment, and these are unnatural, traumatic, and stressful events in the lives of the animals. Captured and confined animals show high degrees of excitement and stress, and frequently injure themselves or others in the group during a struggle or when attempting to escape. Further, the inability to adapt to confinement often results in exhaustion from constant pacing, and marked loss of condition due to a refusal to eat and drink resulting from unfamiliar food and water delivery systems.

All long-acting neuroleptics used in wildlife are phenothiazine derivatives, and share structural similarities to chlorpromazine. These formulations were developed with the specific goal of achieving prolonged tranquillisation of the patient, without the need for frequent, repeated injections that would be required with the traditional agents. Achieving prolonged duration of effect has been met by creating a fatty acid ester of the active drug ingredient, and then dissolving this entity in a vegetable or medicinal oil. When this formulation is injected intramuscularly, it forms a depot at the site of injection. With the slow breakdown of the oil solvent, the ester diffuses out of the depot into muscle. Once absorbed into the blood, the ester is then hydrolyzed, and the active ingredient is able to exert its clinical effect. They are all metabolized in the liver, and their metabolites are excreted in the feces. There are neuroleptics available for use in wildlife that will produce a duration of effect ranging from 3 to 30 days, depending on the active drug, the structure of the ester, and the type of oil base. All long-acting neuroleptics must be administered intramuscularly and never intravenously.

Side-effects: There exist several important side effects that can occur with the use of long-acting neuroleptics. Excessive blockade of dopamine receptors in the basal ganglia can result in extra-pyramidal signs, and hormonal side-effects may result from excessive blockade in the hypothalamus. In people, oral formulations are often used to establish tolerance, and to determine individual responses prior to the depot injection being given. In wildlife, this is rarely possible, and the injectable neuroleptic is frequently given when the animal is first handled. As a result, the potential for side-effects in animals is greater, and it is important to understand how the side-effects can manifest, how to recognize them, and how to treat them if they do occur.

Extra-pyramidal signs (EPS) have been reported with the use of long-acting neuroleptics in wildlife and domestic species. Mild EPS in animals include continuous licking and chewing of objects, while severe signs include restlessness, circling, recumbency, paddling, and altered levels of consciousness. EPS have been found to manifest in wildlife when animals that were already tranquilized were further stressed with hyperthermia, sudden loud noises, and increases in activity associated with transportation.

Treatment of EPS in animals is generally symptomatic. Several drugs have been used in attempt to limit the excitatory signs that are seen, including sedatives such as xylazine, butorphanol and acepromazine, as well as anticonvulsants such as diazepam and the barbiturates. Short-term relief (< 2 hours) of EPS can be achieved with these agents, but with variable success. In people, EPS are treated with antiparkinsonian drugs such as diphenhydramine and benztropine. It is thought that the EPS may be the result of an imbalance between dopamine and acetylcholine in the striatum, and that diphenhydramine acts to restore this balance. In the one successful reported treatment of EPS in a horse, 0.7 mg/kg diphenhydramine IV resulted in resolution of signs within 3 minutes, and lasted 18 hours. One additional dose was required at 18 hours when EPS returned, and no further doses were necessary.

Zuclopenthixol is a thioxanthine derivative, and shares general properties with the other phenothiazines. There are two formulations of zuclopenthixol that have been used in wildlife, the shorter-acting acetate ester, and the longer-acting decanoate ester. Zuclopenthixol acetate causes a nonspecific sedation within a few hours of administration, and its effects last 3 - 4 days. The decanoate ester requires several days (up to one week) for onset, but its clinical effects last up to three weeks. Zuclopenthixol acetate can be used alone for short duration tranquillization, or it can be used in combination with longer-acting agents to provide "loading" effects prior to the clinical onset of the slower-acting agent. Zuclopenthixol acetate

has been used successfully in a variety of species of wildlife. Several authors have examined both subjective and objective effects of this drug, in attempt to describe its usefulness. Its effects have been evaluated in red deer, bison, Nile lechwe, wapiti, white-tailed deer, and cheetahs. With doses less than 1 mg/kg IM, the side effects are usually minimal, except for cheetahs, in whom zuclopenthixol acetate is not recommended

Perphenazine enanthate is a phenothiazine derivative dissolved in a sesame oil vehicle. The onset of action is slow, taking 12 - 16 hours in some cases. Peak effects are reached at three days, and clinical effects may last 7 - 10 days. Recommended doses range from 0.5 - 3.3 mg/kg IM: Use of perphenazine has been reported in several species, including impala, red deer, cheetahs, and equids such as domestic horses and Przewalski's horses.

Pipothiazine palmitate is also a phenothiazine derivative dissolved in a sesame oil. It is reported to have action similar to perphenazine. It has a markedly delayed onset of up to three days, and a prolonged duration of two to four weeks. Reported doses range from 4 - 25 mg/kg; the lower doses used for hoofstock and the higher doses for wallabies and cane rats.

Although its use in wildlife has been described in a variety of references, it has only been critically evaluated in impala, cane rats, and wallabies. Impala showed decreased flight distance and were easier to handle. Wallabies and cane rats demonstrated marked decreases in stress-related behaviours during handling, and clinical effects lasted two to four weeks in both cases. No extra-pyramidal side-effects were observed in any of these studies, although appetite suppression has been reported in a group of impala after administration of pipothiazine.

IX) Neuromuscular blockers

Muscular activity can be affected by modifying the neurotransmission at the neuromuscular endplate. Neuromuscular blocking agents cause relaxation and muscle paralysis by interfering with the ability of acetylcholine to activate nicotinic cholinergic receptors of skeletal muscle cells. Neuromuscular blocking agents are classified as depolarising and nondepolarizing drugs. Neuromuscular blocking agents were some of the earliest drugs used for immobilization of wild animals. They have subsequently been replaced by more effective and safer drugs, but are still fairly often used for immobilization of reptiles. It is important to remember that these drugs do not anesthetize animals, and do not provide analgesia. Therefore, the patient should either be given adequate analgesia or be anesthetized so that it is unconscious and unaware.

The safety margin between the effective and the toxic dose is very small. Respiratory failure, as a result of paralysis of the respiratory muscles, may occur.

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THE PROCEDURE OF WILD ANIMAL IMMOBILISATION: IN THEORY AND PRACTICE

Wolfgang Zenker

Chemical immobilisation may be considered a specialised form of veterinary anaesthesia, executed under the most difficult circumstances and imposed without the benefit of any preanaesthetic evaluation and preparation (Nielsen 1999). It poses a certain risk to humans and animals. In order to minimise the risks and maximise the chance of success, it is important that the worker not only know the function and limitations of the drug delivery equipment and understand the action of the immobilising drugs, but he must also have a good knowledge of animal behaviour, physiology and anaesthesiology. In addition, the worker must be aware that the planning, preparation, organisation and procedure of wild animal immobilisation in the field is of the utmost importance.

The Differences between anaesthesia in domestic animals and chemical immobilisation in wildlife

Definitions

Unlike anaesthesia, immobilisation is a state in which an animal is rendered immobile, senseless, or unconscious. In this state the animal can be handled safely and with little risk to human workers (Nielsen 1999). This can be achieved by mechanical or chemical means.
The drugs for chemical immobilisation can meet the requirements of an anaesthesia but do not necessarily do so (e.g. immobilisation with muscle relaxants).

Clinical examination

In general, it is not possible to clinically examine or weigh the wild animal prior to chemical immobilisation. Unlike domestic animals, wild animals often mask illness as a survival trait. This means that, in most cases, immobilisation of wild animals bears a significantly greater risk than anaesthesia in domestic animals.

No premedication/Volume limitation

Under field conditions there is generally only one chance to dart a wild animal. Most remote drug delivery systems have a volume limitation of about 3 – 6 ml for distances greater than 10 – 15 m. That means that everything needed for chemical immobilisation, no matter what species, must be compressed into these 3 – 6 ml.

Fear of humans

Under field conditions, in particular, most wild animals try to avoid human contact. When darted, they will, facing their “biggest enemy”, fight the effects of chemical immobilisation as much as they can. It is therefore necessary in many cases to increase the initial darting dose to close to toxic levels (e.g. xylazine).

Antagonists

The importance of antagonists is significant greater in wild animals than in domestic animals for several reasons (s. chapter 3.2).

Delivery and dart systems

The choice of the delivery system depends on many factors. It may vary from species to species, but also from animal to animal, according to the size, distance from the operator, ability to partially confine the animal, and other circumstances.

Oral

A great variety of different drugs has been used for oral sedation of wild animals, among them acepromazine, haloperidol, perphenazine, zoletil, α-2 agonists, ketamine, diazepam-related drugs, etc. The oral route is limited to sedating the animals, but it is almost impossible to immobilise them. There are certain unpredictable circumstances in oral sedation, especially when sedating a group of hoofstock where the more dominant animals will sometimes eat much more medicated food than others. However, in some situations it can be useful.

Pole syringe

Pole syringes act as extensions of the hand for administering drugs to bigger animals in small enclosures or where approach up to 1 – 3 m is possible. They are commercially available. The injection volume is bigger than in most darts (about 12 ml).

Blow-pipe

Blow-pipes can be purchased commercially (Telinject, Daninject, Distinject) or manufactured from aluminium or plastic. The major advantage of blow-pipes is the silent projection with less trauma and reduced impact energy. The average distance for blow pipe darts is 5 – 10

m. A CO_2 pistol adapter can be added to the blow pipe, which improves accuracy and reliability. This arrangement is the projector of choice, together with CO_2 guns (see later), in a zoo environment.

Dart guns

There are many different types and designs of dart guns. Some use powder charges ("hot gas") to propel the syringes (Pax-Arms®, Pneu-Dart®), some use carbon dioxide or compressed air ("cold gas") (Telinject®, Daninject®), some companies offer both possibilities (Cap-Chur®, Dist-Inject®, Pneu-Dart®). The major problem when using dart guns is to reduce the impact energy, which depends on velocity and mass of the syringe ($E = m \times v^2/2$). It is of the utmost importance to minimise impact energy to avoid severe tissue trauma. This can be done in two ways: reduction of the syringe weight + filling volume and/or by reduction of the shot velocity. Fast darts have a flat trajectory. In order to reduce the dart velocity it is necessary to "lob" a dart. However, reducing the shot velocity means automatically reducing the accuracy because the flat trajectory will be changed into a rainbow trajectory. Consequently, when using "slow darts", it is crucial to estimate or measure the distance as exactly as possible, which is of less importance in "fast darts".

The optimal effective range for guns with a rainbow trajectory (mostly cold gas systems) lies between 15 – 30 m. Shots of greater distances (- 40 m) are possible, but bear a higher risk of missing the target, as experienced animals – i.e. animals that have already been immobilised – may have enough time after hearing the shot to jump away during the flight phase of the syringe. The temptation to use powerful projectors at close range to improve accuracy should be avoided at all costs.

The maximal effective range of guns with a flat trajectory (mostly hot gas, but some CO_2 guns can be adapted to flat trajectories by using higher CO_2 pressure) is 60 – 80 m. It must be stated, that, at this distance, projectiles can cause severe tissue trauma also in large animals.

Adjusting power: In general, cold gas projectors are more easily adjustable by increasing or decreasing CO_2 pressure. In hot gas guns it is possible to regulate dart velocity by opening or closing a ported velocity control valve or using different strength .22 calibre charges.

In general, dart guns should not be used in animals weighing less than 15 kg, in these cases blow pipes can be used. Shooting animals smaller than 60 kg at distances > 50 m should be avoided in any case, as the risk of severe injury is high.

Remote drug delivery darts

Like in the projectors, the drug delivery darts can be classified as “hot gas” and “cold gas” projectiles. In the hot gas projectiles (e.g. Pneudart, CapChur) the impact will cause the charge inside the syringe to explode when it hits the animals. A disadvantage of this system is the high velocity of the injection which can cause tissue damage, thus reducing the absorption rate.

The cold gas projectiles (Telinject, Daninject, Paxarms, Distinject) are filled and pressurised with room air or butane gas using special syringes. These darts are much less traumatic (lower weight and slower injection velocity) than hot gas projectiles.

There are more systems (spring activated or soda acid activated), which are less common and not discussed here.

Some companies offer transmitter darts, which eliminates the need to search for a darted animal disappearing in the bush. Their use is limited by two disadvantages:

- heavy darts, thus causing limited effective range and high impact energy
- unstable trajectory due to unbalanced weight in the dart, the heavy transmitter is located near the tail of the dart

In the experience of the author, Pneudart offers the best solution to date.

Target sites

The best injection sites in mammals are where large muscle masses are present. The darter must try to hit the animal perpendicular to its surface with the dart. The most suitable regions are: neck, shoulder, hindquarters. Try to avoid the head, abdomen, thorax, legs or joints. Darting an ostrich, the thighs are the target sites.

Planning and organisation of an immobilisation

Pre-darting aspects

When preparing chemical immobilisation, the following should be considered:

- *Species*: Every species requires its own species-specific capture technique.
- *Tameness*: In general, animals of a given species require under zoo conditions much less (up to 50% less) of a particular immobilisation drug than under field conditions.
- *Darting distance*: The darting system/technique used depends on how close the darter can get.

- *Terrain*: The flight distance of darted animals depends on many different factors. It varies a lot between species and can be as much as several 100 meters in ungulate species. In rough terrain enough personnel may be needed to search for the darted animal. Alternatively, transmitter darts can be used to alleviate the search. Aquatic animals (marine mammals, beavers, etc.) must be kept in a dry place without access to water, as they will seek refuge in the water after being darted.
- *Feeding times*: Animals in enclosures are best approached during the feeding times. However, this might prove difficult, as the animals will note any differences in the feeding routine.
- *Purpose*: The purpose of the immobilisation (transport, identification, surgery/therapy, etc.) influences the choice of immobilising drug.
- *Weather/Temperature*: Immobilisations in extreme temperatures (> 27°) should be avoided as some of the drugs used for immobilisation may inhibit the ability to regulate body temperature. Severe capture-induced hyperthermia or hypothermia can be life-threatening. At very cold temperatures (<-20°C) the drugs in the syringes can freeze within a very short time (30 seconds). Adding 1-2 drops of propylene-glycol to the syringe can help avoid this. Also consider that warm weather will increase the efficiency of the carbon dioxide projector, cold will have the opposite effect.
- *Time of day*: Apart from avoiding the hottest time of the day, captures late in the day impose the risk of losing a partial drugged animal in the dark.
- *Time of year*: Many species in temperate areas (many deer species, chamois, etc.) have considerable differences in their metabolic rate during the year (slower metabolic rate during late winter months), thus influencing the amount of drug being used. Note that some truly hibernating species such as the Alpine marmot can reduce their body temperature after immobilisation to 20°C for several days without posing any harm to their body.
- *Chasing*: Avoid chasing the target animals under any circumstances (this is, of course, not possible when shooting from a helicopter). Stressed animals will require much higher drug dosages, which are very close to toxic concentrations. In addition, stressed animals are much more prone to capture related diseases such as capture myopathy.
- *Hierarchical status/mobbing*: When immobilising animals within a group be aware of the fact that darted and struggling animals might get attacked and killed by group members very easily. This can happen in darted dominant animals when the lower ranked individuals try to use the opportunity to gain hierarchical standing.

Post-darting aspects

- *Undisturbed induction time*: After darting, do not follow the darted animal immediately. Wait at least 10 minutes before leaving your position (except under potentially life-threatening circumstances such as drowning in standing water or potential attacks by group members). The undisturbed induction time is much more important than in domestic animals (s. chapter 1.4.).
- *Optimise contact*: When approaching an immobilised animal, try to avoid any noise and start the approach from the dorsal aspect (back) of the animal. In potentially dangerous animals, try to ascertain the depth of anaesthesia from a distance using a stick.
- *Blindfold*: First thing after the successful approach, place a blindfold over the animal's eyes.
- *Correct positioning*: Ruminants should be kept in sternal position or, if this is not possible, position them on the right side. To prevent potentially fatal consequences of regurgitation, the head should be elevated in relation to the body, pointing downwards. Elephants must lie in lateral recumbancy, sternal positioning would impair respiration due to the weight of the digestive system on the diaphragm.
- *Monitoring*: Start to monitor the immobilised animal immediately after the successful approach. The most practicable methods in the field are temperature, respiration rate, heart rate, mucous membrane colour, capillary refill time and reflexes. In addition, oxygen saturation and blood pressure could be monitored by portable instruments.
- *Examination*: Examine the animal from the head to the tail for any abnormalities, including dart wounds.
- *Supplemental dosing*: If supplemental dosing is needed for a partially immobilised animal, use half of the initial drug combination amount as a rule of thumb, or use ketamine alone instead. If the supplemental dosing has no effect, abort the capture. Never ever force a chemical immobilisation.
- *Antagonists*: In most cases, immobilising drugs in wild animals in the field should be antagonised for several reasons:
  - Predation: All animals – pray animals or predators – are subject to predation if immobilised in the field. When left alone under such conditions after the procedure, the drugs have to be antagonised.
  - Medical complications: Unlike in veterinary hospitals, anaesthesia or immobilisation must be aborted in case of severe clinical problems (hyperthermia, shock, bloat, regurgitation, etc.).

- Transport: In case relocation is necessary, wild animals must be transported awake and must therefore be antagonised prior to their transport.

- *Human safety*: Almost all the immobilising drugs are potentially dangerous to humans. Because of the high toxicity and commonly high concentration of these drugs, exposure to even minimal amounts can be fatal to humans.

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RHINO ANAESTHESIA NOTES
Ch. Walzer

Many zoo rhinos, which are used to humans, are kind and good-natured. They tolerate minor manipulations and will lie down when being rubbed between the legs, stomach, mammary gland, or preputium. Nevertheless, one should always keep in mind that they can be up on their feet in seconds. Chute training can and should be used for minor manipulation such as blood sampling, etc. The following dosages are meant to serve as a guideline. The character of each individual should be considered prior to any procedure.

Sedation

Sedation is indicated for minor manipulations (blood sampling in untrained animals, translocation, etc.). Various drugs can be recommended. They vary with regard to onset and duration of the sedative effect. The choice of drug depends on when and how long a tranquillizing effect is desired.

The following drugs have been used on a variety of occasions: To reduce anxiety, aggression and capture/transport related stress (Atkinson, 2001; pers. com.). The experience with these drugs has shown that they proved highly effective in transports and pre-transport related training. During transportation most animals remained calm, were eating and fewer problems occurred when reaching a new zoo / enclosure / environment, than those which were crated and transported without any drugs. Especially in long distance transportations some of these drugs should be given serious considerations.

<u>The following drugs have been recommended</u>:

Diazepam (Valium®)

0.5-1.0 mg/kg BW per os (Göltenboth, 1995), lasting for 60-90 min.

Azaperone (Stresnil®)

0.05-0.1 mg/kg IM. (Atkinson, 2001; pers. com.), 100-200 mg total dose for an adult IR. Will last for 2-3hours.

Acepromazine (Vetranquil®, Aceprom®, Combistress®, Neurotranq®)

0.5-1.0 mg/kg BW per os (Göltenboth, 1995), lasting for 4-8 hours.

Detomidine HCL (Domosedan®) 8 – 14 mg IM total dose for adult White Rhino alone or in combination with **Buthorphanol** (Butomidor®, Turbogesic®) 8 – 14 mg IM total dose. Onset IM 20 minutes, duration 1 – 2 hours. Can also be used IV at a reduced dosage of 4 –6 mg Detomidine + 4 – 6 mg Butorphanol. (Walzer 2002 used in 60 + minor procedures) Can be used as an adjunct in Ethorphine anaesthesia (see below).

Haloperidol USP (Serenace® , Haldol®)

0.05–0.1 mg/kg per os (Atkinson, 2001; pers. com.) (max. 200 mg for an adult male IR), lasts up to 16 hours.

NB! Various formulations of Haloperidol exist – duration of action!

Zuclopenthixol acetate (Clopixol-Acuphase®)

Up to 300 mg for an adult rhino (Atkinson, 2001; pers. com.). Onset of action 1 hour after administration, tranquillisation effect will last for 72 hours.

Perphenazine enanthate (Trilafon LA®, Decentan®)

500 mg (2.800 kg) s.c. (behind the ear) were used in one occasion (Rietschel, 1998). Average dosage for an adult IR: approx. 200-300 mg (50-150 mg in juveniles and sub-adults). The effects are seen 10-16 hours after deep IM injection, peak effect is usually reached after approx. 72 hours. Duration of this form is described as being up to 7 days (Atkinson, 2001; pers. com.).

Anaesthesia

General comments:

Monitoring of anaesthesia is essential in Rhinos. In procedures in which the animal is recumbent ventilation / perfusion mismatches will occur. Initial respiratory acidosis can furthermore be aggravated through metabolic components. Minimum monitoring requires the use of a dedicated person, and a pulseoximeter. Ideally sequential arterial blood gas analysis should be performed and a capnograph used.

Make sure that both nostril airways are free and off the floor – provide additional oxygen through a nasal tube.

NB! Tracheal intubation possible in Black and Indian Rhino but extremely difficult and time consuming in White Rhinos.

Ethorphine (M99®) and **Etorphine-acepromazine** (Large Animal Immobilon®)

Is the 'drug of choice' for anaesthesia in rhinos and is often used in combination with detomidine (Domosedan®), butorphanol (Turbugesic®), ketamine (Ketaset®, Narketan®, Vetalar®), and xylazine (Rompun®, Xylazine Injectable®). As pre-medication some of the drugs mentioned above have been used as well.

Others prefer the combination of etorphine, ketamine, and detomidine (Atkinson, 2001). The combination of butorphanol, detomidine, and etorphine was successfully used in White rhinos (Walzer et al., 2000, 2001, 2004).

There are a number approaches for anaesthesia in Indian rhinos. The three most common ones are listed here:

APPROACH 1: (Indian and Black Rhino)

Some zoos use Large Animal Immobilon® alone (dosages see below) and top up either with ketamine or LA Immobilon® during anaesthesia (Göltenboth, 1995).

LA Immobilon®

(per ml: 2.45 mg etorphine HCL and 10 mg acepromazine) 1.2-1.6 ml (2.94 mg-3.92 mg) for an **adult** animal

In some cases the dosage of LA Immobilon® increased to1.8-2.0 ml (4.32 mg-4.9 mg) for females and 2.5-3 ml (6.13 mg-7.35 mg) for males with the frequency of sedation (Flach, 2000; pers. com.).

A 10-year-old Indian female being eight months pregnant was safely anaesthetised by using 1.5 ml LA Immobilon® (Schaftenaar, 2000; pers. com.).

This high dosage can be avoided by combining LA Immobilon® either with a previous dosage of perphenazine (see above) or with ketamine / xylazine or xylazine alone. Stress syndromes were significantly reduced and the combination led to a good anaesthesia.

Ketamine/Xylazine	30-50 mg (each)
Xylazine	50 mg
Perphenazine	500 (300) mg per adult animal three to five days prior to anaesthesia, s.c.

<u>Reversal</u>

Diprenorphine (Revivon LA® per ml: 3.26 mg diprenorphine HCL). This drug has agonistic and antagonistic properties 1 ½ -2 the amount of LA Immobilon® half IV, half IM.

NB! Beware the agonistic properties especially in white rhinos.

APPROACH 2: (Indian Rhino)

The combination of etorphine, detomidine, and ketamine had been used successfully in over 24 anaesthetic episodes of an adult male Indian rhino at 6-8 weeks interval (Atkinson, 2001).

Etorphine (M99®)	3.7 mg in combination with
Detomidine	14 mg and
Ketamine	400 mg

All drugs were given together IM. During anaesthesia, ketamine was used (100-250 mg IV) for maintaining a good sedation.

Reversal

Naltrexone (Trexonil®, Trexan®)

It is a pure opioid antagonist, which avoids the problems associated with re-narcotisation (150-300 mg divided IV / IM).

APPROACH 3: (Black, Indian and White rhinos)

Used in **Black, Indian and White rhinos** (southern and northern subspecies), the following combination was successfully used in over 140 procedures (Walzer et al., 2000, 2001, 2004):

Butorphanol	10-15 mg per adult animal and
Detomidine	10-15 mg per adult animal

Wait 15-20 minutes, then apply:

LA Immobilon®	0.8-1.4 ml

Dosages depend highly on age, state of health, and nature of the animal. In safari park – large enclosure situations 200 mg ketamine is additionally added to reduce the “pacing effect “ of the Ethorphine – animals remain “glued” to the ground

Reversal

Reversal was achieved by injecting 250 mg naltrexone (Trexonil®) and 20 mg atipamezole (Antisedan®), given combined IV. Omit the use of atipamezole if you what slight sedation due to alpha – 2 agonist post procedure.

Important considerations before and during anaesthesia

- No stressed, nervous animal should be sedated. The risk of fractured bones, pulled tendons or broken horns is high.

- Stressed animals also need a higher dosage for full anaesthesia. The risks associated with this drug increase. (One 6-year old rhino died under anaesthesia of heart failure. He had been sedated with LA Immobilon® on several occasions before, due to severe foot problems. He needed increasing doses for induction due to aggression, possibly associated with the pain from the foot lesions. In addition he was topped up as well during anaesthesia (Flach, 2000; pers. com.).
- Rhinos tend to push their head between bars when going down. This can be avoided by using appropriate covers of heavy wooden panels. Enough staff should also be available in case of emergency. (The staff has to be experienced and aware of the risks.) The use of adjuncts to the ethorphine anaesthesia also reduces the "head press" effect.
- No slippery substrates should be on the floor for sedation. The animals tend to slip when going down. Rubber mattresses, which cover the whole ground are ideal, sand might prove helpful as well. Straw bales should be available to cover hard edges etc. On wet floors the use of cement powder has proven very useful in reducing slipping.
- No food for at least one day (esp. hay, straw) - minimises the risk of regurgitation. NB! Walzer et al. Do not recommend this as it appears unnecessary.
- Helpful tools:Straw bales (to assist in comfort when the animal goes down).Ropes (to pull / hold the animal in case this is needed).Non-translucent blankets (to cover the eyes as soon as the animal lays down).
- Ear plugs to reduce effect of noiseIn Wild / Safari Parks Water (to cool the animal if needed. Immobilisation on hot days should generally be avoided).
- Oxygen (essential in order to ensure adequate supply, especially if the head lies in an awkward position), emergency case (Doxapram®, 10 mg Nalorphine, naloxon, antidote), pulsoximeter (clip on the tongue, the ear, vulva).
- Make sure you have the human antidote naloxon (Narcanti®) ready before drawing up Immobilon.
- Injection site: muscles of the neck, between the folds, or the medial side of the leg. Use adequate needle length – at least 55 mm.
- After injecting etorphine, it takes on average 10 minutes for the animal to become recumbent.
- Ensure intravenous access (ear veins). Eye ointment should be applied before covering the eyes with a blanket. It is often helpful to put cotton wool into the ears to avoid stimulation, especially when working with noisy tools.
- Close monitoring of heart and breathing rate. Average parameter under anaesthesia are:
    - Heart rate: (50) 65-90 /min
    - Respiratory rate: 6-10 /min
    - $Sa0_2$ - mean: 77-89 %

- For surgical work on the feet, straw bales should be available to put the legs on. Hard material should not be used as it might lead to temporary nerve damage as a result of prolonged compression of the neural tissues.
- Reversal takes about 1-2 minutes (it is possible that the animal becomes re-narcotised during the following hours if not enough Revivon® has been applied, esp. when the animal had to be topped up with Immobilon®). By using naltrexone, a pure antagonist, one can avoid the risk associated with re-narcotisation.

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EXPERIENCE – A MEASURABLE ANAESTHESIA BENEFIT

By C. Walzer,[1] S. Silinski,[1] F. Göritz,[2] R. Hermes,[2] T. Hildebrandt,[2] F. Schwarzenberger[3]

Extended Abstract

In order to elucidate the problems of poor reproductive performance in captive white rhinoceros *(Ceratotherium simum),* the European Endangered Species Program (EEP) committee has encouraged intensive and serial reproductive monitoring in this species (SCHWARZENBERGER et al. 1999). Although the reasons for these problems have not been identified definitively, a multi-disciplinary, multi-institutional research proposal aims to work on possible solutions. The overall objectives of this project are to use an integrated approach to enhance breeding of southern white rhinoceroses in the EEP (SCHWARZENBERGER et al., 2001). The development of a reliable and safe anaesthesia method was an essential factor in this project. During the period March 1999 to January 2003 more than 110 elective anaesthetic events were performed using a combination of Detomidine–HCL (Domosedan®, Orion Corp. Farmos Finland), Butorphanol (Torbugesic®, Fort Dodge Animal Health, Iowa, USA) and additional Ethorphine-Acepromazine (Large Animal Immobilon® C-Vet Veterinary Products, Lancs, UK). Anaesthesia was reversed in all cases with an i.v. combination of Naltrexone (Trexonil® Wildlife Laboratories Inc., Fort Collins, Colorado, USA) and Atipamezole (Antisedan®, Orion Corp. Farmos Finland) (WALZER et al., 2001).

We wanted to evaluate if the experience gained over the course of these numerous anaesthetic events directly benefited the animals – was anaesthesia measurably better due to our experience?

Seventy-four well-documented individual anaesthetic events between 07.01.2000 and 24.11.2002 were evaluated. The events were numbered sequentially in order of occurrence. In this initial study 3 arterial blood-gas derived criteria were used to define anaesthesia quality 1) pH; 2) $PaCO_2$; 3) PaO_2. Arterial blood samples were drawn from an auricular artery. The arterial blood samples were processed immediately with a portable blood gas analyzer (i-Stat®, SDI Sensor Devices Waukesha, Wisconsin USA). For this evaluation 217

individual samples were used for pH and $PaCO_2$ and 188 samples for PaO_2. Prolonged recumbency in white rhinos is associated with hypoventilation resulting in hypercapnia, hypoxemia and respiratory acidosis (WALZER et al., 2001; HEARD et al., 1992). We therefore assumed that the average pH and PaO_2 would increase and $PaCO_2$ would decrease with anaesthetic quality.

The data was analysed in SPSS v.10.07 (SPSS Inc., Chicago, Illinois 60606, USA). A logistic correlation between independent function 'experience' as defined by the sequential order of anaesthesias over time (with 1 being the procedure with the least experience and 74 with the greatest accumulated experience) and the dependent functions pH, $PaCO_2$ and PaO_2 was calculated. The results are shown in Figs. 1-3.

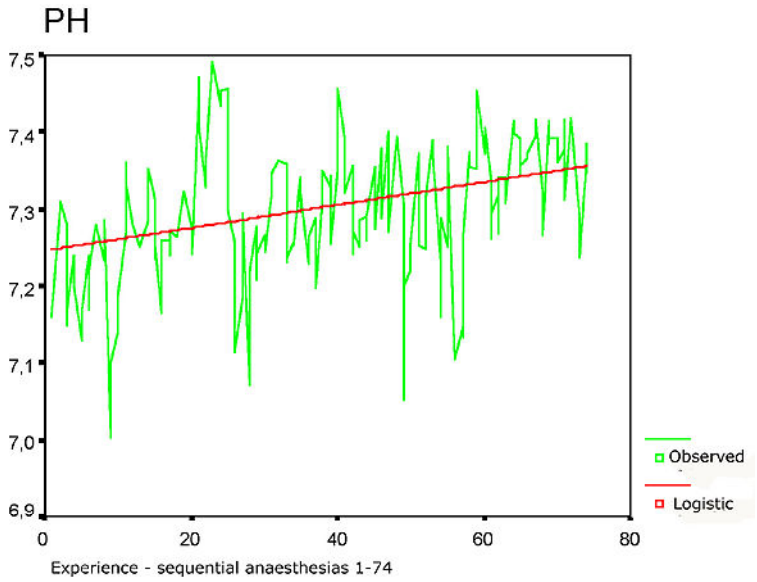

Fig. 1 Correlation: Experience and pH (r2 =0.146; p<0.001)

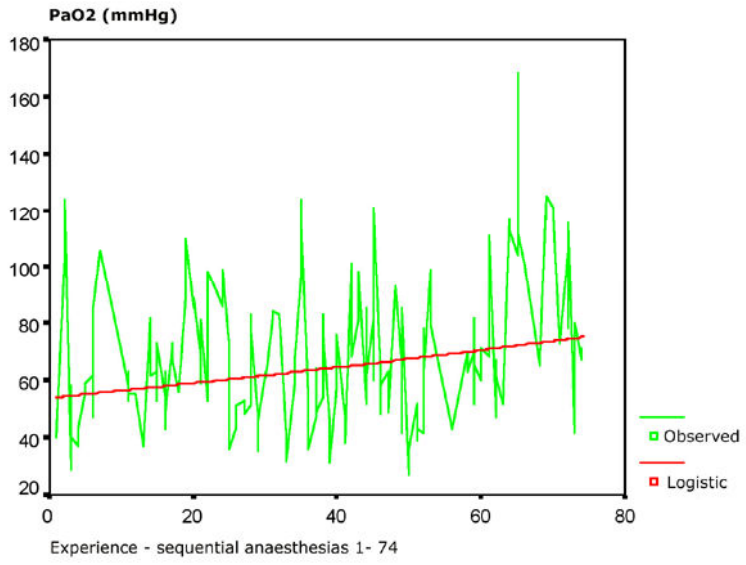

Fig. 2 Correlation: experience and PaO_2 mmHg (r2 =0.064; p<0.001)

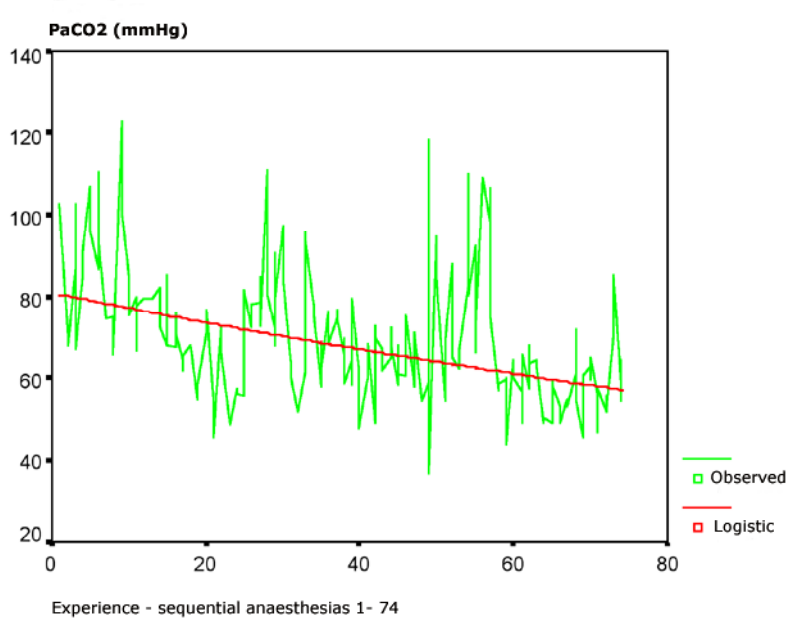

Fig. 3 Correlation: experience and $PaCO_2$ mmHg (r2 =0.225; p<0.001)

Though these evaluated anaesthesias are influenced by a multitude of factors (e.g. various procedures, sex, individual animal variation) the results demonstrate that there is a significant correlation between the number of procedures and an increase in the average pH, PaO_2 and a decrease of $PaCO_2$. Though the r^2 values are not very high a marked improvement in the anaesthesia quality can be attributed to experience and the subsequent protocol development and enhancement over time. However, it is important to note that the collated data clearly demonstrates that rhinoceros anaesthesia was associated with hypoventilation resulting in hypercapnia and respiratory acidosis in all cases. Additional efforts into improving and adapting this protocol in the future are warranted. Familiarity with the anaesthetics and their effect on the target species and consequent monitoring allow for an improved anaesthesia management and constitute important safety factors in the rapid recognition of problem onset.

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ANESTHESIA MANAGEMENT IN WHITE RHINOS FOR REPRODUCTIVE EVALUATION, SEMEN COLLECTION AND AI – A TEAM APPROACH

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Extended Abstract

In order to elucidate the problems of poor reproductive performance in captive white rhinoceros *(Ceratotherium simum),*[8] the EEP committee has encouraged intensive and serial reproductive monitoring in this species. Although the reasons for these problems have not been identified definitively, a multi-disciplinary, multi-institutional research proposal aims to work on possible solutions. The overall objectives of this project are to use an integrated approach to enhance breeding of southern white rhinoceroses in the EEP. Focus is placed on older non-breeding animals (F0 and F1). These older animals are targeted in order to conserve their genetic potential within the breeding program. Our combined approach to enhance breeding and overcome reproductive problems includes endocrine monitoring, transfer of animals to enhance natural breeding, and the development of artificial insemination (AI) techniques (see Schwarzenberger et al. these proceedings).

The transfer of animals between institutions requires only minimal applications of chemical restraint. Although several authors have demonstrated that ultrasonographic evaluation of the genital tract and semen collection are possible on unrestrained animals,[4,6,7,9] this requires the commitment of a minimal training program and zoo management/keeper compliance. Presently with exception of the Salzburg Zoo,[9] no rhino chutes are available within the EEP. Various authors have described anesthetic procedures in white rhinos. [1,2,3]

During the period March 1999 to July 2001 a total of 53 elective anesthetic events were performed on 14 male and 28 female animals. Using the experience gained with the combination of Detomidine–HCL (Domosedan®, Orion Corp. Farmos Finland) and Buthorphanol (Turbugesic®, Fort Dodge Animal Health, Iowa, USA) in the standing sedation

of white rhinos, and the experience with this combination and additional Ethorphine-Acepromazine (Large Animal Immobilon® C-Vet Veterinary Products, Lancs, UK) in Przewalski´s Horses (Equus prezwalskii)[10] we elected to apply this combination in the white rhinoceros.

Following a pre-anesthesia evaluation questionnaire (institution veterinarian and Rhino keeper) all animals (estimated weight range 2000 – 3100 kg) were initially sedated with a combination of Detomidine-HCL 10 - 15 mg; and Butorphanol 10 - 15 mg. This combination was injected into the neck muscles caudo-ventral to the ear using a dart pistol and 3.5ml plastic darts with a 60-mm needle (Dan-inject International Gelsenkirchen, Germany). After 20 minutes anesthesia was induced with intramuscular Ethorphine 3 ± 0.6 mg and Acepromazine 12 ± 2.5 mg. In safari park settings or when it was deemed difficult to dart an animal twice induction was carried out with an initial combination of all three drugs. In most procedures an additional i.v bolus application of Ketamine 100 – 300mg (Narketan®, Chassot AG, Bern, Switzerland) was
used to reduce the time to lateral recumbancy, and thus facilitate the correct placement of the animal within the enclosure. A heavy-duty tire inner tube was placed beneath the shoulder in order to alleviate possible compressive trauma. All animals received supplemental oxygen at a rate of 15 l/min through a nasal tube. The mean duration of anesthesia was 76 ±48 min and a total down time in excess of 50 hours has been accumulated during these procedures. Anesthesia was reversed in all cases with an i.v. combination of Naltrexone 250 mg (Trexonil® Wildlife Laboratories Inc., Fort Collins, Colorado, USA) and Atipamezole 20 mg (Antisedan®, Orion Corp. Farmos Finland). Reversal was smooth and without signs of excitation. All animals were standing and alert approximately 2 min following administration of the antagonists.

Once in lateral recumbency, rhino monitoring included measurement of the heart rate by direct cardiac auscultation and Doppler; Respiratory rate by direct observation of thoracic excursions. The percent oxygen saturation of hemoglobin (SpO_2) was continuously monitored using a hand-held pulse oximeter (Nellcor NP-20, Hayward, California USA). The ideal placement of the probe varied between individuals. Sites used included, the medio-proximal aspects of the front leg, the mammary gland, and using reflective probes the nasal and oral mucosa. Additionally sequential venous blood samples were drawn from auricular veins. Arterial blood samples for monitoring purposes were drawn from the auricular artery. The arterial blood samples were processed immediately with a portable blood gas analyzer (i-Stat®, SDI Sensor Devices Waukesha, Wisconsin USA).

Mean heart rate was 97 ±47 bpm and in most cases decreased over the duration of the anesthesia. Mean respiratory rate was 6 ±3 breaths per minute, and in most cases remained stable during the procedure after a phase of initial stabilization (mean 20 min). Both the heart rate and the respiratory rate were influenced by the procedures (ultrasound, electroejaculation, etc.) being carried out and must be evaluated in this context. Mean SpO_2 values were 83.5 ± 13 % with supplemental nasal O_2 (measured over the total time frame). SpO_2 gradually increased over the duration of anesthesia in most individuals.

Collection of sequential arterial blood samples from the auricular artery proved difficult under the field conditions but markedly improved with experience. The evaluation of the

arterial samples revealed an extremely low mean pH of 7.29 ± 0.08; The arterial carbon dioxide partial pressure (PCO2) revealed a marked hypercapnia 73 ± 13 mmHg which

remained relatively constant in each individual over the complete duration of anesthesia. The arterial oxygen partial pressure (PO2) varied greatly between individual animals but on the whole demonstrated a mean tissue oxygenation of 67 ± 23 mmHg. In all animals where sequential samples were obtained, PO2 increased over the duration of the procedure. Oxygen saturation (SO2), the amount of oxyhemoglobin expressed as a fraction of the total hemoglobin able to bind oxygen, is a useful predictor of the amount of oxygen that is available for tissue perfusion. In all measured samples SO2 were elevated when compared to the pulse oximetry derived oxygen saturation values. Low SpO2 values always corresponded to low S02 values and should be acted on accordingly. While this partially validates the use of pulse oximetry, severe pitfalls are possible and the reader is referred to Saint John (1992) for a discussion of the limitations. Elevated mean Base Excess (BE) 10 mmol/l and HCO3 34 mmol/l values demonstrate a primary respiratory acidosis with metabolic (compensatory) alkalosis.

Similar to the experiences in Prezwalski´s horses,[10] the combination of ethorphine, buthorphanol, and detomidine provided a safe and reliable method for long term anesthesia in the white rhinoceros. These initial findings correspond in principle to those described by other authors.[1,2,3] In our experience the agonistic / sedative properties of buthorphanol seem to outweigh any possible antagonistic properties in this species, although this is unknown. As we already described in the Przewalski horse,[10] the pacing – a normal side effect with ethorphine – is greatly reduced due to the addition of buthorphanol and enhances the safety of the procedure in many enclosures. The animals suffer from marked hypercapnia and severe hypoxemia. As observed by Heard et al. 1992, this recorded hypoxemia may be adequate for tissue oxygenation due to higher oxygen affinity of hemoglobin and lower tissue metabolic rate in large mammals. It is possible that our incorporation of butorphanol into the

initial dart protocol may have helped partially antagonize some of the respiratory depressant effects of etorphine and thus improve SpO_2 values in this study. The average arterial carbon dioxide partial pressure measured in our procedures is markedly elevated when compared to those described by Heard et al. (1992) in one animal.[2]

Prolonged recumbency in white rhinos is associated with hypoventilation resulting in hypercapnia and respiratory acidosis. Through the provision of supplemental oxygen the severity of hypoxemia can be limited. Pulmonary shunting and ventilation/perfusion mismatch also likely play a role in recumbent anesthesia of the white rhino. It is the authors opinion that in order to fulfill the necessary monitoring and therapeutic interventions in long-term rhino anesthesia it is essential to establish an anesthesia team with individually clear defined tasks.

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Interesting Books

1.
Chemical immobilisation wild and exotic animal
Leon Nielson
Iowa state university press
ISBN:0-8138-2936-4

2.
The capture and care manual
Edited by Andrew A. McKenzie
Wildlife Decision Support
ISBN 0-620-17608-3

3.
Handbook of wildlife chemical immobilization
Terry Kreeger
ISBN: 0-9654652-0-9
Ordering information for european orders:
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Interesting links

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