UNIVERSIDADE LUSÓFONA

**CENTRO UNIVERSITÁRIO DE LISBOA**

FACULDADE DE MEDICINA VETERINÁRIA

MESTRADO INTEGRADO EM MEDICINA VETERINÁRIA

# VETERINARY INTERVENTIONS SUPPORTING CONSERVATION MANAGEMENT

## Overview of wild terrestrial mammals of Mozambique

Relatório de estágio apresentado a provas públicas para a obtenção do grau de mestre em Medicina Veterinária, orientado pelo Professor Doutor Tiago Alexandre Leandro Gomes e Dr. João Simões de Almeida (Orientador externo).

Leonor Campos de Moura Souto, nº 21801699

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VERSÃO FINAL

Relatório de Estágio defendida em provas públicas na Universidade Lusófona, Centro Universitário de Lisboa, no dia 12/02/2025, perante o júri, nomeado pelo Despacho de Nomeação n.º: 57/2025 de 9 de Setembro, com a seguinte composição:
Presidente: Professora Doutora Cátia Marques
Arguente: Professora Doutora Sónia Fontes (Escola Universitária Vasco da Gama).
Orientador: Professor Doutor Tiago Alexandre Leandro Gomes
Este trabalho também foi orientado por: Dr. João Simões de Almeida (Orientador externo).

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# RESUMO

Com o crescimento populacional e a sobre-exploração dos recursos naturais, a conservação da vida selvagem tornou-se crucial.

Os veterinários fazem parte de equipas multidisciplinares necessárias às intervenções de conservação e têm um papel crítico pois são necessárias capacidades médicas para manter o bem-estar destas espécies selvagens quando manipuladas. Mas para haver um impacto real, os veterinários têm de trabalhar em conjunto com entidades nacionais e internacionais para implementar diretrizes que regem o comércio internacional de animais e produtos de origem animal (Convention on International Trade in Endangered Species - CITES), que ensinam as comunidades a conviver pacificamente com a fauna selvagem, que protegem a saúde e o bem-estar dos animais e dos seres humanos, mantêm a integridade dos ecossistemas e habitats e, em última instância, conservam a biodiversidade.

Para se conseguir capturar e manusear de forma segura para a equipa, e ainda reduzir o stress dos animais, é necessário a sua imobilização física e/ou química.

A imobilização física aplica-se sobretudo para animais pequenos e para capturas de grupos de animais e inclui a utilização de redes, jaulas, cordas na maioria das vezes combinado com sedação/imobilização química.

A imobilização química envolve a administração de fármacos (tranquilizantes, sedativos e anestésicos) na maioria das vezes remotamente através de uma arma de dardos pelo veterinário. A precisão e o local correto de aplicação do dardo são essenciais para garantir a eficácia do fármaco e minimizar danos ao animal. A colocação do dardo geralmente visa áreas musculares grandes, como o ombro ou a coxa, dependendo da espécie, para garantir a absorção adequada sem causar lesões.

É um método de contenção do animal que utiliza fármacos, nem sempre anestésicos, para induzir uma perda parcial ou total de consciência, podendo ou não alcançar anestesia cirúrgica. Quando é necessária anestesia cirúrgica, o protocolo envolve um fármaco principal – geralmente um opióide potente (como etorfina e tiafentanil) para herbívoros ou uma ciclohexilamina (tiletamina/zolazepam ou cetamina) para carnívoros – combinado com um tranquilizante ou sedativo.

A segurança e sucesso deste procedimento dependem de vários fatores, como a espécie, o estado de saúde do animal e o ambiente/terreno. Para reduzir os riscos da operação, é necessário um planeamento rigoroso, determinando qual o melhor método de administração (por dart-gun, seringas, a pé, numa carrinha ou de um helicóptero) e qual o protocolo anestésico de forma a ter uma indução rápida. Após a imobilização, é aplicada uma venda nos olhos e tampões nos ouvidos do animal para reduzir estímulos externos, e a respiração é monitorizada. Após cumprir os objetivos da imobilização e tratar a ferida do dardo com antibiótico (utilizam-se antibióticos de aplicação intra mamária pois o facto de serem tubos, permite a sua inserção no interior da ferida), o veterinário administra o antídoto e a equipa espera, a uma distância segura, que o animal recupere.

A captura não é inerente de riscos para o animal. Os efeitos adversos subjacentes são causados principalmente pelo stress, pelos fármacos utilizados, pelo tempo de indução e pela posição em que o animal cai após o efeito anestésico, além de fatores como o terreno acidentado.

Iniciando pelo sistema respiratório, que acaba por ser dos mais afetados, é impactado pelos fármacos ou pela posição de queda. A monitorização do grau de oxigenação é feita observando a cor do sangue e das mucosas puncionando uma artéria. Relativamente aos efeitos cardiovasculares, com o stress há um aumento da frequência cardíaca, que pode levar a edema pulmonar.

Quanto ao posicionamento do animal após a queda e quando a equipa já se aproximou, os ruminantes deverão ficar em decúbito esternal para evitar problemas como aspiração ruminal ou distensão do rúmen. Já os animais herbívoros não ruminantes, com fermentação no intestino grosso, assim como os carnívoros deverão estar posicionados em decúbito lateral.

Já o controlo da temperatura corporal é afetado pelo stress e o tempo de perseguição da captura podendo provocar hipertermia, agravada se a temperatura ambiente também estiver elevada. A hipotermia pode desenvolver-se se as temperaturas ambientes estiverem baixas.

Outra consequência é a miopatia de captura, que é uma das principais causas de morte nos ungulados. Finalizando, também podem ocorrer traumas físicos, principalmente em terrenos acidentados.

Os objetivos da imobilização, resumidamente, são a colocação de dispositivos de localização (telemetria), translocações, tratamento de ferimentos, descorna de rinocerontes e colheita de amostras.

A colocação de dispositivos de localização é uma intervenção realizada pelos veterinários essencial para monitorizar os movimentos e comportamentos dos animais. Os componentes mais usados neste tipo de dispositivos são VHF (very high frequency) e/ou GPS (global positioning system).

As translocações envolvem o transporte de um animal selvagem de um sítio para o outro com propósitos de conservação como reforçar populações, gerir conflito e até doenças. São intervenções que envolvem um planeamento extremamente rigoroso: avaliação da adequação do habitat de destino, riscos (como doenças, impacto ecológico) e requisitos legais.

Os animais selvagens podem ficar feridos por várias razões: predação, armadilhas, ferimentos por tiros (ou qualquer outra tentativa de matar o animal). Os veterinários de vida selvagem geralmente tratam ferimentos causados por humanos, embora existam algumas exceções: quando se trata de uma espécie considerada criticamente ameaçada ou em perigo (status International Union for Conservation of Nature - IUCN) e devem ser feitos os possíveis para salvar o animal, se houver uma boa probabilidade de sobrevivência; se for um animal de uma população biologicamente valiosa, como no caso da reintrodução de uma espécie numa determinada área, qualquer animal ferido deve receber cuidados médicos.

Em resposta à grave ameaça de caça furtiva dos rinocerontes, realiza-se a sua descorna a cada 12 a 24 meses, de maneira a reduzir o seu valor comercial para os caçadores.

O procedimento deve ser realizado por um veterinário experiente e é indolor se feito corretamente. Esta intervenção não afeta negativamente a sobrevivência, saúde ou a reprodução dos rinocerontes, embora possa ocorrer um aumento do stress imediatamente após o procedimento.

No que diz respeito à colheita de amostras em vida selvagem tem dois principais objetivos: gestão e controlo de doenças e promoção da diversidade genética (exemplo: gestão de populações para garantir a biodiversidade em reintroduções). As amostras mais comuns em animais vivos incluem sangue, fezes, ectoparasitas, cartilagem e pêlos para vários estudos.

Todas estas intervenções são realizadas para combater as ameaças à conservação da biodiversidade que são a perda de habitat, o conflito entre a fauna bravia e o ser humano, a caça furtiva e o comércio ilegal de vida selvagem e surtos de doenças. A perda de espécies e biodiversidade impacta ecossistemas inteiros.

A perda de habitat é a principal ameaça à biodiversidade global e resulta da destruição, degradação e fragmentação dos habitats naturais. A destruição de habitat pode dever-se a atividades humanas como agricultura intensiva e a urbanização, ou a catástrofes naturais que levam à extinção de espécies e perda de biodiversidade. A degradação ocorre devido à poluição ou alterações climáticas, sendo agravada pela presença de espécies invasoras. A fragmentação de habitats ocorre pela sua divisão em áreas menores e isoladas devido à presença de construções humanas, o que aumenta o risco de cruzamentos consanguíneos e torna as populações mais vulneráveis a doenças e desastres.

O conflito entre os animais selvagens e as pessoas, existe quando as atividades humanas invadem os habitats selvagens e ocorrem interações negativas como danos a plantações, predação de gado e riscos à segurança humana. É uma situação desafiante para a conservação porque pode levar a que as comunidades matem os animais selvagens e enfraqueça o suporte das pessoas para os esforços de conservação. Ou seja, esta diminuição e degradação dos habitats, a expansão agrícola e a competição por recursos como água e comida são gatilhos para o conflito.

A caça furtiva perturba a dinâmica populacional e provoca declínios graves no número de espécies, especialmente em espécies de alto valor como rinocerontes, elefantes e pangolins.

As motivações desta atividade ilegal passam por incentivos comerciais e crenças culturais. A caça furtiva não é apenas uma questão de conservação, mas também uma preocupação de segurança pública, pois os lucros do tráfico de vida selvagem frequentemente financiam organizações criminosas.

A implementação de leis de conservação, como os apêndices da CITES, que regulam o comércio internacional de animais selvagens e respetivos produtos, é essencial para promover mudanças significativas. Além disso, programas de conservação complementares oferecem alternativas de subsistência e incentivos financeiros para as comunidades locais, promovendo a educação sobre os benefícios ecológicos e económicos da conservação.

A degradação do habitat e as construções humanas em áreas de conservação estreitam a interface entre animais selvagens, humanos e gado e aumentam os riscos de saúde, com impactos para a conservação e a saúde pública (*One Health*). Esta interação provoca taxas mais altas e maior gravidade de surtos de doenças endémicas (quer em humanos, quer em animais), introdução de novas doenças e zoonoses. Os veterinários desempenham um papel crucial no controlo epidemiológico através da colheita de amostras de animais vivos.

Resumindo, os veterinários desempenham um papel essencial na mitigação de ameaças à conservação, oferecendo conhecimentos que vão além dos cuidados médicos. Estão profundamente envolvidos no planeamento avaliando riscos e assegurando o bem-estar dos animais durante procedimentos como a captura e o transporte. Determinam os métodos mais seguros de imobilização, podem ainda participar na logística das operações, garantir as autorizações necessárias e preparar o equipamento e a equipa.

No terreno, há um conjunto de eventos comuns na sua maioria coordenados pelo veterinário: dar instruções à equipa, testagem do equipamento e meios de comunicação, preparação dos dardos, dardar, aproximação segura ao animal, realização da intervenção e reversão da anestesia.

Durante o estágio da autora com a Mozambique Wildlife Alliance (MWA), foram realizadas diversas operações veterinárias em várias áreas de conservação de Moçambique, das quais foram destacadas cinco neste trabalho.

A primeira operação descrita (encoleiramento de um elefante-africano, *Loxodonta africana*) teve lugar na região de Ressano Garcia, após o avistamento do animal pela comunidade. Os elefantes estão frequentemente envolvidos nos conflitos entre humanos e fauna bravia em Moçambique. A existência de migrações pelos corredores ecológicos, faz com que abandonem as zonas de conservação e entrem em plantações e povoações à procura de recursos. A colocação de dispositivos de localização é uma solução para atuar preventivamente.

Os veterinários da MWA foram de helicóptero até à zona onde o animal foi avistado pela equipa de mitigação de conflito. Um dos veterinários dardou o animal do helicóptero (protocolo anestésico: 15 mg de tiafentanil, 20 mg de azaperona e 2500 UI de Hyalase®). Durante o procedimento o animal manteve uma frequência respiratória de 6 rpm, a coleira foi colocada e ajustada antes de se reverter com 150 mg de naltrexona via intravenosa (IV) numa veia auricular. O único contratempo foi ter aparecido outro elefante que foi repelido sonoramente.

A intervenção foi bem-sucedida. O animal recuperou a consciência no espaço de 7 minutos e pôde ser posteriormente localizado e monitorizado.

A segunda operação (captura e translocação de hienas-malhadas, *Crocutta crocutta*) fez parte de um esforço para tentar repovoar o Parque Nacional do Gorongosa com predadores após a guerra civil em que grande parte da fauna bravia desapareceu deste parque. Em 2022 foram introduzidas novamente hienas e em 2023 (data desta operação) esta população foi reforçada. Para atingir este objetivo foi necessário capturar pelo menos 6 hienas da reserva de Karingani e transportá-las para o Parque Nacional do Gorongosa. Foram necessárias duas operações de captura para atingir este número de hienas.

Na primeira operação de captura, realizada ao longo de oito noites, capturaram-se três hienas e alternou-se entre dois locais de captura diferentes. Para atrai-las, foram montadas "estações de captura" onde se utilizaram carcaças de zebra, gnus e impalas amarradas com arame a árvores, além de sons de hienas e presas emitidos por uma coluna de som presa à árvore. Apesar de um início bem-sucedido (capturaram-se três hienas nas primeiras quatro noites), os desafios surgiram com o aumento do comportamento esquivo das hienas, a presença de outros animais como elefantes e um leopardo, e a dificuldade de localizar algumas das hienas dardadas. A boma de carnívoros (local cercado para albergar os animais capturados), encontrava-se a duas horas do local de captura e foram necessários reforços anestésicos administrados a cada 45 minutos durante o transporte.

Na segunda operação de captura, o objetivo foi capturar pelo menos mais três hienas numa área diferente da reserva que era próxima de uma boma de antílopes. Utilizou-se uma carcaça de impala e dois veículos: um para dardar e outro com uma caixa de transporte num atrelado. Foram capturadas quatro hienas numa noite mas um dos animais sofreu uma apneia transitória, e foi reanimado com doxapram e compressões torácicas, acabando mais tarde por morrer na boma de carnívoros. A localização mais próxima da boma permitiu fazer duas viagens numa noite transportando um dos animais numa caixa de transporte que permitiu capturar duas hienas de cada vez. Após a captura, os animais receberam fluídoterapia e já na boma antes da reversão da anestesia com atipamezole via intramuscular (IM)., foram administrados 5 ml de Catosal ® como suplementação (IM).

Os procedimentos comuns realizados a todas hienas após a aproximação dos veterinários ao animal foram vendar os olhos, colocar tampões nos ouvidos para minimizar o stresse, e tratar os ferimentos causados pelos dardos com antibiótico e só depois colocar na carrinha para serem transportadas. Os protocolos anestésicos consistiram em 70–80 mg de Zoletil® e 3–4 mg de medetomidina consoante o tamanho e idade.

Quinze dias após a segunda operação, as hienas foram recapturadas para a translocação para o Parque Nacional da Gorongosa. Foram anestesiadas com Zoletil e medetomidina e transportadas numa uma avioneta. A anestesia durou oito horas.

O objetivo da intervenção foi atingido e as hienas não tiveram posteriormente problemas de adaptação na nova localização, no Gorongosa.

A terceira operação (remoção de uma armadilha numa girafa do sul, *Giraffa giraffa*) teve lugar na área de conservação de Incomati. As armadilhas para caçar animais são normalmente de arame e não são seletivas; nesta reserva os alvos são os búfalos, mas esta girafa, descoberta pelos guardas desta área de conservação (responsáveis por vigiar os animais e atividades suspeitas de caça furtiva), foi apanhada por uma e apresentava uma lesão no membro posterior direito.

Os guardas já tinham uma localização aproximada da girafa. Com o helicóptero, a girafa foi localizada e dardada do helicóptero pelo veterinário responsável com 7 mg de tiafentanil e 7 mg de etorfina. Após 7 minutos, o animal caiu num pequeno rio, pouco profundo. Após o posicionamento de um dos veterinários no pescoço da girafa para auxiliar na sua imobilização, a venda foi colocada nos olhos do animal e a anestesia logo revertida com 140 mg de naltrexona IV, na veia auricular. A girafa estava, portanto, consciente durante o procedimento. O tratamento consistiu em cortar o arame que envolvia o membro, e que já estava a causar isquemia e edema na extremidade distal. A monitorização incluiu a verificação da frequência respiratória.

Não houve complicações apesar da queda da girafa no rio. Recuperou totalmente e a armadilha foi removida com sucesso.

A quarta operação (captura e translocação de um leão, *Panthera leo*) teve lugar no Parque Nacional do Limpopo. Existe um programa para reduzir o conflito homem-vida selvagem (promovido pela organização Peace Park Foundation), que consiste em realocar comunidades das áreas centrais de conservação do parque para zonas periféricas, zonas tampão.

Neste caso, um leão macho jovem passou para as zonas tampão e estava a caçar gado das comunidades.

A equipa veterinária partiu do Parque Nacional de Maputo, viajou de helicóptero até ao Parque Nacional do Limpopo. A reserva orientou a parte dos guardas responsáveis pela vigilância da reserva e detetar atividades suspeitas, da carrinha coberta com oleados para transportar o leão com sombra, dos jerricãs de água, dos sacos de gelo e um soprador de folhas para ajudar no arrefecimento do animal. Os guardas já tinham uma localização aproximada do animal antes dos veterinários chegarem. Durante a noite, o veterinário responsável usou sons e uma carcaça para atraí-lo, mas sem sucesso, apesar do leão se ter mantido perto. De madrugada, após horas de procura de pegadas com ajuda de membros da comunidade e vigilância aérea, acabou por se localizar o leão.

Após localizar o leão, o veterinário dardou-o uma primeira vez (150 mg de Zoletil® e 6 mg de medetomidina) do helicóptero. Foi necessário um segundo dardo (80 mg de Zoletil® e 3 mg de medetomidina), desta vez da carrinha, para garantir a perda completa de consciência. No local, foi colocada uma venda nos olhos e tratou-se da ferida do dardo, a equipa arrefeceu o leão com água com gelo e colocou-se a coleira para localização.

Durante o transporte de 4 horas para o interior da área de conservação, foram geridas as doses de anestesia e implementadas medidas de arrefecimento para combater a hipertermia (a temperatura corporal foi de 41ºC) causada pelas altas temperaturas e pela perseguição de helicóptero. Para além de reforços anestésicos, deu-se suplementação de oxigénio e dexametasona para prevenir complicações respiratórias e metabólicas.

Na área de conservação, a coleira foi reajustada e após 25 minutos da administração do antídoto (80 mg de atipamezole IM) o animal começou a demonstrar sinais de recuperação da anestesia, apesar da hipertermia.

A operação foi bem sucedida e o leão foi realocado para a área de conservação pretendida e ficou localizável.

Por último, na quinta operação são descritas três descornas de rinocerontes-brancos (*Ceratotherium simum*) em alturas diferentes e em localizações distintas: Massitonto, Sábiè Game Park (SGP), e Parque Nacional de Limpopo (PNL). Os procedimentos foram muito semelhantes em todas as operações: o animal é dardado do helicóptero (os protocolos anestésicos consistiram em 2–4 mg de etorfina com 20–40 mg de azaperona consoante a idade e o tamanho. Em seguida colocou-se uma venda nos olhos do animal, reverteu-se parcialmente a anestesia com butorfanol IV e administrou-se oxigénio intranasal. Com o rinoceronte posicionado em decúbito esternal, e após a marcação da zona de cortecom uma caneta, utilizou-se uma motosserra para cortar o corno. A zona restante do corno no animal era depois aparada e no final colocou-se terramicina em spray na região de corte. Sempre que possível retiraram-se amostras de sangue e biópsias de cartilagem da orelha. Posteriomente a anestesia foi totalmente revertida com naltrexona IV.

Na operação realizada em Massitonto, usou-se para além do helicóptero, uma avioneta para localizar os três rinocerontes dado que era uma área muito grande.Durante a intervenção, um dos machos jovens apresentou depressão respiratória significativa, por isso realizou-se o procedimento o mais rápido possível (15 minutos) e não se recolheram amostras.

No Sábiè Game Park, a fêmea adulta intervencionada apresentava uma cria. A fêmea adulta, devido à sua reatividade, necessitou de cetamina adicional para aprofundar a anestesia. Não houve complicações a nível da anestesia.

No Parque Nacional do Limpopo, além da descorna de um rinoceronte macho adulto, colocou-se uma pulseira GPS/VHF no membro posterior direito. Apesar do sucesso da operação, a intervenção enfrentou desafios logísticos com os veículos usados (carrinha e helicópteros).

O principal objetivo destas cinco operações foi garantir a conservação *in situ* e a segurança das espécies selvagens, apesar da natureza imprevisível do trabalho de campo. Todas as intervenções foram bem-sucedidas com mais ou menos contratempos. A experiência veterinária, a coordenação da equipa e papéis bem definidos foram essenciais para enfrentar os desafios únicos de cada operação.

No caso do elefante, sendo um animal de conflito, foi necessário que se atuasse rapidamente. O único contratempo e risco para a equipa que ocorreu foi aparecer outro elefante, reforçando o facto de neste tipo de operações ser necessária uma vigilância constante do que se passa à volta da intervenção. A coleira ficou bem posicionada e o elefante ficou rastreável, não sofrendo quaisquer complicações anestésicas.

A operação de captura e translocação de hienas foi a mais exigente a nível de tempo e com bastantes imprevistos. Na primeira operação as hienas revelaram-se particularmente esquivas e desconfiadas. Foram adotadas várias estratégias para as atrair: como mudar a "estação de captura", utilizar carcaças com sedativos, entre outros. Também apareceram animais como um leopardo e elefantes nos locais de captura, o que criou perturbação e as afungentou. Para além disso a boma de carnívoros onde ficaram era a 2h do local de captura, só permitindo uma viagem por noite. A segunda operação de captura, apesar da morte de um animal devido aos efeitos da anestesia, foi bem-sucedida no geral, capturando-se quatro hienas numa noite. O facto deste local de captura ser perto de uma boma de antílopes também pode ter ajudado a atrair as hienas. Em ambas as operações, após dardar, a equipa perdeu de vista algumas das hienas devido à escuridão e ao facto de terem tido tempo antes da indução da anestesia de fugir.

Durante a captura do leão, a temperatura ambiente apresentou-se muito elevada, acima dos 40ºC.Isto refletiu-se na hipertermia do animal e, consequentemente no risco de desenvolvimento de miopatia de captura (pois para além da temperatura, o tempo de perseguição foi considerável). A situação foi controlada com a administração de dexametasona e oxigénio intranasal. Não é indicado executar uma captura com estas temperaturas, contudo sendo um leão de conflito, e por questões de logística e articulação dos veterinários com a reserva optou-se por aceitar o risco para aproveitar a oportunidade. Acabou por ser uma operação bem-sucedida.

Na operação de remoção da armadilha da perna da girafa, o único imprevisto foi a queda do animal num pequeno rio, contudo não houve ferimentos ou complicações associadas. Tirou-se apenas a armadilha e não se desinfetou porque o membro afetado da girafa encontrava-se debaixo de água.

A descorna de rinocerontes segue protocolos rigorosos para minimizar o stress e complicações respiratórias, pois estes animais são muito sensíveis à anestesia. Os procedimentos são coordenados para serem rápidos e eficientes e as tarefas realizadas simultaneamente, sempre que o número de membros da equipa o permitir.

Na descorna de Massitonto, no segundo animal, a equipa que estava no terreno não chegou a tempo. São necessárias no mínimo três pessoas para realizar uma descorna, neste caso foram dois veterinários e o piloto, que também acabou por dar uma ajuda durante o procedimento. No SGP a equipa deparou-se com uma situação de uma progenitora com cria. Optou-se por imobilizar a fêmea adulta primeiro, pois podia tornar-se agressiva e protetora ou fugir e abandonar a cria. Por outro lado, a cria vai sempre permanecer perto da mãe. No

Limpopo, depois de o animal ser imobilizado do helicóptero, houve dificuldades em aterrar o helicóptero devido à dimensão reduzida da estrada. Foi necessário, por isso, gerir a situação a partir de terra, onde se encontrava parte da equipa, transferindo parte do material necessário (venda para os olhos e as substâncias anestésicas) a partir do helicóptero em pleno voo.

Para concluir, os protocolos para este tipo de intervenções e os planos de anestesia para a vida selvagem estão bem estabelecidos, mas continuam sujeitos a riscos e desafios devido a inúmeros fatores relacionados ao animal e ao ambiente. Para serem eficazes estas operações requerem um planeamento detalhado, anestesia adequada e capacidade de resposta a emergências, destacando por isso a necessidade de capacidades veterinárias nos procedimentos.

O sucesso na conservação depende tanto de políticas e gestão do habitat (entre as comunidades e populações de animais) mas também de de ações imediatas como as descritas que priorizem o bem-estar animal e a biodiversidade.

Os cuidados veterinários são essenciais para a manutenção das populações de vida selvagem em ecossistemas complexos, sublinhando a necessidade de investigação, padrões éticos e recursos adequados para proteger espécies em risco.

**Palavras-chave:** Conservação, Moçambique, Intervenção Veterinária, Mamíferos selvagens, Gestão de Operações.

## ABSTRACT

This study is based on the author's curricular internship with the Mozambique Wildlife Alliance, a non-profit organization dedicated to wildlife conservation services in Mozambique. Conservation is a complex field requiring collaboration across numerous entities and professionals, including veterinarians, whose role is essential to manage wildlife safely and supporting biodiversity goals. Veterinary interventions are crucial for conservation management, enabling the safe handling, tracking, and relocation of animals, as well as protection from threats like poaching, habitat loss, disease, and the prevention of human-wildlife conflict (HWC).

The role of veterinarians extends beyond medical care, including planning operations, species monitoring, and supporting local and international conservation policies.

To illustrate the practical aspects of conservation operations, five interventions conducted across different species and settings are detailed: collaring an African-elephant (*Loxodonta africana*) to reduce human-wildlife conflict; capturing and relocating spotted hyenas (*Crocuta crocuta*) to bolster population numbers of Gorongosa National Park; treating a southern-giraffe (*Giraffa giraffa*) injured by a snare; capturing and relocating a lion (*Panthera leo*) involved in conflicts; and dehorning white rhinoceros (*Ceratotherium simum*) to deter poaching. These operations were conducted in the Mozambican regions of Ressano Garcia, Limpopo National Park, Karingani Game Reserve, and Sábiè Game Park.



**Key-words:** Conservation, Mozambique, Veterinarian Intervention, Wild mammals, Operation management

**List of abbreviations**

ANAC - National Administration of Conservation Areas of Mozambique (from the Portuguese: Administração Nacional das Áreas de Conservação de Moçambique)

CITES – Convention on International Trade in Endangered Species of Wild Fauna and Flora

FAM – fecal androgens metabolites

FGM – fecal glucocorticoid metabolites

FPM – fecal progesterone metabolites

GPS – Global Positioning System

HWC – Human-Wildlife Conflict

IM – Intramuscular

IU – International units

IV – Intravenous

IUCN – International Union for Conservation of Nature

LNP – Limpopo National Park

M – Medetomidine

Mg - milligram

MWA – Mozambique Wildlife Alliance

RPM – respirations per minute

SGP– Sábiè Game Park

VHF – Very high frequency

Z – Zoletil®

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# I - INTERNSHIP DESCRIPTION

The present dissertation aims to describe the activities developed by the author during the curricular internship of the Integrated Master's Degree in Veterinary Medicine of the Faculty of Veterinary Medicine of Lusófona University. This disposition complies with the curricular structure and the study plan made public by Order number 15989/2009 (2nd series) published on the Portuguese Public Journal of June 13th 2009 and changed by Order number 8686/2020 of September 9th [from the original Portuguese: Despacho nº 15989/2009 (2ª Série) publicado no Diário da República de 13 de junho de 2009 e alterado pelo Despacho nº 8686/2020 de 9 de setembro].

The internship, which took place between September, 2023, and January, 2024, under the academic supervision of Professor Tiago Gomes, consisted in 2 distinct segments: A – Mozambique Wildlife Alliance; and B – Lisbon Aquarium (Oceanário).

**A- Mozambique Wildlife Alliance**

The first part of the author's curricular internship took place in Mozambique, at the Mozambique Wildlife Alliance. It started on September 1st, 2023 and ended on November 25th, 2023 under the supervision of Dr. João Simões de Almeida, Dr. Hagnésio Chiponde, Dr. Hugo Pereira and Dr. Isabel Simões de Almeida. This segment of the internship included approximately 600 hours of work.

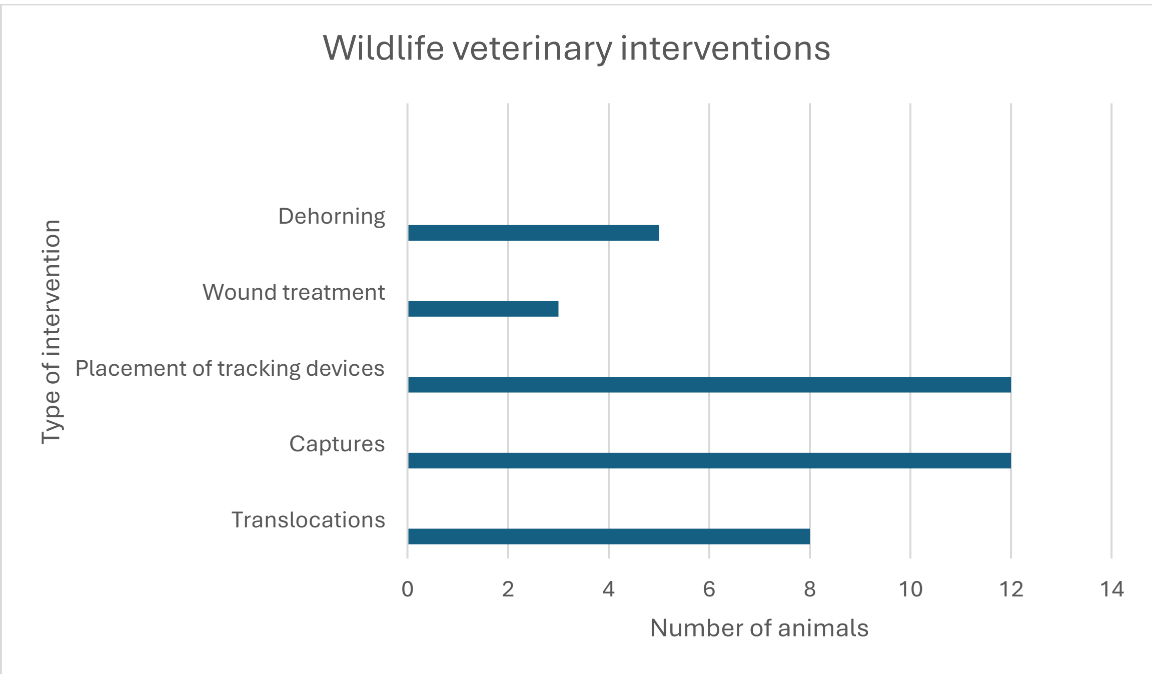
Mozambique Wildlife Alliance is an organization that works with ANAC and regional stakeholders to provide conservation services that benefit wildlife, communities and habitats throughout Mozambique (Annex C).

During this portion of the internship, the author performed interventions specially in free-ranging wildlife but also in domestic animals (dogs, cats and horses).

Table 1- Characteristics of the wild species dealt with during the Mozambique Wildlife Alliance internship in Mozambique

| Species | Scientific name | IUCN Status | Number of animals |
|---|---|---|---|
| **African elephant** | *Loxodonta africana* | Endangered | 1 |
| **African wild-dog** | *Lycaon pictus* | Endangered | 4 |
| **Spotted-hyena** | *Crocuta crocuta* | Least Concern | 7 |
| **White rhinoceros** | *Ceratotherium simum* | Near threatened | 5 |
| **Common eland** | *Taurotragus oryx* | Least Concern | 10 |
| **Lion** | *Panthera leo* | Vulnerable | 1 |
| **Southern giraffe** | *Giraffa giraffa* | Least Concern | 1 |
| **Nyala** | *Tragelaphus angasii* | Least Concern | Ind* |
| **Impala** | *Aepyceros melampus* | Least Concern | Ind* |

(*Ind: Indeterminate - it was not possible to determine the exact number).




Graphic 1 - The number of wild animals per conservation action in which the author was involved during the internship in Mozambique.

All wildlife interventions involved chemical immobilization, with a total of 29 chemical immobilizations (Table 1, Graphic 1) required for manipulation to perform captures and translocations, wound treatment, placement of tracking devices, and dehorning of white rhinoceros. There were animals on which more than one type of intervention was performed. These procedures will be further described and discussed in chapter III. The nyalas and impalas did not require chemical immobilization, they were released from the truck into the holding facility after being transported to Karingani Game Reserve and the veterinarians just accessed their health by observation (Figure 1). The main reason why the veterinarian had to be present in the offloading of the impalas, nyalas and elands was to tag with a location device eight elands (six females and two males). From the top of the truck (Figure 1a), the elands that would be tagged were chosen and with a pole syringe[1] they were immobilized. In Figure 1b, two anesthetized elands which had just been tagged with a location device in the ear.

(a) (b)

Figure 1 - Offloading a truck for reintroduction purposes: elands (*Taurotragus oryx*), nyalas (*Tragelaphus angasii*) and impalas (*Aepyceros melampus*) (original pictures from the author).

Regarding domestic animals, a week-long rabies vaccination campaign (203 animals) for dogs and cats and male castration (15 animals) (Figure 2b was carried out in more remote

[1] Pole Syringe: essentially a manual injection with the added safety of a long handle.

communities near Maputo National Park. In Karingani Game Reserve, the author also had the opportunity to help with four horses: conducting vaccinations, collecting fecal samples directly from the rectum and treating an injured hoof (Figure 2a).

(a) (b)

Figure 2 - (a) Horse with an injured hoof with affected frog *(Cuneus ungulae)* and heel*(Pars mobilis*) (b) Castration of two dogs (original pictures from the author).

**B- Lisbon Aquarium (Oceanário)**

The second part of the internship took place at the Lisbon Aquarium (Oceanário), in Portugal, between November 28th, 2023, and January 28th, 2024, for a total of 176 hours.

During this period, the author was under the supervision of Dr. Nuno Marques Pereira and Dr. Hugo David.

The Lisbon Aquarium is an institution that contributes to the conservation of marine species, education and sustainable practices.

Table 2 - The marine animal species from the Lisbon Aquarium, in which the author participated in the interventions

| Species | Scientific Name | IUCN Status | Intervention |
|---|---|---|---|
| **Elasmobranchs** | | | |
| **Lesser devil ray** | *Mobula hypostoma* | Endangered | Treatment |
| **Common eagle ray** | *Myliobatis aquila* | Critically endangered | Treatment, X-ray (Fig.4), necropsy |
| **Port Jackson shark** | *Heterodontus portusjacksoni* | Least concern | Treatment: Observation, eggs ecography |
| **Zebra shark** | *Stegostoma fasciatum* | Endangered | Treatment |
| **Leopard Shark** | *Triakis semifasciata* | Least Concern | Treatment, abdominal echography |
| **Bottlenose wedgefish** | *Rhynchobatus australiae* | Vulnerable | Weighting |
| **Pyjama shark** | *Poroderma africanum* | Near threatened | Treatment, weighting. |
| **Teleosts** | | | |
| **Wolf-eel** | *Anarrhichthys ocellatus* | Least Concern | Treatment, surgery, necropsy |
| **Spotted garden eel** | *Heteroconger hassi* | Least Concern | Treatment |
| **Ocean Sunfish** | *Mola mola* | Vulnerable | Treatment |
| **Clown anemonefish** | *Amphiprion ocellaris* | Least Concern | Necropsy |
| **European plaice** | *Pleuronectes platessa* | Least Concern | Treatment, necropsy |
| **Atlantic cod** | *Gadus morhua* | Vulnerable | Treatment, x-ray, necropsy |
| **Monkfish** | *Lophius piscatorius* | Least Concern | Treatment, necropsy |
| **Cephalopods** | | | |
| **Common cuttlefish** | *Sepia officinalis* | Least Concern | Treatment, necropsy |
| **Birds** | | | |
| **Common murre** | *Uria aalge* | Least Concern | Blood sampling - biochemistry, hemogram |

| | | | |
|---|---|---|---|
| **Razorbill** | *Alca torda* | Least Concern | Surgery |
| **Mammals** | | | |
| **Sea otter** | *Enhydra lutris* | Endangered | Training |

During this internship, the author mastered the ability to observe under a light microscope: performing manual hemogram (in elasmobranchs ‘blood), observing necropsy samples and skin scrapings from live animals to check for the presence of parasites (Table 2).

The author also participated in the training of a sea otter (Enhydra lutris) with the veterinarians (Table 2), which consisted of teaching the otter how to be handled and accustoming the animal to human contact so that if it needed medical care in the future, it would be familiar with the handling procedure.

For sharks in particular, ultrasound scans of females for reproductive control and ultrasound scans of eggs for viability (for Port-Jackson's sharks) were a common activity.

Treatment for teleosts often consisted of anti-inflammatories and/or antibiotics for animals with wounds. Condrovet (chondroprotector for joint wear) was also often administered as the chondroitin in fish stimulates healing (epidermal cells).

Figure 3 shows the surgery on a wolf eel that had a wound in its tail that was not healing. It was therefore decided to amputate the tip of the tail. The anesthesia consisted of tricaine and sodium bicarbonate (1:2) dissolved in the water.

Figure 3 - Inhalation anesthesia system in fish and maintenance of inhalation anesthesia in a wolf eel (*Anarrhichthys ocellatus*).

Radiographs were performed in marine animals under sedation (tricaine and sodium bicarbonate) as observed in Figure 4.

Figure 4 - Radiograph of a common eagle ray (*Myliobatis aquila*) taken under sedation.

# II – INTRODUCTION: LITERATURE REVIEW

With the growth of the world's population, the overexploitation of natural resources, both habitat and the animals themselves (for example, the poaching of Rhinoceros for the value of their horn), it has become important to take action to conserve wild species. Governmental entities (such as the International Union for Conservation of Nature, the United Nations Environment Programme) created the Global Conservation Strategy, which was the first action in 1980 to establish a balance and interdependence between conservation and human well-being (Bottrill *et al*., 2014). Other non-governmental organizations (e.g. Fauna & Flora International, World Wildlife Fund), agreements (e.g. the Endangered Species Act) and meetings (Convention on International Trade in Endangered Species) have played and continue to play an important role in the conservation of wildlife species (Kappus, 2023b) .

However, some of the measures developed and applied in relation to wild (and domestic) animals are ultimately dependent on veterinary intervention.

It is important to note that wildlife operations require multidisciplinary teams (IUCN guidelines) of which veterinarians are a part, and their importance is increasing, not only for health and disease management but also for conservation purposes.

Depending on the complexity and scale of the operation, a diverse and specialized team may be required, including biologists and ecologists, experts in pre- and post-operation monitoring and risk assessment, capture personnel, laboratory support, animal keepers or caretakers, logistics personnel, media coordination and management staff, laborers, qualified pilots (both helicopter and fixed-wing), security and safety officers, medical personnel, drivers and others. There are many institutions and stakeholders that can provide expertise, funding or support (universities, zoos, conservation organizations, funding agencies, wildlife departments, local communities and host government agencies) ( Kock *et al*., 2007).

Particularly in the field of wildlife conservation, veterinary medicine is changing and success in this profession requires not only technical and medical expertise, but also common sense, non-technical skills, a broad understanding of how the world works (interconnectedness between humans, animals and the environment) and an awareness that human lifestyle choices affect the environment in which we live (Mazet, Hamilton & Dierauf, 2006).

## 1. Veterinary interventions performed on free-ranging wildlife.

Working with these wild animals requires physical and/or chemical immobilization in order to place tracking devices, perform translocations, treat injuries, dehorn rhinoceros, and collect samples. Because this is a stressful event and the use of drugs is almost always necessary and can have health consequences for the animals, a veterinarian must be present.

### 1.1 Physical Restraint

Physical restraint is often used in groups of animals (e.g. impalas, *Aepyceros melampus*; nyalas, *Tragelaphus angasii*). It is supplemented by chemical immobilization when an individual animal is captured to increase the success rate and reduce stress on the animal. This type of immobilization is achieved with ropes, cages, 'squeeze cages' (combined with sedation and of varying shape and size depending on the animal), net guns[2] and traps (for mass captures) or opaque plastic sheeting (plastic/net boma[3])(Atkinson, Kock & Burroughs, 2021; Shury, 2014).

### 1.2 Chemical Restraint

For most procedures on wild animals, chemical restraint (with sedatives, tranquilizers, anesthetics) is necessary to manipulate the individual, always carried out by a trained veterinarian, for the safety of all concerned and the animal itself. Delivery systems for chemical restraint include a dart gun, pole syringe, oral medication and hand-held injection (e.g. when the animal is in a crate).

#### *1.2.1 Anesthesiology and applied pharmacology*

Anesthesia can be defined as an "intoxication" of the central nervous system that induces a controlled and reversible state of unconsciousness achieved with general anesthetics (Hawkins, Guzman & Paul-Murphy , 2020) (such as alfaxalone, tiletamine, propofol, ketamine,

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[2] Net Gun: Weapon designed to catch animals by projecting nets.
[3] Boma - Temporary plastic/net structure for mass capture. A helicopter is used to drop the animals into a boma that closes as the animals approach the loading area where they are tranquilized and loaded into transport vehicles. It can be used as an enclosure where the animals rest before being released after a translocation.

among others), characterized by lack of memory, pain, and perception, and response to any stimulus (Dugdale, Beaumont, Bradbrook & Gurney, 2020). The electrical impulse will be altered, with effects at the presynaptic level (in sodium, calcium, and potassium ion channels) and post-synaptic level (neurotransmitters and their receptors) (Platholi & Hemmings, 2022).

General anesthesia is achieved when the anesthesia triad components are suppressed, including: Unconsciousness, without perception or memory (amnesia) of any sensory or motor event; analgesia (antinociception); both autonomic reflexes (e.g. hemodynamic, thermoregulatory) and somatic reflexes (proprioceptive reflexes). However, while the suppression of the latter is desirable for muscle weakness and relaxation, a fourth component of anesthesia can be considered to be the maintenance of stability of autonomic reflexes, along with the fact that in wild animals, breathing is autonomous (spontaneous) during anesthesia (Dugdale *et al*., 2020).

Chemical immobilization is a method of restraining an animal using drugs that are not necessarily anesthetics. This term covers a variety of effects where animals are immobilized with or without partial suppression of consciousness but may achieve general/surgical anesthesia (Raath & Semjonov, 2022).

If general anesthesia is required, the protocol includes a primary drug: a strong opioid (etorphine, thiafentanil) for herbivores or cyclohexylamine (tiletamine/zolazepam or ketamine) for carnivores, combined with a tranquilizer or sedative. The animal may be sedated or tranquilized only, depending on the purpose of the immobilization (Meyer, Burroughs & Morkel, 2021)

When chemically restraining a free-ranging wild animal, the safety of the procedure and whether or not it should be carried out depends on the species (behavior and health) and the environment (ambient temperatures, terrain, habitat, wind, time of day). In order to reduce the risks of chemical immobilization, the following aspects should be considered by the team when planning the operation (Atkinson *et al*., 2021):

- The drug used: dose, route of administration, delivery system (dart gun, tranquilizer, syringes) and whether darting is done on foot, in a vehicle or by helicopter (a helicopter allows the animal's movement to be controlled before immobilization, which is very important if the animal is heading towards rough terrain or a river where it could drown);

- The induction phase (overdosing with anesthetics can result in a short induction time, with strong opioids it is preferable to go higher. If underdosed, the animal will take longer to fall, increasing the risk of accidents and mortality (Meyer *et al*., 2021).

Following induction, the team (or veterinarian) should approach the animal carefully, having ensured that it is fully immobilized, as there are cases of sudden arousal or incomplete drug delivery due to dart failure (stones can be thrown, or a long stick or syringe can be used to touch the animal, particularly in carnivores). Someone from the team then blindfolds the animal and puts earplugs in to reduce external stimulation, and the animal is placed in a safe position (for breathing). The dart is then removed, and the dart wound is treated (with antibiotic, and in the field it is easier to use the intramammary antibiotic tubes that are inserted into the wound). When all procedures necessary to achieve the objectives of the operation have been completed, the equipment is removed and personnel not required for the reversal (performed by the veterinarian) remain at a safe distance. After administering the antidote, which will reverse the anesthesia, the veterinarian moves away and waits for the animal to fully recover (Atkinson *et al*., 2021).

### *1.2.2 Dart gun and dart placement*

Dart guns are often used for chemical restraint. The Model 389 Pneu-Dart cartridge-fired projector (Pneu-Dart, Inc.) is widely used for free-ranging African mammals (Figure 5a) because of its long-range accuracy (Kock *et al*., 2021).

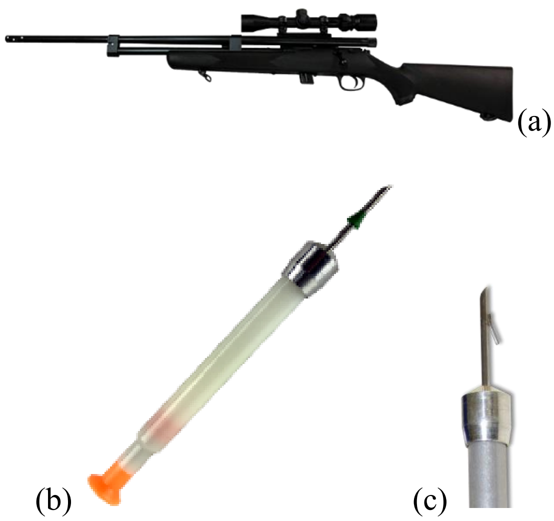


Figure 5 - Dart-gun: model 389 Pneu-Dart cartridge-fired projector (a), Type-C bulbed dart with a gelatin collar (b) and dart needle with a wire barb (c) (Pneu-dart, Inc., n.d).

The remote delivery devices (darts) are usually the pneu-dart barbed type C (needles should have a wire barb or gelatin collar (Figure 5b, 5c) to prevent the dart being pushed out of the animal's tissue). It is often necessary to use pliers to remove a wire barb dart from the animal. They can be filled with 2 or 3 ml, depending on the model. The length and diameter of the needle varies from species to species.

The charge loads used in this model (Pneu-dart, inc) are divided into three colors: brown, green, yellow with five port settings; a combination of port setting and load color determines the speed at which the dart is fired, depending on the species and distance ( Kock, Jessup, Morkel & Burroughs, 2021).

At distances of more than 40 meters, it is generally difficult to deliver drugs accurately.

The dart should be placed on the muscle mass of the shoulder, neck, withers and hump, chest [in certain species and not as a first option: southern-giraffe (*Giraffa giraffa***),** Common eland, (*Taurotragus oryx)* and African buffalo *(Syncerus caffer*) ] and hindquarters (Atkinson *et al*., 2021; Caulkett & Arnemo, 2015).

**1.3 Capture-related adverse effects or death**

The negative effects of capture are a consequence of the physiological process of stress (fight-or-flight response, release of catecholamines and glucocorticoids), the secondary effects of the immobilizing drugs, the time of induction and the position in which the animal falls, and the terrain (Caulkett & Arnemo, 2015; Meyer, Hofmeyer, Cooper & Kock, 2021a).

The respiratory system is profoundly affected by both the drugs administered and the position in which the animal falls, potentially inhibiting or preventing gas exchange. Strong opioids are of particular concern due to their tendency to cause significant respiratory depression (Lamont & Grimm, 2014),especially in species such as white rhinoceros (*Ceratotherium simum*), northern giraffe (*Giraffa camelopardalis*) and impala (*Aepyceros melampus*) (when approaching an immobilized animal of these species, immediate reversal of anesthesia with naltrexone or partial reversal with butorphanol is essential), but as rapid induction is critical, these drugs must be used (Meyer *et al*., 2021).

Oxygenation is monitored by observing the color of the arterial blood (bright red indicating good oxygenation, dark red indicating poor oxygenation) and the color of the mucous membranes (there are species such as giraffes that have dark gums, so this is not viable in the oral mucosa), as pulse oximeters are impractical in the field. Constant vigilance regarding respiratory rate and depth is essential (rhinoceros for example, can drop to four breaths per minute under anesthesia and the average normal breathing rate is 19, varying from 16 to 23 breaths per minute) (Meyer *et al*., 2021a; Ozeki & Caulkett, 2014; Van Zijll Langhout *et al*., 2016).

Emergency medicines such as doxapram HCL (stimulates cardiovascular and respiratory centers) and an oxygen cylinder should always be available (Fahlman, 2014; Meyer *et al*., 2021).

Cardiovascular side-effects are also possible. Opioids cause tachycardia and hypertension; alpha-2 agonists cause initial hypertension followed by bradycardia. Monitoring includes auscultation, assessment of capillary refill time and observation of mucosal color. Neurogenic, anaphylactic and cardiogenic shock are fatal consequences of drug- and stress-induced cardiorespiratory changes(Meyer, *et al*., 2021; Meyer *et al*., 2021a) .

The positioning of the animal is a critical consideration. Foregut fermenters [ giraffes, antelopes in general: impalas; nyalas (*Tragelaphus angasii*)*;* African buffalos (*Syncerus caffer*)] must be positioned in sternal recumbency and hindgut fermenters [common zebras, (*Equus quagga*); Rhinoceros; elephants] can also be positioned in lateral recumbency (however, since elephants have abdominal rather than thoracic breathing, sternal recumbency causes abdominal compression, so this position is only recommended for short procedures) (Burroughs *et al*., 2021; Meyer *et al.*, 2021a).

For foregut fermenters, lateral recumbency, especially on the left side, can lead to rumen distension and regurgitation, which can result in aspiration of the rumen contents, so sternal recumbency and the head should be held with the nose down and in a position that places the pharynx higher than the mouth opening to allow saliva to drain from the mouth (these animals produce large volumes of saliva). Carnivores have an emetic reflex, so ensure proper positioning to manage any vomiting, the tongue should be pulled out and the jaws open (lateral recumbency is ideal) (Arnemo, Evans, Fahlman & Caulkett , 2014; Meyer *et al.*, 2021a)

Heat regulation, which is controlled by the hypothalamic thermoregulatory center, is disrupted by most immobilizing drugs, although capture stress and exercise contribute significantly to hyperthermia. Conversely, hypothermia may result from prolonged immobilization under adverse environmental conditions (night, low temperature). Prevention strategies include avoiding capture in unfavorable conditions and having methods available to regulate the animal's temperature (Caulkett & Arnemo, 2015; Ko & Krimins, 2014; Meyer *et al., 2021a)*.

Exertional capture myopathy is a major cause of mortality in ungulates, but all animals are susceptible. Animals are not adapted to running at full capacity for long distances. Chasing wildlife with a helicopter or vehicle puts the animal under great stress. This is compounded by muscular exhaustion, which leads to lactic acid production and metabolic acidosis. Dead myocytes release myoglobin, calcium and potassium. The accumulation of myoglobin can lead to acute renal failure, and potassium and acidosis can lead to arrhythmias and heart failure. All possible measures should be taken to prevent this (e.g. shortening the pursuit time, giving higher doses to reduce the excitatory phase of induction). Treatment is not very effective, so these animals may die suddenly or succumb months after the episode (Breed *et al.*, 2019; Meyer *et al., 2021a; Paterson, 2014)*.

Physical injuries such as contusions, lacerations, abrasions, punctures and fractures are also common (Arnemo *et al.*, 2014; Caulkett & Arnemo, 2015; Meyer *et al.*, 2021a).

### 1.4. Collaring and placement of tracking devices: telemetry

Effective conservation strategies rely on accurate data and monitoring of animal movements, and to achieve this, telemetry is used. The use of collars in wildlife must have clear management, ecotourism and treatment objectives.

The two most commonly used components of a wildlife tracking collar are VHF (Very High Frequency) and satellite (using the Global Positioning System, or GPS), and the collar can have both components at the same time. Wildlife tracking began about a century ago with the use of VHF collars, which are still very useful today. These collars consist of a transmitter (collar) that can be located using an antenna. The advantages of these collars are that they are smaller (suitable for very small animals), cheaper and have long-lasting batteries (so it is not necessary to recapture the animal several times). However, in order to locate the animal, the antenna needs to be relatively close (10 to 15 km) and can be affected by various factors, especially when tracking on the ground, such as the local environment (mountain areas, for example, because of the rocks), and if the animal enters a burrow, the signal is lost(Haupt *et al.*, 2021).

Satellite tracking collars provide a very accurate position in near real time. This helps managers and researchers better understand erratic behavior, activity patterns, predator-prey interactions, migration routes and habitat preferences, and allows a more effective response to human-wildlife conflict and poaching situations.

The spectrum of research and conservation applications is constantly expanding, driven by the incorporation of a variety of telemetric sensors: accelerometers, gyroscopes, magnetometers, cameras and environmental sensors, which enable the recording of a wide range of behaviors, movements, environmental temperatures and associations (co-location) between individuals (Haupt, Kock, Hofmeyer & Allen, 2021) . Technological advances such as longer battery life, solar charging, and improved memory storage are significantly reducing the size and weight of these devices (Hofman *et al*., 2019). Despite these advances, there are still some limitations with regard to batteries: their longevity (depending on the type used, three years is usually the maximum) and size (the larger the battery, the more power and therefore the longer the transmission and reception of the VHF or GPS unit, but these devices cannot exceed 3–5 % of the animal's body mass) (Mesquita *et al.*, 2023), which vary according to the variability of each species, animal behavior, habitat and climate (Haupt *et al.,* 2021).

Another component being tested is the use of LED (light emitting diode) lights that can be remotely activated by reserve managers to easily track animals at night and on the ground. This is particularly useful for human-elephant conflict management and mitigation (João Almeida, personal communication, 2024).

The GPS location of animals plays a crucial role in the management of wildlife in large parks and landscapes, in particular by enabling geo-fencing. Geo-fencing involves setting GPS boundaries in the program (software) used, which triggers events, configurations and alarms when the animal with the collar exceeds the defined boundaries, a notification is received (mobile phone message, email). Another important motive for tracking animals is ecotourism, which generates income for conservation efforts, but the presence of these external devices must be explained to tourists to avoid misinterpretations, as they are not familiar with this subject (Haupt *et al.,* 2021).

Depending on the morphological differences between distinct species and whether it is a female or a male (due to anatomical and behavioral differences), there are various types of attachments: collars, implants (horn, abdominal and subcutaneous), screw-ons (pangolins, family Manidae), head harnesses, backpacks, leg bands, ear tags, remote barb attachments via projectiles (e.g. transmitters attached with the use of darts), glue and epoxy-mediated attachments.

When fitting collars, tighter is better in almost all cases, except for young animals that can grow and for ankle collars on rhinoceros, where it is beneficial to be slightly loose (this has clear welfare benefits).

Veterinarians usually are responsible for the fitting of these devices and must ensure that do not adversely affect the animals' long-term behavior or welfare. These devices must always be tested and adjusted prior to fitting and should then be retested. One of the major shortcomings in the fitting of equipment is the lack of budgeting or planning for the removal and recovery of equipment, which is an ethical issue. Therefore, a very common practice is the use of drop-off devices, especially when there is a slim hypothesis of recapturing the animal (Haupt *et al.*, 2021).

## 1.5 Translocations

"Translocation is the human-mediated movement of living organisms from one area, with release in another" (IUCN–SSC 2013).

Conservation translocation, which describes the deliberate movement of wildlife for conservation purposes (Batson *et al.,* 2015) , results in benefits to populations, species or ecosystems. This is achieved through population augmentation and reintroduction within a species' native habitat (native range), as well as conservation introductions, which involve assisted colonization and ecological replacement outside the species' native range (Beckmann & Soorae, 2022). It is also used to mitigate human-wildlife conflict, for commercial, political, and recreational interests, to manage disease risk, and to promote genetic diversity (IUCN/SSC Reintroduction Specialist Group, 2013). It is important to note that a translocation is not limited to transport; it involves extensive planning, capture of the animal(s), loading and unloading of the animals onto the chosen means of transport, and post-release monitoring.

To be successful, detailed planning is required because, although it is a common conservation tool, results vary, and it can be a very expensive process.

First, the objective, benefits and feasibility of this change should be established, depending on the species, ecology and human communities, through an exhaustive assessment of all these categories (feasibility phase).

According to IUCN/SSC, 2013 before animals are exported, a comprehensive assessment should be made of:

- The habitat of the receiving area (availability of resources: food and water);
- Risk analysis: disease and health in the source and recipient populations (infectious and non-infectious problems such as stress during the process and at the destination, predation and poaching for e.g. (Beckmann & Soorae, 2022), ecological risk (impact on other species), gene escape (intraspecific and interspecific hybridization), associated invasion risk, socio-economic and financial risks;
- Species selection (which individual or population source should be selected) in conservation translocations);
- Legal requirements (CITES for international transport, phytosanitary permits, veterinary movement permits), public/community engagement, habitat management and interventions (such as pathogen, predator or invasive alien species control, food provision, assisted reproduction or protective fencing, depending on the species);
- Release model: soft or hard release;
- Post-release monitoring.

Based on this assessment and a cost analysis, the team will decide whether to perform a soft release or a hard release. Soft release includes, firstly, an acclimatization period (to develop adaptive behaviors), i.e. placing the animals in an enclosure to recover from stress, to become familiar with the terrain, to adapt to the climate, to be exposed to natural (food and water) and artificial resources if necessary, and to allow them to establish intra-specific relationships. Secondly, there is pre-release anti-predator training and thirdly, there is post-release food supplementation. Hard release simply means that the animals are released without this adaptation period, not that they are not monitored afterwards(Resende *et al*., 2021). According to the study done by Resende *et al.* (2021), a meta-analysis of which option is better, even though wild-caught animals have a better chance in hard release than captive-bred animals, soft release is preferable.

Depending on the species, the number of animals, the size/weight of the animal, the method of capture (using a dart - typically for larger species such as elephants, rhinoceros, or when only a few animals are being captured - or mass capture using a plastic boma, net bomas, net lines, drop or pop-up bomas, net guns and cage traps), the duration and distance, the type of loading required by the animal (for example, using a crane for elephants), the environment (temperature, dense vegetation, roads and access are in good condition) and the type of transport available or required, veterinarians must take steps to ensure the animals' welfare: checking the vital signs, behavioral changes and if there is a possibility and qualified personnel to do it, fecal glucocorticosteroids metabolites (FGM) should be measure, to assess the physiological stress of the animal, especially in mega-herbivores and ungulates, before and after the transportation (Implementation phase) (Yang *et al.*, 2019).

The variability of results in the implementation and success of translocations is due to the unpredictability of biological and behavioral responses to different methods and external factors (Batson *et al*., 2015).

In summary, the variables that influence success are: the species (physiology and ecology), whether they are wild-caught or captive-born, ecology, genetic diversity, plasticity, the presence of an experienced and trained translocation team (safety when translocating species with high commercial value, monitoring and responding to animal escapes), local adaptation and dynamics between populations and communities (without community attachment, there is a high risk that the population will not thrive in the new habitat).

In a translocation, veterinarians are part of a team of specialists. Therefore, in order to provide an informed opinion on whether the translocation should take place, they must be familiar with all available scientific data on the species, as this may help to anticipate veterinary problems. The veterinarian's role is to ensure the health and well-being of both the animals being transported and those in the recipient area. This involves conducting a series of health analyses, including pathogen detection, serology, hematology, biochemistry, gut microbiota analysis, and parasite load assessments. These tests help determine the need for prophylactic measures.

Veterinarians must also adhere to health regulations set by the authorities of the receiving country and make necessary quarantine arrangements. During transport, monitoring physiological parameters is critical, especially for long translocations, to ensure the animals remain calm and stress-free. Treatment of any injuries that occur during capture or transport is also essential.

There is an increased risk of disease transmission during intercontinental transport, so careful monitoring for behavioral changes (often the first sign of health issues) is vital. This includes being vigilant for infectious agents, particularly those that pose zoonotic risks or affect livestock health (Kock *et al.*, 2007). Additionally, knowledge of the species' physiological and behavioral traits is crucial, and input from animal keepers (if it is a captive animal) can provide valuable insights.

Prior to release, ensure that the animals are in good physical condition, use tracking devices, carry out health assessments (FGM for e.g.) and treat/supplement, if necessary, modify behavior in the boma/ holding facility (soft release), treat any serious injuries that occur and conduct necropsies if any individuals die, helping to identify underlying causes.

Post-release monitoring may or may not be more stringent depending on the purpose of the translocation. In other words, there will be differences between a translocation in response to a conflict and a reintroduction/introduction. In a reintroduction veterinarians need to pay particular attention to the adaptation of the population because the animals are in an environment that was previously hostile, and on the other hand, if a conflict animal is supposedly translocated to the conservation area where it came from, it will be more accustomed to it (this does not mean that these conflict animals will thrive in that location). The general issues that should be considered in population monitoring (relying on different specialists) are demographic performance, behavioral, ecological, social, genetic, health and mortality, cultural and economic monitoring (IUCN/SSC Reintroduction Specialist Group, 2013).

The success of translocations can be measured by factors such as survival rate, dispersal of animals (e.g. ability to establish in the site, it is normal for animals to move several kilometers to explore the area), number of recaptures required (to return them to the designated site), weight and body condition, reproduction and offspring (De Milliano *et al.,* 2016; Resende *et* *al.*, 2021). Ultimately, it's about the resilience (genetic diversity, resistance to disturbance) and persistence of the population (Weeks *et al.*, 2011).

However, translocations must be part of a broader conservation strategy, as they can be expensive and may not succeed without addressing the socio-economic causes of species decline. The causes of failure of this intervention include predation, adverse weather, stress, infection and anthropogenic trauma.

Finally, it is important to note that planning, management and financial support will be more or less demanding depending on the scale and complexity of the translocation. It is cyclical process, depending on success or failure, adjustments in planning are made at each stage until goals are achieved (IUCN/SSC Reintroduction Specialist Group, 2013), and it is important to publish methods and results of previous projects (Beckmann & Soorae, 2022) so that they can be used in future translocations.

### 1.6 Treatment of injured wild animals

Wild animals can be injured for several reasons: natural causes such as predation, and human-induced injuries caused by snares, gunshot wounds (or any other attempt by a human to kill the animal).

Wildlife vets usually treat animal injuries when they are caused by humans, but there are some exceptions. For example, when dealing with a species that is considered critically endangered or endangered (IUCN status) the veterinarian should do everything possible to save it if there is a good chance of survival. If the animal is part of a valuable population, for example when reintroducing a species to a particular area, medical care should be provided if any of the individuals in the population are injured for any reason (Haggblade *et al.*, 2019).

### 1.7 Dehorning of rhinoceros

To help prevent rhino poaching, dehorning is used as a deterrent. While the effectiveness of dehorning alone is not well-documented, it can discourage poachers when combined with additional security and conservation measures.

Effective anti-poaching strategies should include collaring for monitoring, relocating rhinoceros to safer areas, reducing population density by dispersing rhinoceros across locations, and enhancing genetic diversity to reduce inbreeding risks and increase resilience in protected areas. Collaboration with private landowners who can provide robust security also strengthens these efforts.

It is important to note that dehorning without adequate security support is generally ineffective, as even the remaining horn stumps retain value to poachers(Cheteni, 2014; Lindsey & Taylor, 2011).

To explain the dehorning process, it is first necessary to understand the anatomy of the rhino's head.


Figure 6- White rhinoceros' skull (*Ceratotherium simum*). There are prominent bone rugosities where the horns sit (Witmer lab, Ohio University, 2017).

### *1.7.1 Rhino head anatomy*

The horn is not a bony structure, so it does not grow from the bones of the nasal cavity (Figure 6), it is neither vascularized nor enervated (Penny *et al.*, 2020).

The horn is an intricate composite of keratin filaments embedded in a keratin matrix (rather than a bony core surrounded by a keratin sheath like *Bovidae* horns or solid bone horns of *Cervidae*). They are attached to the dermis covering the frontal and nasal bones, and are associated with pronounced bony rugosity in most individuals (Hieronymus, Witmer & Ridgely, 2006; Jha & Kshetry, 2015). It is constantly growing (like human fingernails) but is subject to wear and tear as many social interactions require its use and white rhinoceros (*Ceratotherium simum*) have a habit of rubbing and scratching against objects (Estes, 2012). Typically, white rhinoceros' two horns must be trimmed every 12 to 24 months (Pfannerstill *et al.*, 2023) to prevent them from reaching a normal size that makes them more vulnerable to poachers.

### *1.7.2 Procedure description*

It is important to note that the procedure should be carried out by an experienced veterinarian (due to the risky anesthesia) and is a painless experience for the immobilized animal if done correctly. Rhinoceros are usually darted from a helicopter and occasionally from the ground. As the animal is approached, a blindfold and earplugs are applied to reduce visual and auditory stimuli and to partially reverse anesthesia (usually with butorphanol to improve respiratory activity). A pen is used to mark the point of removal, usually the horn growth plate, and 9 to 11 cm of horn is left intact (normal size of the horns: 94 cm to 201 cm, the front horn and rear horn is 55 cm long) (International Rhino Foundation, n.d; Penny *et al.*, 2020; Pfannerstill *et al.*, 2023). The horns are cut transversely with a chainsaw or handsaw. The stump is trimmed to remove excess horn at the base, then it is important to finish with a spray of Terramycin (to treat prophylactically for infection).

This procedure has no contraindications in terms of survival. According to the study done by Penny *et al*. (2020) there are no serious implications in health and reproductive rate, measured through fecal metabolites of corticosteroids (FCM), fecal androgens metabolites (FAM) and fecal progesterone metabolites (FPM), even in multiple dehornings. Rhinoceros experienced a spike in FCM levels (stress) immediately after dehorning, which is an acute endocrine stress response that returns to normal levels within the first week. With multiple dehornings, there is no evidence of chronic stress, FPM in females does not suffer changes, but in males, the rate of change of FAM concentrations after each procedure is affected.

Some behavioral changes are expected in the first week, but without major consequences (e.g. males may reduce locomotion and avoid confrontation at territorial boundaries). Rhinoceros can adapt well to this significant change in structure (a male's horn can weigh up to 7 kg) as their horns can naturally break off and wear away (Pfannerstill *et al.*, 2023).

## 1.8 Collecting samples from live wild animals

It serves two main purposes: disease management (epidemiology, pathogen detection) and the study and promotion of genetic diversity (biobanking; biopreservation tool). Sampling for genetic studies (genomic analysis) is thus used to manage animal populations to ensure biodiversity (e.g. in reintroductions) (Robbins, Hunt, Pelegri & Gilbert, 2023). It can also provide information on a species' diet and nutrition, reproductive capacity, exposure to pollutants (including pesticides and heavy metals) and behavior (stress hormones and other physiological indicators of animal welfare and behavior) (Schilling , Mazzamuto & Romeo, 2022). Investigation of physiological and immunological parameters (serological tests), e.g. to study the disease cycle and the host-pathogen dynamic (it is crucial to know the health status).

Sampling from live animals is usually an additional procedure to the main objective of the operation (trapping, translocation, dehorning...). However, there are situations where, in the event of an outbreak of disease in domestic animals or in human communities in contact with wildlife, animals are deliberately captured in order to take samples and determine how to contain the disease (Gortazar *et al*., 2015; Ryser-Degiorgis, 2013).

Passive surveillance of diseases in wildlife can be carried out using samples from carcasses, which, although a very useful and easier method to carry out, can lead to bias in epidemiological studies. Random sampling of live animals is therefore preferable. This requires the presence of veterinarians (Schilling *et al*., 2022).

According to Mitchell, Foggin & Kock, (2021) the most common biological samples taken from live animals (and respective purpose) are:

- Blood (hematology, biochemistry, serology, toxicology, nutrition);
- Feces (parasitism, nutrition);
- Ectoparasites (parasite identification);
- Cartilage (molecular genetic studies);
- Hair (molecular genetic studies, toxicology).

**2. Threats to biodiversity conservation**

Although the purposes of each intervention have been mentioned, it is important to clarify some aspects of the conservation problems. The extinction and significant decline of wildlife can largely be explained by anthropogenic actions. In Africa, as the human population grew and rural poverty increased, so did the demand for land for agriculture. These human settlements began to be established close to the boundaries of protected areas, changing the dynamics of wildlife movement and increasing human-wildlife conflict (Kinnaird & O’brien, 2012).

Poaching, human-wildlife conflict and habitat destruction are some of the main causes. And because of the close interface between domestic animals, wildlife and humans, disease is a major concern not only for species conservation but also as a public health issue, making this subject even more important (Kappus, 2023).

Veterinarians have an important responsibility for mitigating the threats to wildlife and public health.

### 2.1 Habitat loss

Habitat loss has become the most serious threat to biodiversity worldwide. It is defined as the disappearance of natural environments as a result of habitat destruction, degradation and fragmentation (Kappus, 2023a).

Habitat destruction occurs when the physical environment required by a species is damaged or destroyed to such an extent that species and ecological communities can no longer survive there. It often leads to extinction and loss of biodiversity (Kappus, 2023a)

It can be caused by human activities such as deforestation, agriculture, urbanization, bush fires, mining and others, or by natural disasters. Habitat degradation results from pollution, climate change and the introduction of invasive species that deteriorate the environment. Habitat fragmentation occurs when a contiguous habitat is divided into smaller, more isolated patches by roads or other structures. This leads to the creation of isolated subpopulations, increasing the risk of inbreeding and making it easier for a disease outbreak or natural disaster to eradicate that population. If these patches of land protect biodiversity hotspots, that is a major conservation risk, because it can lead to the extinction of threatened species (Hecht & Allcock, 2020; Kappus, 2023a)

These fragments affect ecological connectivity, which is defined by the Convention on Migratory Species (2020) as "the unimpeded movement of species and the flow of natural processes that sustain life on Earth". This includes structural connectivity, or the ease with which animals can move across landscapes due to the physical characteristics of the habitat (topography, hydrology, vegetation) and human land use patterns (which create barriers), and functional connectivity, or how well genes, gametes, propagules or individuals move across the land. In other words, how the ecological characteristics of the animal relate to the structure of the landscape (Hilty *et al.*, 2020; Rudnick *et al.*, 2012).

Dispersal to other areas to maintain gene flow (searching for mating partners and establishing a new population) and demographic connectivity, migration dynamics, search for resources (food and water), escape from catastrophic events and climate change are the reasons why wildlife must be able to move across different habitats and landscapes to establish this connectivity (Ament *et al*., 2014). This will increase the resilience of species and ecosystems.

For example, predators are at the top of the food chain and require large areas to find suitable prey. Their function is to regulate the populations of other organisms, so their disappearance disrupts the ecosystem (Kappus, 2023a).

To combat this fragmentation, the only measure initially available was the creation of protected areas (national or private), but this can lead to the formation of habitat islands and in isolated areas extinction is a real possibility. The long-term survival of species depends on their ability to adapt to changes by moving long distances across human-altered landscapes (Morales-González,Ruiz-Villaret, Ordiz & Penteriani, 2020). Therefore, the strategy that began to be applied was the establishment and protection of wildlife corridors (Dalziel & Evans, 2024), which are "a clearly defined geographical area that is governed and managed over the long term to maintain or restore effective ecological connectivity" (Hilty *et al*., 2020), made up of native vegetation. In situations where it's impossible to establish and protect wildlife corridors, and therefore there is a restriction on the animals 'movement, particularly in protected areas and intensive protected zones, translocations can be considered as an alternative strategy to maintain gene flow.

Corridors can be identified by reserve managers and wildlife researchers who know where they might exist through observation/patrolling (cost effective); GPS/VHF collars on animals and modeling landscape connectivity using satellite imagery data to identify wildlife corridors (Riggio & Caro, 2017).

Corridors vary in size, ranging from a few meters to many kilometers in width and length. These ecological connectors have different designs: those that cross barriers (community houses, roads), continuous corridors that connect two or more large habitat patches (core areas) and stepping stones, small patches of suitable habitat scattered across a landscape between larger habitats. These linkages can be natural or man-made (bridges, vegetated tunnels) (Land for Wildlife Queensland, 2011).

The maintenance of these corridors depends on the compliance of human communities (social and cultural acceptance, support for reforestation of small corridors), land/urban planning and management, restrictions on resource exploitation and, above all, national legislation and recognition of the importance of this connectivity at the level of international policy and law (Hilty *et al*., 2020).

### 2.2 Managing human-wildlife conflict

Human-wildlife conflict (HWC) is a complex conservation issue.

It comprises two elements: impacts resulting from direct interactions between humans and wildlife species; and conflicts among humans themselves over how to manage the impacts resulting from human-wildlife interactions. These negative interactions take the form of crop raiding, livestock depredation, and human injury or death (Shaffer *et al*., 2019).

One of the main causes of conflict is habitat loss and degradation (due to pollution, global warming) and the expansion of human settlements.  Therefore, HWC is recognized as a global priority and an emerging area of research due to its significant impact on rural livelihoods, and its potential to reduce overall support for conservation projects (Kansky, Kidd & Knight, 2016). Diagram 1 (Decree-Law No. 5/2017, 2017) summarizes the approaches to conflict mitigation in Mozambique.

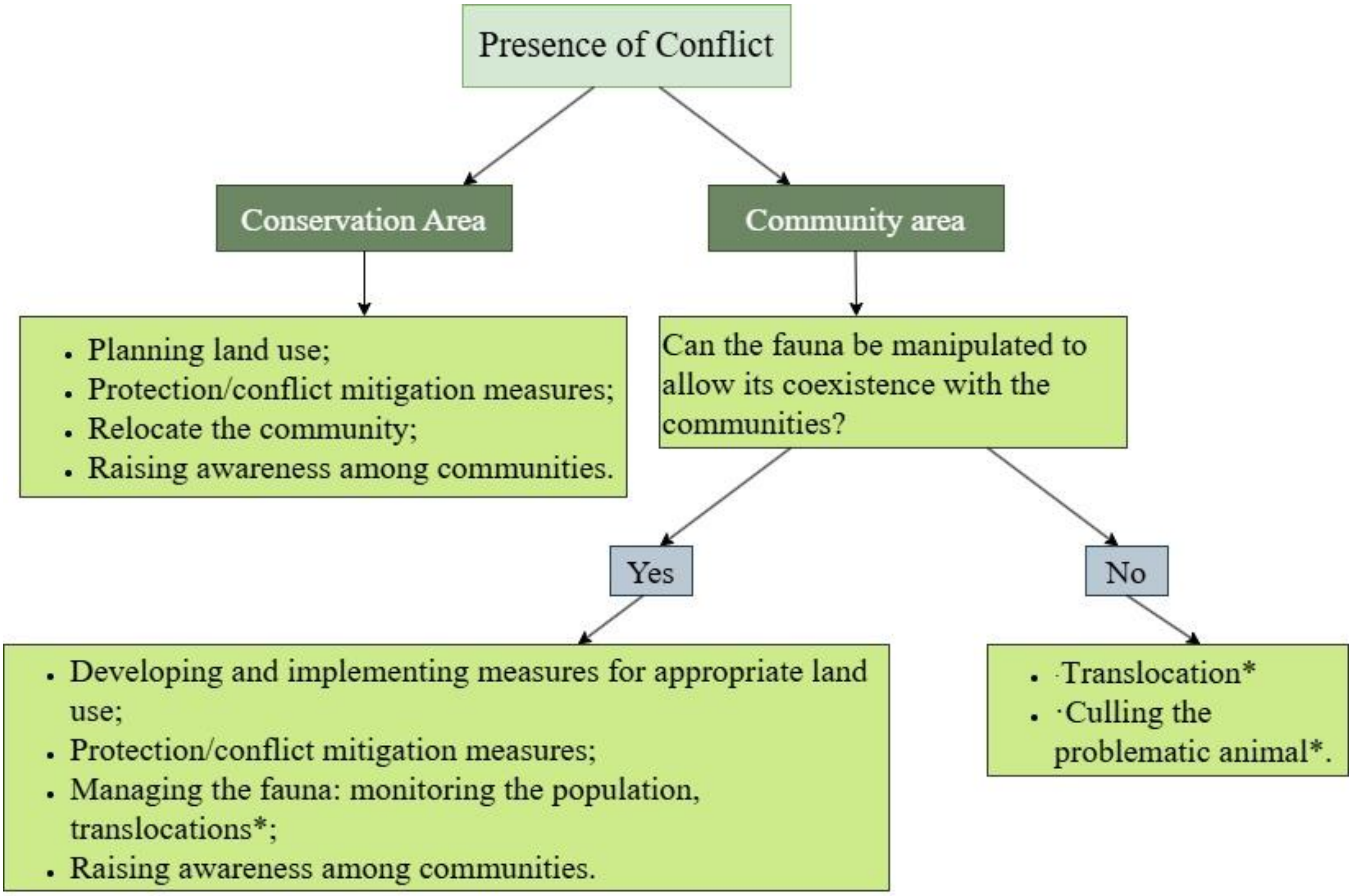

Diagram 1 - Conflict Management Measures in Mozambique (Decree-Law No. 5/2017, 2017). * Where the veterinarians usually act.

Detailing about Diagram 1 land use planning includes clearly defining buffer zones and conservation areas to relocate communities from the center of protected natural park areas to peripheral areas with better livelihood resources. Constructing barriers around human settlements (such as fences, walls or nets) where possible for greater protection. If relocation of the community is the solution, this includes finding new sources of income for the population and sometimes providing financial incentives to move. Conflict mitigation measures often involve educating communities about the benefits of wildlife (increased tourism, higher incomes) and teaching people deterrents measures such as natural barriers (like other animals, e.g. beehives), powerful lights, blocks of soil mixed with piri-piri. Strengthening laws to protect wildlife species also helps to resolve the conflict.

Veterinarians, by placing tracking devices, can help manage human-wildlife conflicts by monitoring animal movements near human settlements and identifying patterns that lead to conflicts. This data allows for timely interventions, such as adjusting land use practices or implementing mitigation strategies to reduce negative interactions between wildlife and humans, translocate and prevent the last resort of culling problematic animals (done especially if there are human casualties) (Decree-Law No. 5/2017, 2017; Nyhus, 2016; Shaffer *et al*., 2019).

To intervene in an ethical and situationally appropriate way, it is ideal to adhere to the following principles: modifying human practices (if this solves the problem); having a justification for control (the damage is serious enough); setting clear and achievable results-based objectives; considering animal welfare; social acceptability (incorporating scientific and technical knowledge while ensuring that decisions are guided by community values and, consequently, we have community support to implement the measures); systematic planning (systematic, long-term management program); decision making by specifics rather than labels (decisions are based on the specifics of the situation rather than being influenced by negative labels attributed to the animals) (Dubois *et al*., 2017).

### 2.3 Poaching and illegal wildlife trade

Poaching is the illegal hunting, killing and subsequent trade in animal parts and is one of the most significant threats following habitat destruction. The main causes of poaching are: subsistence (usually the poachers are individuals with important livelihood needs and perhaps the least documented but most widespread use of wildlife in the world) (Cerda & Webb, 2023); and commercial/ trafficking (e.g. some cultures believe in the medicinal properties of certain animal parts, leading to their illegal trade and consumption) (Mudumba, Jingo, Heit & Montgomery, 2021). Trafficking is carried out by structured organizations motivated by financial gain and has become a global security issue as the unregulated profits from poaching support terrorist organizations (Nguyen *et al.*, 2016). Poaching poses a severe threat to biodiversity and ecosystems, leading to population decline and even the extinction of endangered species.

The approach to this problem is through conservation laws (national and international) such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). It is an international agreement between governments to ensure that international trade in specimens of wild animals and plants does not threaten the survival of species. It only applies in member countries, and each party adopts national legislation to ensure its implementation (CITES, 2022) as this illegal market is estimated to be worth billions of dollars each year (Chanyandura, Muposhi, Gandiwa & Muboko, 2021).

CITES has three appendices, which are lists of species with different measures and levels of protection from overexploitation (the first is for species threatened with extinction, so has the stricter rules) (CITES, 2024).

Another measure to prevent this activity is the organization of a team of trained rangers to patrol wildlife parks (Nguyen *et al*., 2016). This is a particularly challenging task, as the areas are very large (so they cannot be patrolled every day), the behavior of poachers is very difficult to predict, and in most cases, it is not possible to link the poacher to the crime.

Using collars with accelerometers to detect movement, a mercury switch to determine if the animal is active, GPS (location) and data generated by body and/or ambient temperature and heart rate, the combination of these factors makes it possible to predict whether the animal has been killed or is in distress, thus helping to detect poaching. However, this is still not a very effective measure as we cannot reach the animal before the event (Haupt *et al*., 2021).

But for these measures to be successful, we also need to consider the human factor (which cuts across all conservation issues). Rural human communities, which are increasingly expanding into wilderness areas and therefore competing for resources, ultimately see poaching as a source of income. To mitigate this situation, other economic opportunities must be offered, along with financial incentives to develop practices that do not harm wildlife (e.g. government-sponsored livestock protection programs could reduce the illegal killing of predatory wildlife).

Education should be provided to convey the financial, ecological and cultural benefits of wildlife. The mentality that this is a quick way to get rich has led to an increase in crime, deaths and arrests. In Mozambique, some initiatives have been very successful, such as the Mangalane Community Scouts Programme, which employs men from the community to patrol and control the movement of poachers (comprehensive anti-poaching action) (Massé, Gardiner, Lubilo & Themba, 2017).

A common method used in this illegal activity is the use of wire snares (Figure 7), particularly in the subsistence bushmeat trade, which was originally intended to support local communities but has become increasingly commercialized, driving harvest rates to unsustainable levels. Due to their non-selective nature, snares can cause mortality to a variety of species that are not the target (Becker *et al.*, 2013; Kappus, 2023).

Figure 7 - Wire snare used for poaching. It is not species specific, so any animal can be trapped (League against cruel sports, n.d).

For large herbivores (rhinoceros for their horn and elephants for their ivory, a firearm is usually used. In the case of rhinoceros and elephants in particular, the caliber of the gun used by the poachers often does not kill them instantly. For carnivores - lions (*Panthera leo*) and leopards (*Panthera pardus*) for their skin, fur, claws and teeth - snares, traps and poison are the most commonly used. Poisoning is a common form of killing or weakening the animal, using poisoned bait (with organophosphorus and carbamate pesticides, cyanide, rodenticides) especially for carnivores; elephants and rhinoceros, poisoning water holes or using salt licks with poison to kill them and wildlife sentinels (e.g. vultures, because when there is strange activity, they start flying in circles around the area, revealing the location of poachers) are the main targets of this practice in Africa (Ogada, 2014).

Another species of concern is the pangolin (family Manidae), considered the most trafficked animal in the world. They are sought after for their meat and scales (used in traditional Chinese medicine). Since 2015, the number of seizures in Africa has increased significantly. As a result, all pangolin species were moved from Appendix II to Appendix I (CITES) in 2016, so the restrictions increased (UNODC- Wildlife Crime Pangolin Scales,2020). Pangolins are poached mainly for international markets in China and Southeast Asia, so the main concern has been Asian populations, but their decline may lead to 'hunting' of African pangolins.

Poverty and corruption are still very much present in Mozambique and African countries in general, and even community members who can initially help can be enticed by poachers with money. Even in important positions, bribes are often paid to keep these wildlife products in circulation (Wildlife Justice Commission, 2022).

### 2.4 Diseases Outbreaks

Habitat degradation/destruction and human settlement with livestock in wildlife areas leads to an increasingly narrow wildlife-human-livestock interface, which increases negative health outcomes (One Health approach). In addition to the obvious public health implications, as wild animals are reservoirs of various diseases, from a conservation perspective, the increase in frequency and virulence of endemic diseases, the introduction of new diseases to which animals cannot develop resistance (e.g. introductions without careful health screening), and emerging diseases with zoonotic potential that can be transmitted to humans and livestock may lead to the decline of wild populations (Gortazar *et al.*, 2015). For example, African buffalos (*Syncerus caffer*) are an important interface between wildlife and livestock regarding bovine tuberculosis (Burroughs *et al.*, 2021).

When these wild animals experience some form of stress from external factors, whether human-related or climate-related, their immunity is compromised and epizootic outbreaks can occur as diseases persist in the environment (Reading, Kenny & Fitzgerald, 2013).

To manage wildlife diseases effectively, epidemiological surveillance through sampling is essential. This is especially important for sentinel species, which can indicate emerging diseases and signal ecosystem degradation, particularly when animals show high parasite loads or poor body condition. Observing the animals also provides insight into disease susceptibility and potential outbreaks.

Wildlife disease monitoring and control typically involves prophylactic measures, like parasite control and vaccination. However, these methods as a current practice are questionable and present challenges, including drug resistance, ecological impacts, and the impracticality of administering treatments to free-ranging animals. Sustainable parasite control practices in domestic animals (e.g., cattle, horses, dogs, and cats) that interact with wildlife are necessary to prevent resistance to anthelmintics and antibiotics.

Rabies vaccination is one of the most common preventive measures for wildlife. Oral vaccines injected into carcasses or in capsules/blisters can be used, especially for carnivores.

Biosafety for non-target species and physical stability at adverse environmental temperatures are necessary for successful vaccination. For some wildlife, such as wild dogs, the vaccine may also be administered remotely by injection. However, rabies control often relies on domestic dogs and cats' vaccinations, that live close to wildlife. Consumption of bait by target species is not guaranteed and non-target species may ingest it instead (Rupprecht *et al*., 2024).

Acaricides like ivermectin are also used for vector control through bait stations, helping to manage diseases transmitted by parasites.

Selective or random culling is another control measure used to reduce disease prevalence. This approach promotes the growth of healthy individuals by removing part of the host population, which serves as a reservoir for the disease. However, culling must be approached cautiously to avoid ethical and ecological harm, as eliminating entire populations is unacceptable. Fertility control measures (immunocontraception) are an alternative to host population control (Gortazar *et al*., 2015).

## 3. Contribution of veterinarians in conservation threat mitigation

In order to highlight the integral role of veterinarians in conservation management, it is important to explain what a veterinarian actually does.

The veterinarian's major responsibility is to ensure the welfare and health of the animal, since almost all interventions and handling of these wild species require chemical or physical immobilization, which is a stressful event for the animal and requires medical training. But when it comes to conservation, the role goes beyond providing medical care.

### 3.1 Planning

The veterinarian is primarily involved in planning and ensuring the feasibility of the operation in terms of: epidemiological risk and sanitary requirements, the genetics and resistance of the species in a given environment, and the welfare of the animals during capture and transport. Logistics may also be part of the veterinarian's work: selection of the capture method, transport, management of the necessary personnel and financial support. In fact, all these conservation actions can be very expensive (Atkinson *et al.*, 2021; Cerda & Webb, 2023; Chinnadurai *et al*., 2016).

This is the most time-consuming part of wildlife veterinary work (Table 3). Contact with animals is actually a brief section of the work.

Table 3 - Planning a wildlife operation – veterinarian perspective (adapted from CITES, n.d; CITES, 2022a; Kock & Burroughs, 2021).

| | |
|---|---|
| **1st Establish the objectives, needs and constraints of the capture** | 1. Defining the motivation for restraining the animal;<br>2. Benefits and risks involved – feasibility of the operation (external factors that can impact the success: environment, personnel and resources availability).<br>2.1 Risk analysis: animal and human hazards.<br>3. Choose the method of immobilization and capture that offers less risk;<br>4. How will the animal be immobilized? On foot, helicopter, vehicle.<br>5. Duration of the procedure: factors that will affect it;<br>6. Qualified personnel to accomplish the task; |
| **2nd Overall planning (Logistics)** | 1.Financial support;<br>2.Insurances;<br>3.Choice transportation of the personnel to the location (e.g., Reserve)<br>Vehicle, helicopter, aircraft, commercial plane.<br>Urgency, cost, time spent traveling;<br>4. Emergency evacuation plan;<br>5. Translocations<br>5.1 Local, national and international laws and regulations applicable in the countries of origin, transit, and destination have to be researched and applied: |

| | |
|---|---|
| | • In-transit permits; flight clearances and IATA regulations (International air transport association).<br>• Veterinary health certificates (phytosanitary permits);<br>• Veterinary import/export permits;<br>• CITES import/export/re-export permits or certificates;<br>• Veterinary examinations;<br>• Pre-arrival declarations;<br>• Quarantine arrangements;<br>• Clearance times: quarantine;<br>• Ports of entry;<br>• Border inspection posts and prohibitions or restrictions (may include transportation bans or likely disruptions);<br>• Veterinary restrictions as well as restrictions for food and bedding provided for the animal.<br>5.2 Means of transportation of the animals, cranes, and containers according to the species. |
| **For the capture** | 1.When using a helicopter, the local authorities have to be warned that it is flying due to a conservation operation.<br>1.1 Is it necessary a support aircraft?<br>1.2 Management of fuel for the helicopter (weight of the material, personnel, jerricans with fuel)<br>2.Communication: radios;<br>3. Support team: ground crew, vehicles.<br>- Back-up firearm.<br>4. Spotter team<br>5. General veterinarian equipment:<br>- Rangefinder<br>- Cotton ropes |

| | |
|---|---|
| | - Blindfolds and earplugs<br>- Axe, shovel, chainsaw (not only for dehorning but when the environment is rough)<br>- Stretcher (to carry the animals)<br>- Basic surgical equipment for an emergency<br>- Small trocar and cannula or a few large-gauge needles: prevent bloating in ruminants<br>- Thermometer and stethoscope;<br>- Oxygen cylinder;<br>- Essential drugs (according to specie and the protocol chosen)<br>- Drugs for human emergencies: naltrexone, when using potent opioids.<br>- Collars: drill, screws, metal plates;<br>- Sampling Kit; |

Theoretically, in an operation, personnel can be divided into a darting team (usually the veterinarians, helicopter´s pilot or someone from the reserve), backup/ground team (to carry heavy material and help after the animal falls down) and spotter team (which has the function of helping to find the animal/animals in very large areas). But it depends on the size of the operation, the budget, and the type of operation (Thou1ess, 1996).

### *3.1.1 The operation*

According to Thouless (1996), after planning, and already on the field, there is a sequence of events that occur and are common to all operations, which are:

- Briefing: It is important that all team members know what to do and how to respond to emergencies;

- Radio test: If two or more types of transportation are used, there must be communication between them. In case of an emergency, there must be a way to contact someone;
- Check equipment: testing GPS collars, the dart gun, the chainsaw for example;
- Load darts: During anesthesia, especially when strong opioids are used, at least two trained people must be present, including the veterinarian, who must have someone to assist them preparing the dart and to help him in case he is stung and injected with the drug. Two darts per animal must be prepared immediately before entering the land vehicle or helicopter to facilitate the process of reloading the gun and rapid firing, and also due to the instability of these transports, which increases the likelihood of someone being stung while preparing the darts.
- Dart the animal;
- Approach the animal and the intervention is performed;
- Reversal (of the anesthesia) and release.

### *3.1.2 Considerations of a helicopter operation*

Ultimately, it is safer to use a helicopter for any wildlife conservation operation if budget and terrain allow. Helicopters are usually used with only the pilot and veterinarian on board, allowing for easier maneuvering and pursuit of the animal. The two most important conditions to consider are temperature and altitude (pressure) (McTaggart *et al*., 2021).

Rotor blade load management is critical to a safe and efficient helicopter operation. Excessive loads can lead to mechanical stress or failure. Therefore, key considerations when using a helicopter include: weight capacity, which limits the amount of equipment, number of people, and fuel that can be carried (the ground team can take heavy material and extra fuel, but the essential equipment goes on the helicopter); fuel management, which is handled by the pilot; and restriction to daytime operations only. Early mornings have cooler conditions that are favorable to both the helicopter and the animals, while late afternoons are a suitable choice, but care must be taken as the light diminishes and the animals must be managed in the dark. (McTaggart *et al*., 2021).

If the terrain has obstacles such as trees and power lines, the pilot must limit the helicopter's movement and altitude. Care must be taken with the tail rotor because it allows for recovery procedures (such as autorotation), and in wildlife operations this type of movement is necessary.

The veterinarians just have to follow the safety rules and everything the pilot says: loading and unloading the helicopter when it is not working and the amount of material the pilot decides if it goes or not, when entering a helicopter that is working it is forbidden to go behind next to the tail rotor (McTaggart *et al*., 2021).

# III – MATERIAL AND METHODS

The selected clinical cases (or operations) occurred during the author's curricular internship at the Mozambique Wildlife Alliance (MWA).

The operations highlighted below were chosen due to the diversity of each species, method, capture conditions, and circumstances, and the different objectives of the operation.

The operations took place in various reserves and national parks in Mozambique, and operated on the following species and localities: an African elephant (*Loxodonta africana*) in the Ressano Garcia region (Operation 1); spotted Hyenas (*Crocuta crocuta*) in the Karingani Game Reserve (Operation 2); a southern-giraffe (*Giraffa giraffa*) in the Incomati Reserve (Operation 3); a lion (*Panthera leo*) in the LNP (Operation 4); and white-rhinoceroses (*Ceratotherium simum*) in the Sábiè Game Park (SGP), Incomati and Limpopo National Park (LNP) (Operation 5) (Figure 8).

Only the MWA's responsible veterinarian was allowed to administer anesthesia with a dart gun, whether from a helicopter or a land vehicle. However, the author was able to participate in the planning of the operations, collect samples, administer total and partial anesthesia reversal agents, provide additional anesthesia for transportation, monitor anesthesia during procedures, treat wounds, and administer treatment drugs. It is important to mention that regarding immobilization, it was not always possible to record anesthesia/sedation times accurately, and induction times were not always observed due to the logistical and environmental complexities of the operations (therefore, in some cases an estimate was used).

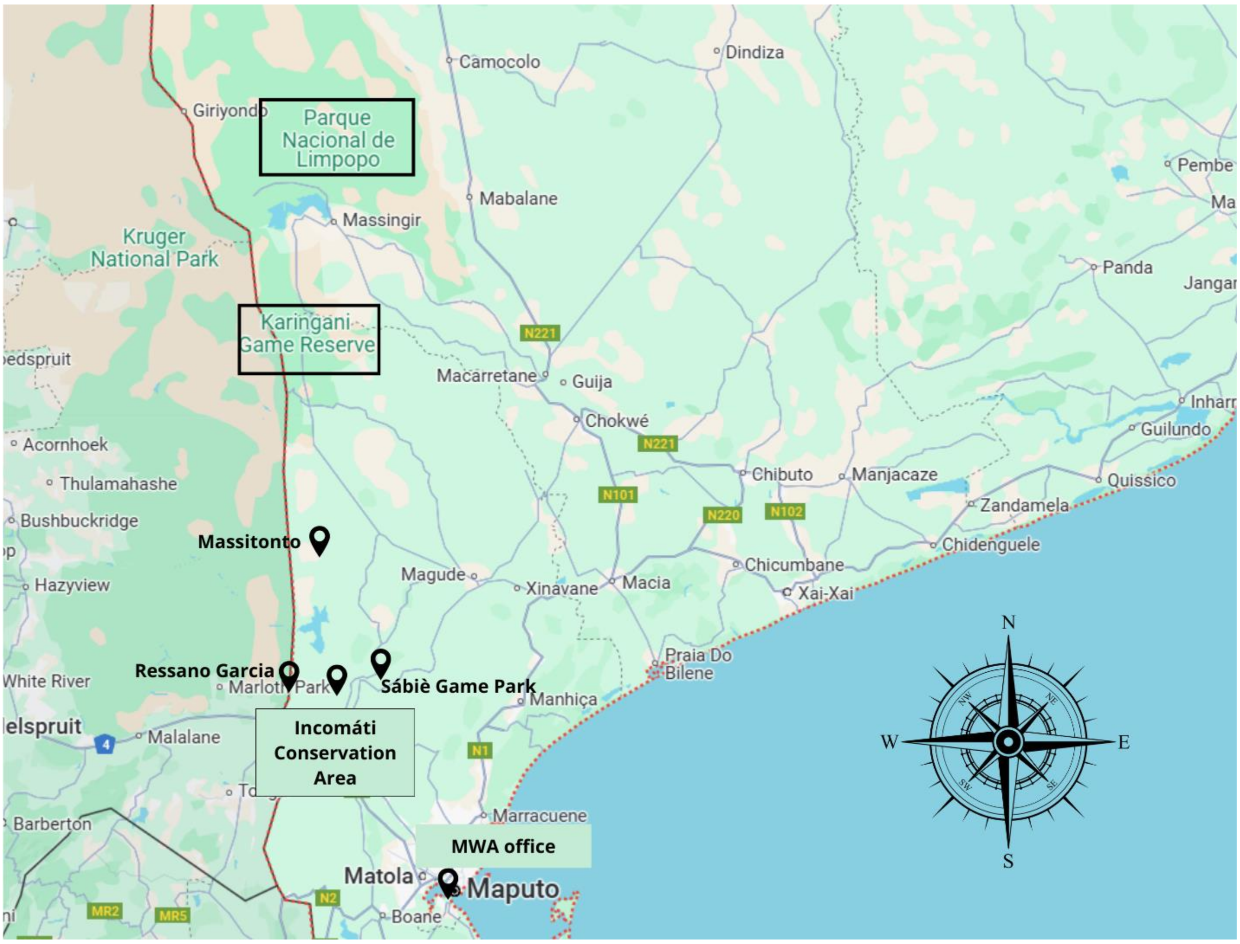


Figure 8 - Approximate locations of the operations in Mozambique (Parque Nacional do Limpopo = LNP; MWA= Mozambique Wildlife Alliance). Scale of 1 cm:25 km (Google maps, n.d)

The operations, which include the clinical cases, will be organized as follows:

A- Context of the operation (Problem identification: why and how the veterinarians MWA team had to intervene);

B- Objective (Resolution of the problem);

C- Planning: necessary equipment and personnel (list of general equipment including medical supplies as shown in Figure 9, essential drugs and personnel needed);

D- The operation (description of the intervention performed, setbacks);

E- Outcome (if the objective was accomplished and follow-up when it was possible to know).

(a) (b)

Figure 9 - Veterinary material taken to the field operations (a) drugs and darts box (b) backpack with surgical material, syringes, gloves, sampling kit, saline solutions (original pictures from the author).

## 1. Operation 1 (Ressano Garcia) - Collaring with a VHF/GPS device an African elephant (*Loxodonta africana*)

### A. Context

Human-wildlife conflict (HWC) is rising as human activity encroaches on natural habitats. In sub-Saharan Africa, elephants are frequently involved in such conflicts. The existence of these ecological corridors, which allow the necessary migrations of this species, causes them to leave the conservation areas. During these movements, they are attracted by resources such as water, plantations (or "machambas" in Mozambique), which are naturally close to communities, causing conflict.

This can lead to retaliatory killing by communities, especially if there are human injuries or deaths, contributing to declining elephant populations and affecting community well-being.

Preventative measures are preferable to reactive responses. Tracking collars on elephants, combined with wildlife census reports from communities, allow for timely interventions. In this case, two elephants were detected near local communities that reported it to ANAC, which in turn reported to MWA. The conflict management and mitigation team of MWA located the two male elephants near the communities in the Ressano Garcia region on the border with the Republic of South Africa.

**B. Objective**

Prevention of wildlife conflict: Place a tracking device on one of the elephants was the strategy to achieve this goal.

**C. Planning**

Before going to the site, the lead veterinarian coordinated and gathered the materials and personnel needed for a collaring operation (List 1). The collar was tested the day before. The authorities were informed that a helicopter would be flying in the area for conservation purposes. The veterinarians took the helicopter to Ressano Garcia while the conflict team drove there.

| **Necessary Equipment/Personnel** |
| --- |
| Helicopter for darting; |
| Essential materials for the veterinary intervention (Figure 9):<br>Drugs: Thiafentanil (ultra-potent opiod), Azaperone (butyrophenone tranquilizer); Naltrexone (opioid antagonist), Hyaluronidase (Hyalase®);<br>Dart gun - darts: 2,5 inch (6,35 cm), 2 ml<br>Antibiotic: Cloxacillin, Fortitude® (tube of intramammary application);<br>Collar VHF/GPS: drill, screws, and metal plate (tested prior to the operation); |
| Chainsaw: In case the animal gets trapped in a log, for example; |
| Radio communication (with the helicopter) |
| Support land vehicle from MWA; |

List 1 - Equipment and personnel required for Operation 1 - Elephant (*Loxodonta africana*) collaring.

## D. The intervention

After spotting one of the elephants (which was relatively close to a road where the team remained in the vehicle), one of the vets in the helicopter darted it (Table 4).

Table 4 - Anesthetic Protocol and Monitoring Parameters for Elephant Immobilization

| **Anesthetic protocol** | **Induction time** | **Respiratory Rate** | **Reversal** |
|---|---|---|---|
| **Thiafentanil (15 mg) + Azaperone (20 mg)+2500 UI Hyalase®** | 5 minutes | 6 rpm | 150 mg Naltrexone |

RPM stands for respirations per minute.

After the helicopter landed, the ground team drove up in a vehicle to reach the elephant and began the procedure. The elephant fell into sternal recumbency and as the procedure would take less than 30 minutes and was easier to collar, the animal was kept in this position. The dart was removed and the dart wound treated with antibiotic, cloxacillin, the nozzle from the intramammary antibiotic application tube was inserted into the wound.

Throughout the procedure, respiratory rate and depth (Volume of air exhaled from the trunk, is a subjective procedure in which a designated person places their hand on the opening of the trunk to assess whether the volume of air is decreasing) were monitored. Blood samples were taken (Figure 10c) from the auricular vein (for the biobank).

For the collar, the plate and screws were placed according to the size of the animal's neck and the excess was trimmed off (Figure 10a, 10b).

During the procedure, another elephant appeared and was scared away (a member of the team vocalized loudly).

(a) (b)

(c)

Figure 10 – Operation with African elephant (*Loxodonta africana*) (a)/(b) Adjusting the collar, placing the metal plate and drills, then cutting off the excess; (c) Collecting blood samples (original pictures from the author);

## E. Outcome

There were no major complications with the anesthesia and the collaring procedure. The operation took almost 20 minutes. The elephant woke up 7 minutes after the naltrexone was administered, and the veterinarians monitored the elephant's recovery from the helicopter. This elephant could consequently be tracked using Earth Ranger (software).

## 2. Operation 2 (Karingani Game Reserve) - Capture of spotted hyenas (*Crocuta Crocuta*) for the subsequent translocation and reinforcement of the population in the Gorongosa National Park

### A. Context

Gorongosa National Park has seen many changes over the centuries. In the 20th century, during Portuguese colonialism, it was a "hunting reserve" and before Mozambique's independence it became a national park. After independence, there was a civil war which had a significant negative impact on Gorongosa's wildlife, resulting in a drastic reduction in the animal population. After peace was restored, efforts were made to restore various species (the first post-conflict wildlife survey recorded few hundred herbivores).

Many of Gorongosa's emblematic large grazers and predators were gone. Hyenas were reintroduced to the park in August 2022 by MWA (having last been seen in the 1960s) and another clan of 6 hyenas from Karingani Game Reserve (KGR) was introduced in November 2023 to bolster the population. It is important to emphasize that hyenas are very important to the health of the ecosystem as they are scavengers. By eating carcasses (including bones and teeth), they utilize carcasses better than any other predator and help to reduce the incidence of disease outbreaks (hyenas have a highly developed immune system and are known to survive exposure to pathogens such as rabies, canine distemper virus and anthrax) (Flies *et al*., 2016). Predators are also needed to control antelope populations.

### B. Objective

Reinforcement of the hyenas' population of Gorongosa National Park. To achieve this goal, at least six hyenas had to be captured and first transported to the carnivore holding facility of KGR. They were then airlifted to Gorongosa under anesthesia. There were two operations to capture this number of hyenas (D.1 and D.2).

## C. Planning

In both operations, the veterinarians went to KGR, but to different locations within the reserve in each case. For a carnivore capture, the materials and personnel needed are in List 2. The main difference in this area between these two operations was that in the second one, the MWA team took a trailer with a crate.

<table>
<tr><td colspan="2">Necessary Equipment/Personnel</td></tr>
<tr><td>Provided by KGR</td><td>What MWA veterinary ‘team had to bring/arrange before</td></tr>
<tr><td>Bait for the capture (carcasses of zebra, impala and wildebeest)</td><td>For the veterinarian intervention (Figure 9):<br><ul><li>Essential drugs: Tiletamine/Zolazepam (Cyclohexylamine/sedative, Zoletil®), Medetomidine (sedative: alfa-2 agonist), Atipamezol (alfa-2 antagonist), Doxopram (cardiovascular and respiratory stimulant), Midazolam (alfa-2 agonist), Catosal ®;</li><li>Dart gun - Darts: 3/4 inch (1,905 cm), 1 ml; flashlight with red filter, blindfolds, loudspeaker,stretcher.</li><li>Antibiotic: Cloxacillin, Fortitude® (tube of intramammary application).</li></ul></td></tr>
<tr><td>Wire</td><td>Crate and trailer: this allows the team, after capturing one of the hyenas, to capture another while the first recovers, instead of taking them to the holding facility/Boma one by one (D.2).</td></tr>
<tr><td>At least one ranger to accompany the veterinarians during the capture</td><td>Chainsaw, sharp knife</td></tr>
<tr><td>Firearm</td><td>Authorizations to translocate wild animals:<br><ul><li>Phytosanitary permits;</li></ul></td></tr>
</table>

| | |
|---|---|
| | • Veterinary movement permits. |

List 2 - Equipment and personnel required for Operation 2 - Spotted hyenas (*Crocuta crocuta*) capture operation. KGR=Karingani Game Reserve; MWA= Mozambique Wildlife Alliance.

## D. The intervention

The capture sites were chosen in communication with the reserve managers.

When capturing wild carnivores, most of the work is done at night as this is when they tend to hunt/feed.

### D.1 First Operation

The first operation took place over eight nights. The team, consisting in the author, a veterinarian from MWA, and the operations manager, successfully captured three hyenas during the first four nights by employing various capture strategies and alternating between two capture sites (location A and location B) because the hyenas were increasingly aware of the team´s presence. But in location B, there was no success and no hyenas were captured (Diagram 2).

Location A was about 45 minutes from location B (approximately 5 km). Even on the nights where the team went to location B, the night started and ended (before the sunrise) at location A.

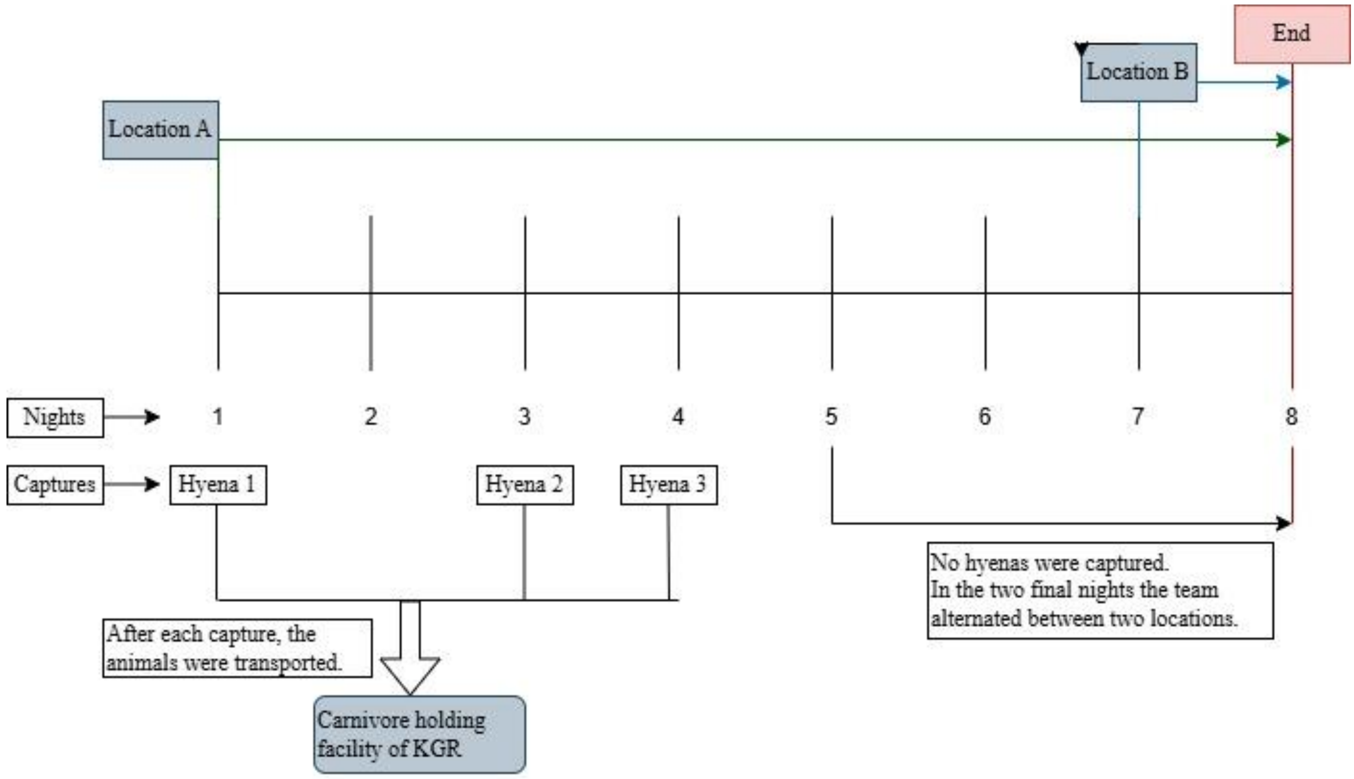


Diagram 2 -Summary of the first operation in which 3 hyenas were captured (KGR – Karingani Game Reserve).

<u>Bait Station Setup</u>

The first night's bait was a zebra (*Equus quagga*) carcass (Figure 11). Additional bait, carcasses of blue wildebeest (*Connochaetes taurinus*) and impala (*Aepyceros melampus*), were needed throughout the nights as the previous carcasses had been eaten by hyenas. The carcasses used in this operation were from animals found dead by the rangers.

A tree was chosen in an area frequented by hyenas. The carcass was tied to the tree with wire to encourage the hyenas to feed at the site. Two 5 mg midazolam pills were inserted into the zebra's liver and heart, and a loudspeaker was attached to the tree to broadcast sounds of hyenas and prey to attract them.

The tree chosen was no more than 20 meters from the team's hiding place and in an open area with few trees to make it easier to track the animals after they had been darted. A small barrier of logs was constructed around the bait.

Figure 11 - Zebra carcass (*Equus quagga*) tied with wire to a tree (Original picture from the author).

Darting Procedure

The first three nights featured clear conditions, allowing the team to dart without a flashlight. Subsequently, a flashlight with a red-light filter was utilized to avoid startling the hyenas. The spotlight was pointed upward by the author before being slowly lowered toward the animal, taking care not to shine directly into its eyes. The lead veterinarian was ready to shoot as soon as visibility improved.

Capture strategies at location A

The team remained at this first capture site until the sixth night, alternating the position of the bait stations and dragging carcasses.

On some nights the team would leave carcasses and livers/hearts with 1ml of medetomidine and 2 tablets of 5mg midazolam and drive a few kilometers for 1 to 1.5 hours. Although hyenas were seen feeding, they would run away when the vehicle approached. During these attempts, headlights were turned off while pursuing hyenas, and only the red-filter flashlight was used. However, hyenas became increasingly aware of the team's presence.

In the final two nights ($7^{th}$ and $8^{th}$), in the beginning of the night a carcass of impala with drugs was left there and the lead veterinarian and the operation manager decided to try the location B and before the sunrise, the team returned to location A.

Capture strategies at location B

On the seventh night, the team relocated to a new capture site, set up a bait station, and dragged a wildebeest carcass. The carcass was left covered with logs for the following night (the last night).

No hyenas were captured in this new location.

Alternative Strategies

A one-person tent (Figure 12) was utilized, with the veterinarian standing by with the dart gun while the author and operations manager distanced themselves by vehicle, in both locations.

Figure 12 - One-person tent is a strategic wildlife management practice for e.g to capture carnivores, which served as a hiding place for the veterinarian in the first hyena capture operation.

Setbacks

On the third night, a herd of elephants caused disturbances at the site. The hyenas became increasingly aware of the team's presence after this night, and as soon as the vehicle approached the capture site, if any hyenas were present, they would run away.

On the fourth night, the lead veterinarian darted three hyenas, but only one was located by the team.

On the seventh night as the team approached the bait after carcass dragging in location B, a leopard (*Panthera pardus*) (Figure 13) appeared and chased the hyenas away, preventing any from approaching.

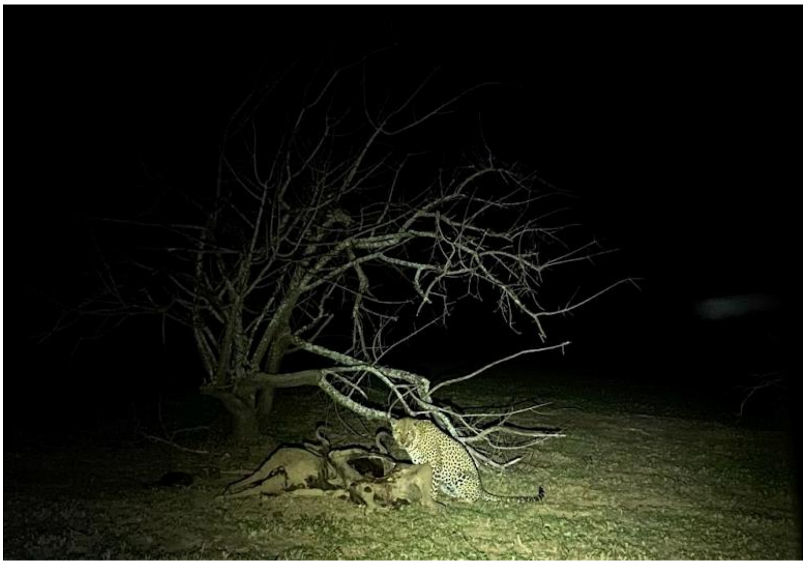

Figure 13 - The leopard (*Panthera pardus*) that approached the bait in location B of the first hyena capture operation.

Transport Logistics

The holding facility was two hours away from the capture site (approximately 100 km), allowing only one trip per night in case a hyena was captured.

During transport, a veterinarian was ready with a syringe filled with a top-up of anesthesia (Table 5). Regular stops were made to check for the presence of reflexes using painful stimuli (pinching of the ears and between the toes).

A top-up was administered every 45 minutes based on the metabolization rate of the drugs used.

Final Night ($8^{th}$ night)

On the final night, the team recovered two wildebeest carcasses. After stopping at location A to leave one carcass with medetomidine (1 ml injected) and two 5 mg midazolam pills, the team proceeded to the new site.

The bait station was set up in location B and the wait began. No hyenas were seen. Between 4:00-5:00 a.m., it was decided to return to the first site (A) but only spotted one hyena, which escaped as the vehicle approached (Figure 13). The MWA veterinarians then returned to Maputo that day.

Table 5 – Hyenas' anesthetic protocol during the first capture operation.

| Hyenas | Night of capture | Protocol | Top-Ups of Anesthesia |
|---|---|---|---|
| **1 - Male** | 1 | 80 mg Z+ 3 mg M | 4x: 20 mg Z+1 mg M |
| **2 - Adult female** | 2 | 80 mg Z+ 3 mg M | $1^{st}$: 50 Z + 1 M<br>$2^{nd}$ 20 Z + 1 M |
| **3 - Male** | 4 | 80 mg Z + 3 mg M | 4x: 20 mg Z+1 mg M |

The transport to the boma was quite long, so it was necessary to have anesthetic top-ups (Z- zoletil ®; M – Medetomidine).

Figure 14 - At the first location, on the last morning, the team found a hyena (black circle) and tried to dart it

The second hyena (Figure 14a) was found only two hours after the first dart, prompting the lead veterinarian to administer a slightly higher first top-up of anesthesia.

After the darts were removed, the lead veterinarian and the author applied antibiotics to the resulting wounds (Cloxacillin, Fortitude®)

(a) (b)

(c)

Figure 15 – Hyenas that were captured during the first operation in Location A (a) Hyena 1; (b) Hyena 2; (c) Hyena 3.

**D.2 Second Operation**

The preparation of the capture site started in the morning before the capture: the tree where the carcass would be tied (Figure 15a) and the place where the team would hide (Figure 15b) were selected. There were two vans, one from MWA with a trailer and a crate, and one from KGR, which was used to dart. The van with the trailer stayed a few meters away during the capture.

(a) (b)

Figure 16 - Capture site of the second hyena capture operation. (a) bait station; (b) where the van was hidden for darting (green oval line).

<u>Capture strategy</u>

That night, the bait station was set up with an impala carcass, four midazolam pills of 5 mg each were placed in the carcass and a loudspeaker was placed on the tree to broadcast sounds of hyenas and prey to attract them.

The night was very dark, so a flashlight with a red filter was used to get a clear dart.

The aim was to capture at least three hyenas to join the others the veterinarians had captured in the previous operation.

Table 6 - Anesthesia protocol and additional treatment for the second capture operation of the hyenas.

| Hyenas | 4 | 5 | 6 | 7 |
|---|---|---|---|---|
| **Sex/age** | Adult female | Adult male | Old female | Young male |
| **Time of anesthesia** | 73 minutes | 63 minutes | 90 minutes | Unknown |
| **Protocol** | 70mg Z+4mg M | 80 mg Z+ 3 mg M | 70 mg Z+3 mg M | 70 mg Z+ 3 mg M* |
| **Approach time** | 9 p.m | 11,20 p.m | 4,30 a.m | 4,50 a.m |
| **Rpm** | 32 | 19 | Uknown | 16 |
| **Reversal** | A: 20 mg | A:15 mg | A:15 mg | A: 25 mg |
| **Other Treatments** | 5 mg Midazolam+ 5ml Catosal® | 5ml Catosal® | 5ml Catosal® | 5ml Catosal® |

Legend: M – medetomidine; Z- Zoletil®; A- Atipamezol; Catosal®: multivitaminic. Rpm: respirations per minute; Approach: to the unconscious animal.

*Hyena 7 had already been darted at 7-8 pm, but its whereabouts could not be determined, therefore it was darted again at 4:20 am. The team approached at 4.50am, with the sixth hyena and this one only a few meters apart;

When the veterinarian and the author got close, the hyena was in respiratory arrest. It had a transient apnea for about 1 minute. The lead veterinarian administered 2 ml IM Doxapram and the team had to perform resuscitation maneuvers (chest massage). Intravenous fluids (about 200 ml of ringer lactate) were administered, the anesthesia reversed with 25 mg of atipamezole (a slightly higher dose, usually the dose of atipamezole is 5 times the dose of the alfa-2 agonist administered) and it was placed in the crate.

Figure 17 - Hyena 4 on the stretcher and then in the crate. (original pictures from the author)

Figure 18 - Hyena 5, administration of saline solution and monitoring vital signs (original pictures from the author).

(a) (b)

Figure 19 - (a) Hyena 6 before the veterinarians carried it on the stretcher to the van; (b) Hyena 7 after stabilization (Original picture from the author)

Post-capture procedures:

For all hyenas, after removing the dart(s), antibiotics were applied to the resulting wound (cloxacillin, Fortitude®). It was used gauze for earplugs and blindfolds; Subcutaneous fluids (ringer lactate, between 100–200 ml for each hyena) were administered.

For the first hyena (Hyena 4), the reversal agent plus 5mg midazolam (to keep it calm until a second hyena was captured) were administered after placing it in the crate in the other vehicle, which was left away from the capture site. Then both hyenas were transported to the boma, which took 40 minutes (approximately 4 km). The second hyena did not need an anesthetic top-up (it is important to mention that reflexes were checked: pinching of the ears and between the toes, and a syringe of 30mg Zoletil® and 2mg Medetomidine was prepared);

The sixth hyena (Hyena 6) also did not need a top up of anesthesia;

The anesthesia of the seventh hyena was reversed in the crate before being taken to the boma.

Figure 20 - Transport to the holding facility of hyena 6 (Original picture from the author).

### D.2.2 Necropsy

Hyena 7 probably died not long after the veterinarians released it into the enclosure at 5:45 am. When the team returned at 11 a.m. and performed a necropsy, the findings were limited due to the advanced state of decomposition caused by the high temperatures.

<u>Observations:</u>

- The intestine was bloating, and the skin was fragile and could be peeled off easily;
- There was some generalized congestion (in the chest wall and some organs such as the liver and heart);
- The lungs appeared to be emphysematous.

Figure 21 - Hyena 7 was found dead (Original picture from the author).

(a) (b)

Figure 22 - (a)/(b): lungs and chest wall with signs of congestion and emphysema. (Original pictures from the author).

### D.3. Translocation to Gorongosa

After 15 days of operation D.2, all the hyenas were recaptured from the holding facility where the veterinarians had placed them after the two capture operations. The anesthetic protocol consisted of 60 mg of Zoletil® and 3 mg of medetomidine, and top-ups IM every hour of 20mg of Zoletil® and 1 mg of medetomidine, and they were anesthetized for 8 hours. All hyenas received saline solution (ringer lactate, subcutaneous).

Table 7 - Mean rectal temperature of each hyena during translocation, not measured at specific intervals.

| **Hyena** | **1** | **2** | **3** | **4** | **5** | **6** |
|---|---|---|---|---|---|---|
| **Rectal Temperature (ºC)** | 36.5 | 37.0 | 36.4 | 36.7 | 35.0 | 36.6 |

Figure 23 - Hyenas after being recaptured from the holding facility, already on the aircraft (original picture from the author).

Hyena 5 was slightly hypothermic (average body temperature of most mammals: 37,776º–40ºC), so it was decided to stop the saline solution, turn off the air conditioning and cover it with a blanket.

### E. Outcome

The goal of capturing at least six hyenas was achieved, despite the death of one of the animals. The adaptation of these hyenas to Gorongosa was smooth and without concerns, according to Gorongosa´s veterinarians.

## 3. Operation 3 (Incomati conservation area, Moamba) - Treatment of a wound on the right hind limb caused by a snare in a male Southern-giraffe (*Giraffa giraffa)*;

### A. Context

This conservation area is targeted by buffalo poachers for the commercialization of meat for subsistence. Illegal hunters set usually wire snares to catch them, then kill them and take part of the meat since these animals can weigh up to 800 kg, and to avoid being caught, much of the carcass is wasted.

These snares are not selective; they can catch any animal. Reserves typically have a team of rangers who patrol the area and remove traps, but the areas are very extensive, making it impossible to track all sites every day. In this case, the rangers detected the injured giraffe and reported it to the reserve manager who contacted MWA team.

### B. Objective

Remove the wire snare from the giraffe's right hind leg;

### C. Planning

The MWA veterinarian team drove to Incomati Conservation area, where the manager arranged the helicopter, the support pick up and the rangers (List 3).

| Necessary Equipment/Personnel |
|---|
| For the veterinarian intervention (Figure 9):<br><br>Essential drugs: Etorphine (ultra-potent analgesic opiod), Thiafentanil (ultra-potent analgesic opiod), Naltrexone (opioid antagonist);<br><br>Dart gun: darts: 1,5 inch (3,81 cm), 2 ml; needles: 18G,20G;<br><br>Antibiotic: Cloxacillin, Fortitude® (tube of intramammary application);<br><br>Blindfolds;<br><br>Ropes;<br><br>Pliers; |

| |
|---|
| Helicopter (from MNP);<br><br>Support pickup truck from Incomati Reserve.<br><br>Rangers responsible to patrol Incomati conservation area. |

List 3 - Equipment and personnel required for Operation 3 - removing a wire snare in a southern-giraffe (*Giraffa giraffa*).

## D. The intervention

The rangers had an approximate location of the giraffe before the intervention team arrived.

Using a helicopter, the animal was located and darted. The protocol consisted of 7 mg of Thiafentanil and 7 mg of Etorphine. After 7 minutes the giraffe fell into a small river.

As soon as the team approached, one of the veterinarians held on to the animal's neck (Figure 24), the blindfold was placed, and one of the rangers sat on the torso. The anesthesia was fully reversed with 140 mg of naltrexone, with a total anesthesia time of 12 minutes. The antidote was administered IV into the auricular vein with an 18G needle.

Figure 24- The veterinarian sat on the neck to prevent the giraffe from getting up (Original pictures from the author).

Care was taken to avoid excessive weight and any obstruction of the airways, and the animal was able to use the maximum capacity of its lungs and take deep, long breaths.

The giraffe was positioned in lateral recumbency and the team stayed behind the torso (this is a safety measure as the giraffe was fully awake and could kick). The treatment was simply to remove (cut) the wire that was encircling the limb and causing ischemia, with the distal part of the limb already edematous. As the animal had fallen into the water, we decided not to disinfect the wound. Monitoring in this case consisted of checking respiratory rate and tidal volume.

### E. Outcome

There were no complications despite the giraffe falling into a small river (it was very shallow). It fully recovered and the wire snare was taken off.

## 4. Operation 4 (Limpopo National Park) - Capture and translocation of a lion (*Panthera leo*)

### A. Context

In response to human-wildlife conflict (HWC), the Peace Park Foundation has initiated a voluntary resettlement program to relocate communities from the park's central and remote areas. Concurrently, efforts are being made to improve the livelihoods of people residing in the park's buffer zone. Although this buffer zone is designated as a safer area, wildlife still intrudes, posing risks to the communities. In this case, a young male lion (2-3 years old) was preying on livestock. Initially, there were two male lions, but one had already been captured and relocated within the park.

### B. Objective

Mitigate the HWC by capturing the lion and relocating it to a conservation area within the park.

## C. Planning

The veterinary team drove to Maputo National Park and from there flew in a helicopter to Limpopo National Park. The equipment and personnel needed to capture this lion are in List 4.

| Necessary Equipment/Personnel |
|---|
| For the veterinary intervention:<br>• Essential drugs: Zoletil®, Medetomidine, Ketamine, Atipamezole, Dexamethasone (emergency drug), Doxopram;<br>• Dart gun - Darts: 1 inch (2,54 cm), 1.5 ml; flashlight with red filter, blindfolds, loudspeaker, stretcher;<br>• Antibiotic: Cloxacillin, Fortitude® (tube of intramammary application).<br>• Oxygen Cylinder. |
| Provided by LNP:<br>• Bait (impala);<br>• Helicopter and fuel (managed by the pilot and operation manager);<br>• Rangers and community members;<br>• Radios for communication;<br>• Collar VHF/GPS: drill, screws and metal plate;<br>• Water jerricans, ice packs, leaf blower to cool the animal;<br>• Van covered with oilcloth to provide shade during transportation. |

List 4 - Equipment and personnel required for Operation 4 – capture and translocation of a conflict lion (*Panthera leo*).

### D. The intervention

Tracking and locating the lion

In the days leading up to the operation, a team of rangers had been searching for the lion and provided an approximate location. During the night before the capture, the tactics used to lure the lion were: Sounds of prey and lionesses were broadcast via a loudspeaker, with an impala used as bait. Although the lion roared in response, it did not approach the bait station.

In the morning, around 5:00 a.m. the search began, the helicopter began aerial surveillance, joined by rangers and community members who helped locate tracks (Figure 24). The lion's movements indicated that it had been scared off by the helicopter. So, it was decided to stop the aerial search and start looking for tracks, to get a more accurate position.

With the help of community members and rangers who joined the team to look for tracks as they were experienced in identifying them, the lion tracks were followed for about three hours, covering about 4 km through dense vegetation in temperatures over 40°C.

Figure 25- Lion tracks were followed with the help from community members (original picture from the author).

Capture and Anesthesia

1. Initial Darting: Once the lion was spotted by the helicopter pilot, the lead veterinarian darted it with 150 mg of Zoletil® and 6 mg of Medetomidine.
2. The helicopter "pushed" the lion towards the road over nearly 2 km, near the vehicles.
3. Second Dart: After 25 minutes, with the lion still partially conscious, a second dart was fired from the vehicle containing 80 mg of Zoletil® and 3 mg of Medetomidine.

4. Sedation Check: Stones were thrown to check for any reaction, and only after confirming the lion's sedation and with armed rangers did the veterinarians approach. The entire induction process took approximately 40 minutes.

On-Site Treatment and Preparation for Transport

The lion was cooled with water thrown in it and using a leaf blower, dart wounds were treated with an antibiotic, cloxacillin (inserting the nozzle of the tube of intramammary applications inside the wound), a tracking collar was fitted, and the lion was prepared for transport.

(a) (b)

Figure 26 - (a) Checking vital signs: respiration rate, cooling the lion, removing the darts and administering antibiotics in the wound, and applying the collar.; (b) The lion being carried on the stretcher to the vehicle (Original pictures from the author).

Monitoring and Transport

It took about 4 hours to get to the final location during which the following top-ups of anesthesia were administered (Diagram 3).

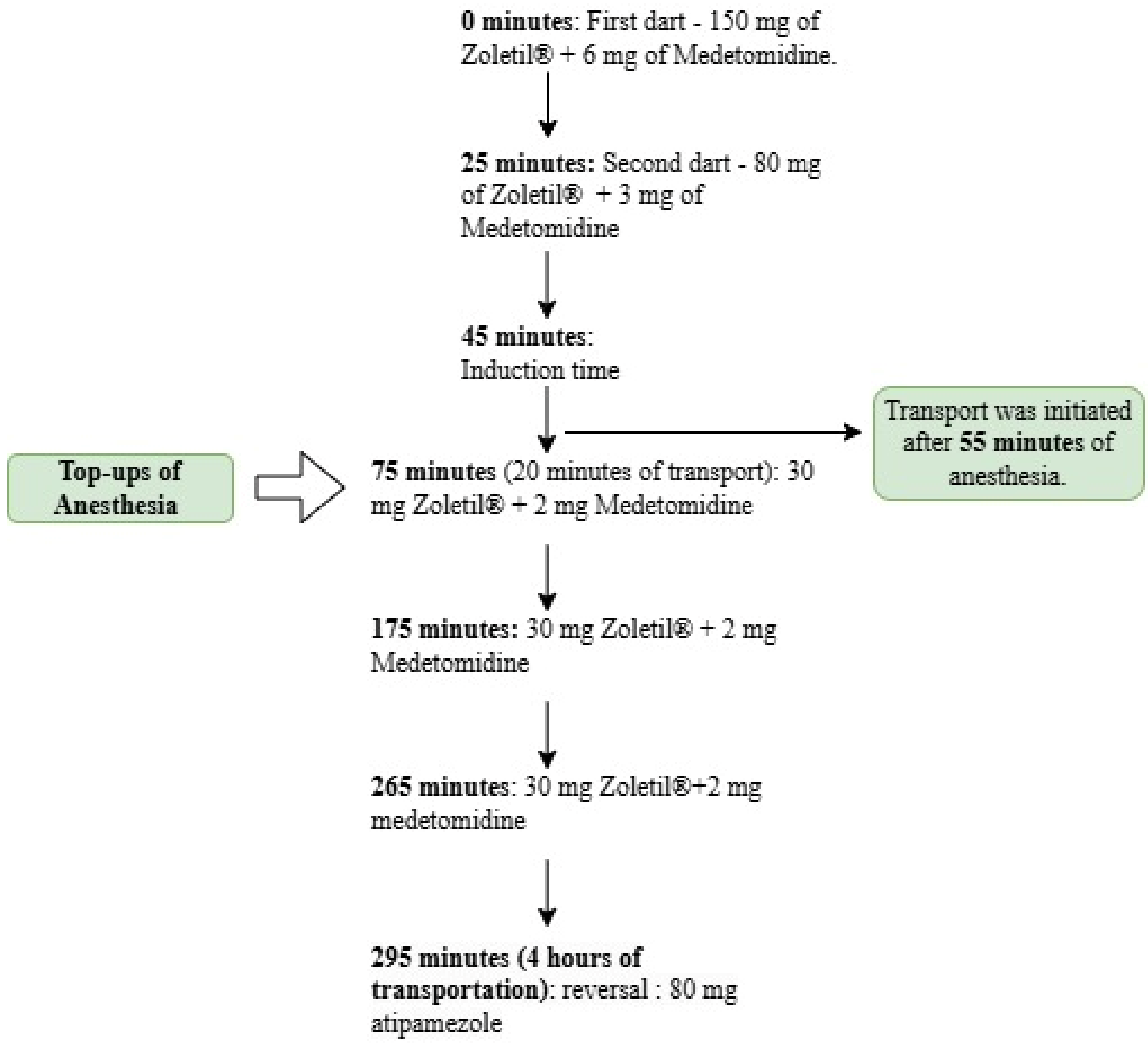


Diagram 3 -Chronology of the lion's anesthesia and respective doses administered.

The ambient temperature exceeded 40°C, leading to hyperthermia in the lion, compounded by the anesthetic effects and the helicopter chase. Median rectal temperature was 41.5ºC during all transportation (Normal temperature of a lion: 37°C–38°C). Attempts were made to control hyperthermia by applying frozen water bottles (Figure 27b) to the inguinal and brachial regions, pouring water from canisters, and placing cloths on the ceiling of the land vehicle to provide shade; 1 mL IM of dexamethasone was administered to reduce the risk of heat stroke. Nasotracheal oxygen therapy (Figure 27a) was given at 5 L/min due to possible hypoxia, potentially caused by drug-induced respiratory depression and hyperthermia, which induced tachypnea (panting).

(a) (b)

Figure 27 - Supplementation of oxygen (a); frozen water bottles placed in the groin and braquial regions (b) (original pictures from the author).

Arrival and Release at the Conservation Area

Upon arrival at the conservation area, the GPS/VHF tracking collar (removed during transport) was refitted, and the anesthesia was reversed with 80 mg of Atipamezole IM (Figure 28). Approximately 25 minutes later, the lion regained enough consciousness to lift its head.

Figure 28 - At the final location, inside the conservation area of Limpopo National Park, before the administration of the antidote to the lion (*Pathera leo*) (Original pictures from the author).

### E. Outcome

Despite the complications of anesthesia (high body temperature and hyperpnea), the lion did not show any health problems. The collar used was for a female (so it wasn not the right size), but it was the only one available at the time. Two months later, the lion was recaptured, and a larger collar was fitted.

## 5. Operation 5 (Masitonto, Sábiè Game Park and Limpopo National Park): Dehorning and collaring Southern white rhinoceros (*Ceratotherium simum*)

### A. Context

Rhino poaching has been a major conservation concern, particularly since the 1970s, due to the drastic decline in rhino populations. It was also during this decade that the trade in rhino horn was banned by CITES, due to the increasing demand and value of the horn (Cheteni, 2014; Wildlife Justice Commission, 2022). To protect this species, one of the measures that gained significant support was dehorning, which began in 1989 in Namibia (Chimes *et al.,* 2022). This practice is not entirely consensual, but it is effective in reducing poaching along with other conservation measures (ranger patrols) and economic and social measures (alternative income for rural and poor communities), private landowners, which end up having anti-poaching security measures more strict and effective.

Because the horn is not removed in whole, there are poachers who try to take what is left. Rhinoceros are often attacked at night, and due to poor visibility, they can be targeted even if they do not have a complete horn. In this case, three rhino dehorning operations are described in three different locations: Masitonto, Sábiè Game Park and Limpopo National park.

**B. Objective**

Dehorn the white rhinoceros to reduce their vulnerability to poachers.

**C. Planning**

For each dehorning operation, the material and personnel requirements are outlined in List 5 and remain largely the same for each intervention. The main difference was in Massitonto where a support aircraft was used and in Limpopo National Park where a tracking device was placed.

| Necessary Equipment/Personnel |
|---|
| Helicopter, support aircraft (in Massitonto, because it was a larger area);<br><br>Support vehicle;<br><br>Radio communication;<br><br>Operation manager of the reserves. |
| Representative of ANAC (National Administration of Conservation Areas of Mozambique) - that assisted to the dehorning procedure and received the horns to burn it (Figure 31). |
| Essential materials for veterinary intervention:<br><br>Drugs: Etorphine (ultra-potent analgesic opioid), butorphanol (analgesic opioid for partial reversal of the anesthesia), Azaperone (butyrophenone tranquilizer), Naltrexone (opioid antagonist), ketamine (cyclohexylamine);<br><br>Dart gun (darts: 2.5 inch (6.35 cm), 2cc ml; needles of 18G,20G. |

| |
|---|
| Antibiotic: Cloxacillin, Fortitude® (tube of intramammary application).<br><br>Chainsaw to cut the horn;<br><br>Horn trimmer;<br><br>Spray of Terramycin;<br><br>Oxygen Cylinder;<br><br>Sampling Kit;<br><br>Collar: Drills, screws, and metal plates (tested prior to the operation) - in LNP;<br><br>Delivery term of the horns (annex B);<br><br>Measuring tape, rulers (to measure the horns); |

List 5 - Equipment and personnel required for Operation 5 – Dehorning and collaring Southern white rhinoceros (*Ceratotherium simum*).

## D. The interventions

### D.1 Massitonto (Moamba district)

The MWA team was notified by the antipoaching manager from this conservation area about three rhinoceros that needed to be dehorned.

Table 8 - Anesthetic protocol of the three rhinoceros dehorned in Masitonto.

| Sex/Age | Protocol (dart) | Rpm | Partial reversal (intravenous) | Full reversal (intravenous) |
|---|---|---|---|---|
| **Adult female (6y)** | 4 mg etorphine+ 40mg azaperone | 4 | 40 mg butorphanol IV (10x etorphine ´dose) | Naltrexone: 80 mg IV (20x etorphine ´dose) |
| **Adult male (6y)** | 3,5mg etorphine +40mg azaperone | - | 35 mg butorphanol IV | Naltrexone: 70 mg IV |
| **Young male (4y)** | 3,5mg etorphine+40mg azaperone | 3 | 35 mg butorphanol IV | Naltrexone: 70 mg IV |

The veterinarian team drove to Maputo National Park and flew by helicopter to Massitonto.

In Massitonto, the lead veterinarians went in the helicopter and the author in a land vehicle. It was necessary a support aircraft to search for the rhinoceros: the operation manager knew an approximate location, but the rhinoceros were distanced from each other.

The only complication during these interventions was on the young male that had more pronounced respiratory depression, so the dehorning took less than 15 minutes, and it was not possible to take samples. This rhino was a little further away from the others.

### D.2 Sábiè Game Park (SGP)

The MWA team was notified by the reserve manager from this conservation area about two rhinoceros that needed to be dehorned.

Table 9 - Anesthetic protocol of the two rhinoceros dehorned in Sábiè Game Park.

| Sex/Age | Protocol (dart) | Additional anesthesia | Partial reversal (Intravenous) | Full reversal (intravenous) |
|---|---|---|---|---|
| **Adult Female, 4y (mother)** | 3 mg etorphine + 40 mg azaperone | 200 mg Ketamine IM | 40 mg butorphanol IV | 60 mg Naltrexone |
| **Female, 2y (calf)** | 2 mg etorphine+ 20 mg azaperone | - | 20 mg butorphanol IV | 40 mg Naltrexone |

The veterinarian team drove to SGP. Then the lead veterinarian darted the adult female and then the calf from the helicopter. To deepen the anesthesia, 200 mg of ketamine was administered intramuscularly with a 20G needle to the adult female as it was very reactive (the vets were close to the animal).

### D.3 Limpopo National Park

Table 10 - Anesthetic protocol of the rhino (*Ceratotherium simum*) dehorned in Limpopo National Park.

| Sex/Age | Protocol (dart) | RR | Partial reversal (Intravenous) | Full reversal (Intravenous) |
|---|---|---|---|---|
| **Male, 5 years** | 4 mg etorphine + 40 mg azaperone | 4 | 50 mg butorphanol | 80 mg Naltrexone |

The veterinarian team drove to LNP. In addition to dehorning, a GPS/VHF ankle bracelet was placed on the right hind limb. The road the animal was on was narrow, the helicopter was unable to land, so the veterinarian threw the blindfold and butorphanol from the helicopter to the author (who was on the ground team) to manage. While the helicopter landed at the base (10-15 minutes away from the animal), the operations manager began placing the GPS ankle bracelet while the author monitored breathing. When the lead veterinarian arrived, the dehorning began.

**Common procedures for all dehorning operations:**

- Partial reversal with butorphanol (10-15x dose of etorphine);
- Put on the blindfold, the earplugs, and position it in sternal recumbency;
- Nasotracheal/Intranasal oxygenation: to improve hypoxemia (10-15 L/min) (Figure 29a);
- The horn is marked with a pen (three fingers from the bottom of the frontal horn and two fingers from the caudal horn), cut off with a chainsaw (Figure 29b) and trimmed afterwards (Figure 30);
- Application of Terramycin spray in the remaining horn;
- Collecting samples - only when the anesthesia was not compromising the animal and there were extra personnel to do it (cartilage biopsy, blood to heparin and EDTA tubes);
- Jerricans with water to cool down.

(a) (b)

Figure 29 – Operation with white rhinoceros (*Ceratotherium simum*): After marking with a pen, a portion of the horn is cut off with the chainsaw. (a) Intranasal oxygen was administered (Massitonto); (b) Sábiè Game Park (Original pictures from the author).

Figure 30 - The horn of a white rhinoceros (*Ceratotherium simum*) from Massitonto being trimmed (Original picture from the author).

Figure 31 - Removed horns of white rhinoceros (*Ceratotherium simum*) and delivery term document, which is signed by the responsible veterinarian, a representative of the National Administration of Conservation Areas (ANAC) of Mozambique and the reserve/operation manager (Annex B). In Mozambique, after the dehorning, the horns are measured and weighted and given to a representative member of ANAC (Original picture from the author).

### E. Outcome

None of the rhinoceroses had post-anesthesia complications. The measurements and weights of each rhinoceros' horns were recorded in the delivery form (Figure 31). Both the delivery term and the horns were placed under the responsibility of the ANAC representative.

# IV - DISCUSSION

The goal of conserving wild species in situ is common to all operations. Due to the diversity of the species and the environment in which they were carried out, there are always setbacks and risks (regardless of whether there has been rigorous planning), and success depends greatly on the versatility, experience of the veterinarians and the availability of resources. No operation can be performed if there is a reasonable chance of the animal dying, and the veterinarian should not be concerned about terminating/postponing the capture if the necessary conditions are not met.

### 1. Elephant (Operation 1)

In this case, the animal had been tagged by the community, so there was some urgency to get a collar on it.

The conflict team went to the location by land vehicle to get a more accurate position of the animal, and the veterinarians flew in a helicopter. The elephant was in a wide area with low vegetation.

One of the veterinarians darted the elephant, while the other veterinarian, the author and the conflict team waited on the road. The ground team was then informed by the veterinarian where the elephant had fallen and approached in a van as soon as it was safe to do so.

During the procedure, a second elephant appeared and posed a safety risk to the team. Therefore, it is important to reinforce that in any type of operation, someone must be responsible for keeping an eye on the surroundings (Caulkett & Arnemo, 2015). So, the number of people that the team will have and the assignment of tasks must be well defined in the planning.

In this particular operation, there were two veterinarians, the author, and three members of the MWA conflict team. Knowing that there were only two elephants in the area, including the one that was immobilized, one of the veterinarians just yelled and waved his arms. However, a team member was already standing by with a gun, that is used in last resort if the animal is not controlled and is aggressive towards the team.

The recommended and ideal position when the animal falls is lateral recumbency, but because this was a short procedure and animal fell in sternal recumbency that facilitates the placement of the collar, the lead veterinarian decided to leave it that way. This position should be maintained for a maximum of 20 minutes: abdominal pressure and pressure on the sternum reduce lung volume. These animals, like mammals in general, have pronounced abdominal/diaphragmatic breathing is made more difficult by this position (Burroughs *et al*., 2021)

The first concern was to clear the airway by extending the trunk (elephants do not breathe through the mouth). To maintain the airway, two small sticks can be placed to keep the entrance to the trunk open and the air flowing. It is important to make sure that the trunk is not obstructed, either by a tusk or because it is under the animal or stuck somewhere, otherwise it could lead to respiratory arrest, hypoxia or even death. (Laubscher *et al*., 2021; Thou1ess, 1996) .

Thiafentanil was chosen instead of etorphine for anesthesia due to its quick induction, minimizing the risk of incidents as the animal falls faster. Hyaluronidase  (trade name of the drug used: hyalase®) also reduces induction time by liquefying the hyaluronic acid that forms the matrix between tissues and cells within tissues, allowing drugs to be absorbed more quickly. (Meyer *et al*., 2021).

Monitoring respiration is essential, focusing on both the frequency and depth, volume of air exiting the trunk. The respiratory rate should be above 5 breaths per minute; in this case, it ranged between 5 and 6 breaths per minute and did not exceed 6. Oxygenation was assessed through arterial puncture (auricular arteries), showing consistently bright red blood, indicating stable oxygen levels (Burroughs *et al*., 2021; Lamont & Grimm, 2014).

A major side effect of these potent opioids is hypertension, including pulmonary hypertension, which can lead to potentially fatal pulmonary edema, known as "pink foam syndrome," where blood leaks from the trunk(Laubscher *et al*., 2021). To counteract this, azaperone is administered to reduce the hypertensive effects of opioids. However, excessive use of azaperone can cause delayed recovery or disorientation, as it lacks a reversal agent. In this case, the anesthesia proceeded smoothly without significant concerns (Burroughs *et al*., 2021).

Body temperature was not taken and as the ambient temperature was not very high (around 25ºC) and the procedure lasted less than 20 minutes, no measures were taken to cool the animal, which in the case of elephants consists of pouring water externally over the ears. (Burroughs *et al.*, 2021; Thou1ess, 1996).

The collar is placed behind the ears, and as it is sometimes difficult to place it around the elephant's head, especially when it is lying sideways, an iron bar is used to move the collar from one side to the other. There is generally no risk of it coming off, but it is important to consider the age and therefore whether the elephant is likely to grow. usually one or two fists between the collar and the neck (Haupt *et al.*, 2021). This elephant was an adult male, so it would not grow any more.

After tidying up the material and re-testing the collar, the anesthesia was reversed with 150 mg of naltrexone IV and the team drove to the road. Later, the veterinarians watched the elephant's recovery from the helicopter. As the frequency of the transmitter can change slightly once it is on the elephant, the radio collar transmitter should be re-tested while the elephant is moving away.

This animal could afterwards be tracked by Earth Ranger (software), and if it comes close to a community it is easier to issue a warning and act promptly and avoid the conflict. The MWA team has access to this software and can monitor the animals fitted with GPS tracking collars and is notified if an elephant comes close to a community.

**2. Carnivores: Hyenas and lions**

These operations with carnivores (hyenas and lions) ended up being the most demanding in terms of time and setbacks, both due to logistics and coordination with reserves, as well as unforeseen events during the operations. These species are most active during the night. They hunt at night and conserve energy during the day. But both hyenas and lions are ultimately opportunistic. They don't chase their prey for long distances. An experienced lion will only try to hunt when the prey is just over 30 meters away (Estes, 2012).

The most common techniques used to capture carnivores are: setting up a bait station and a dart, using traps and cages (although not so common with these large carnivores), or approaching them as close as possible during the day when they are less active and even more so when it is warm and probably in the shade. When using bait, medetomidine or midazolam can be injected into the organs or even the carcass to slow them down and facilitate immobilization.

For these species, special attention must be paid to odors and whether they are accustomed to the presence of vehicles/humans. This will be particularly important in the care that needs to be taken in planning and preparing the capture site (Burroughs *et al.*, 2021).The less these predators sense the presence of humans, the better. Therefore, when using an antelope carcass, the abdomen is opened, the entrails are removed, and the carcass or entrails are attached to the back of a vehicle and dragged in different directions for 1 or 2 km from the bait station location to lure them. Wind direction is also important, because if these animals smell something different than usual, they may not approach the bait station (Smuts, Whyte & Dearlove, 1977).

These animals can also be attracted by vocalizations. That's why a loudspeaker is placed near the bait, which emits sounds of prey and conspecific animals.

On dark nights, an extra person is needed to point the flashlight to assist the veterinarian who has the dart gun loaded and ready to fire. The flashlight must have a red filter, and the moment the animal approaches the bait, the flashlight is aimed from above and lowered until the animal is visible enough to shoot. It should never be pointed directly at the animal's eyes, as this can scare it away (Margetts, Stuart-Fox & Franklin, 2024; Troscianko, Wilson-Aggarwal, Griffiths, Spottiswoode & Stevens, 2017).

After the dart and with the help of the flashlight, it is very important not to lose sight of the animal, often with the initial excitement or stress, the induction of anesthesia can take longer to take effect, giving the animal a chance to run away (Caulkett & Arnemo, 2015).

**2.1 Hyenas (Operation 2)**

The first time the vets went to Karingani to capture hyenas, they stayed 8 nights and only captured 3 hyenas. On the second trip to capture at least 3 more hyenas, the team managed to capture 4 hyenas in just one night. There are factors that influenced the success of both operations, which are summarized in Diagram 4.

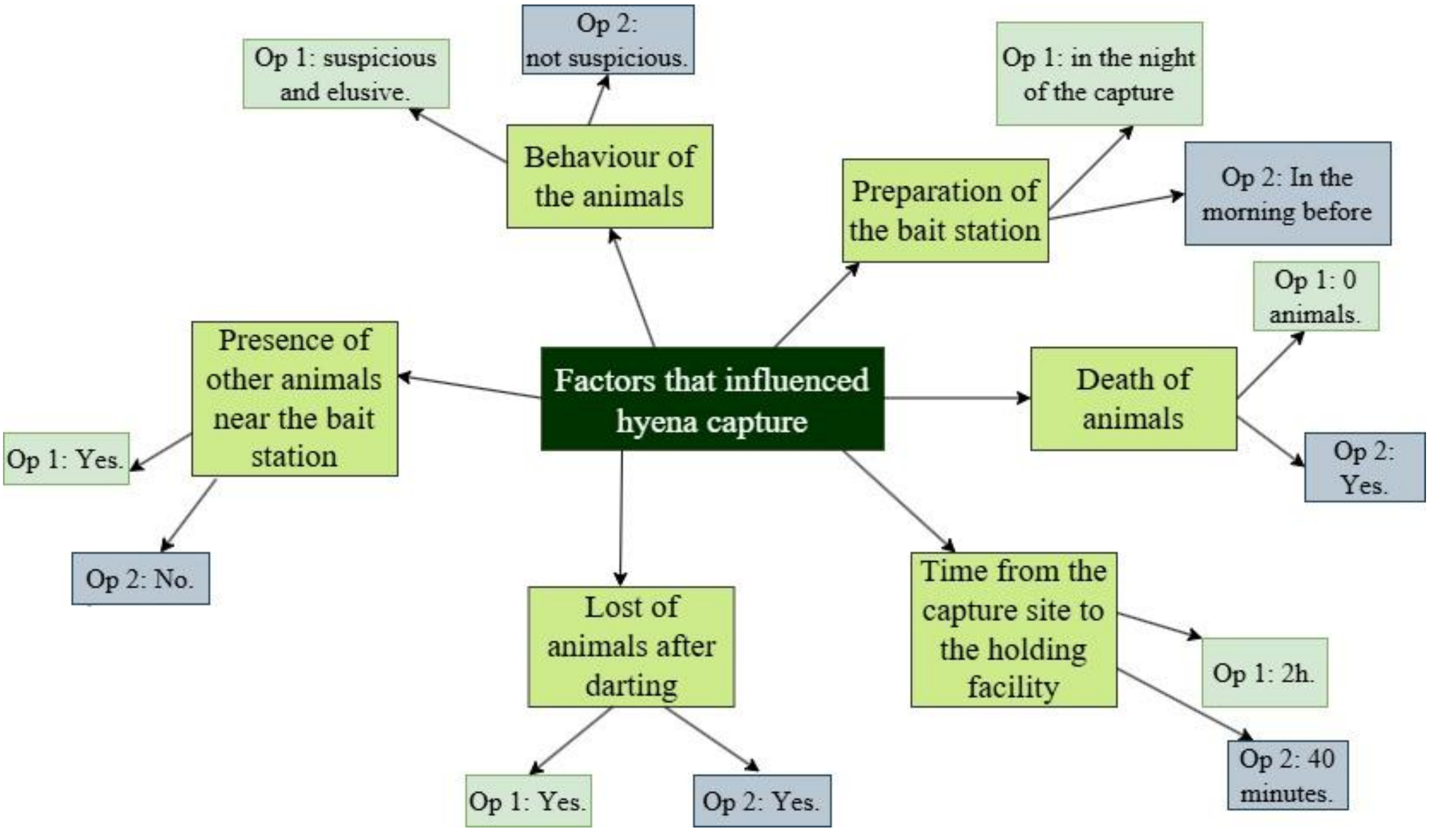


Diagram 4 - Comparison of hyena capture operations 1 and 2 based on the events that occurred during each operation described in chapter III (Operation 2 – Capture of spotted hyenas (*Crocuta Crocuta*).

The locations for the captures are usually given by the Reserve Operations Manager and Rangers who have previously observed the areas and know where the targets tend to be vocalizations, presence of dens, tracks. However, in this first capture, they seemed to be very scattered or in small clans and were much more suspicious, and the team went to another location (B) for the last two nights but no hyenas were seen or heard, so it was decided to call it off. In the second operation, the team moved to another part of the reserve, close to an antelope boma, where there was a greater concentration of hyenas, or at least they were less suspicious and shy because they associated this area with easy food, making it easier to catch them.

In the first operation, there was no opportunity to prepare and select the bait station prior to the start of the capture to avoid losing a night, as the veterinarians arrived at the reserve at the end of the day. The fact that the team was searching for the best location, cutting logs, and hiding the van on the night of the capture may have caused some disruption. The second time, the reserve staff had not defrosted the carcasses, so the capture had to start the next night. And in the morning, the veterinarians had the opportunity to go to the capture site and choose where to place the bait station and where to hide the van.

During the first capture, the hyenas became increasingly suspicious, as soon as these predators heard and sensed the team's presence, they fled.

Several of the strategies mentioned in the clinical cases above were therefore tried:

- Changing the bait station position;
- Place midazolam pills/ Inject medetomidine in the liver/heart of the carcasses;
- Leave the capture site for one/two hours with the bait station set up and with drugs on the organs;
- Chase them by van after eating the drugged organs;
- Use of a one-person tent so that the animals were less aware of human presence.

In both operations, the team lost animals after darting. On the fourth night of the first operation, the veterinarian managed to dart three hyenas, but only one was found. In the second operation, the hyena that escaped returned to the bait station hours later and was darted again. The difficulty in finding these hyenas has several possible explanations: the anesthesia took longer to take effect (due to the excitement and stress), or the dart was not well placed and the drugs were not fully injected, giving the hyena time to escape. Therefore, the capture area should be wide without dense vegetation and a barrier should be placed in the bait area to control the direction of the animals.

Regarding the hyena that died and was darted twice, the necropsy, although inconclusive because of the decomposition of the body due to the high temperatures, does not rule out the possibility that it was a result of anesthesia, which is the most likely cause given the type of drugs used. With the protocol used (medetomidine combined with Tiletamine-Zolazepam, Zoletil®), even when dosed correctly and in a healthy animals, respiratory depression, initial tachycardia that normalizes during anesthesia, atrioventricular blocks, and very marked hypertension may be observed (Chang *et al.*, 2024; Donaldson *et al.*, 2023).

Alpha-2 agonists have cardiovascular and respiratory effects. First, there is an increase in blood pressure caused by peripheral vasoconstriction and an increase in peripheral resistance, followed by an abrupt drop in pressure with a decrease in heart rate and cardiac output. At the respiratory level, it causes bronchoconstriction and pulmonary hypertension (pulmonary vasoconstriction), leading to pulmonary edema and impaired oxygenation of the blood, resulting in hypoxemia, which can be fatal. (Dugdale *et al.*, 2020; Lamont & Grimm, 2014; Meyer, Burroughs, *et al*., 2021). Tiletamine-Zolazepam also has respiratory and cardiovascular effects. Overdose may cause transient apnea and cardiorespiratory arrest (other possible adverse effects are vomiting, excessive salivation, muscle rigidity, which were not observed).

This could be an explanation for the cardiorespiratory arrest in this animal: an individual inability to metabolize Medetomidine and Tiletamine-Zolazepam due to a higher dose. And the findings at necropsy: generalized congestion (in the chest wall and organs such as the liver and heart) and the lungs appeared to be emphysematous, confirm this respiratory and cardiovascular depression.

Another factor that facilitated the second operation was that the holding facility was 40 minutes away from the capture site. The team also took a trailer with a crate. This allowed two hyenas to be captured before the first trip to the boma and quickly returned to the capture site. The first time, because it was two hours away and the team did not bring the crate, there was no more than one trip per night.

The presence of other animals in the first site, such as a herd of elephants and a leopard (*Panthera pardus*), caused disturbance and chased the hyenas away.

Then, fifteen days after the last capture, all the hyenas in the holding facility were recaptured and transported by aircraft to Gorongosa National Park. They were anaesthetized for about 8 hours, with the only major concern being that one of the hyenas became slightly hypothermic - the average body temperature of most mammals ranges from 37.778°C to 40°C (Bewig,M & Mitchell, M., 2009). The adaptation of the hyenas to the Gorongosa National Park was the responsibility of the Gorongosa reserve veterinarians. The hyenas have adapted well to their new environment.

**2.2 Lion (Operation 4)**

It took a month to capture this lion. Veterinarians traveled to Limpopo National Park on three separate 3-4 day trips. Lions, especially conflict lions, end up being more timid, suspicious and elusive, and it becomes difficult to capture them. As an animal that will always try to hide and escape human presence, the normal approach of setting up a bait station may not be the solution (Burroughs *et al*., 2021).

Initially there were two lions, one of which had been previously captured by one of the MWA veterinarians.

The techniques used to ambush the animals included setting up a bait station and dragging carcasses by their entrails, but without success. In the final attempt of the third trip to the park, this method was used to lure the lion during the night and some roars were heard, meaning that the lion stayed in the area all night long. At dawn, a different ambush strategy was adopted: as the temperatures were already very high (almost 30ºC at 5am) and knowing that lions tend to be less active during the day, and especially in the heat and stay still under the shade, the team decided to look for tracks with the help of rangers and community members.

After the team started to follow the footprints for about two kilometers through dense vegetation, with a more precise location, the lead veterinarian finally immobilized it from the helicopter.

The presence of a helicopter was essential here because of the dense vegetation and for the safety of those who would go out to dart. But on the first trip to the park, after a team of rangers and reserve staff located the lion and finally spotted it, the veterinarians did not have a helicopter available that morning, which delayed the capture, and it was decided to postpone it.

The challenges of this transport were largely due to the imminent risk of hyperthermia of the animal as this was a prolonged and stressful induction and pursuit with high ambient temperatures (Ko & Krimins, 2014).

The normal body temperature of a lion is around 37°C–38°C (Friend, Corsini, Manero & Cocco, 2020). Hyperthermia may play a critical role in the development of capture myopathy. Excess heat generated by the accelerated metabolism of muscle cells due to stress and physical exertion of the chase, combined with the anesthesia and ambient temperature, leads to heat-induced cytotoxic damage to muscle cells. During transport, the lion already showed signs of developing this pathology, such as a body temperature of 41ºC, tremors and tachypnea as a compensatory mechanism for cooling (Arnemo *et al*., 2014; Breed *et al*., 2019; Meyer, *et al*., 2021a; Paterson, 2014). To meet the increased oxygen demand (due to accelerated metabolism, hyperthermia and drug-induced respiratory depression which can lead to hypoxia) and to prevent brain cell damage, intranasal oxygen supplementation was vital. Ventilation should be closely monitored and assisted in hyperthermic animals. Given the highly inflammatory component of this condition, 1 mL of intramuscular dexamethasone was administered (Arnemo *et al*., 2014; Fahlman, 2014; Meyer *et al*., 2021; Ozeki & Caulkett, 2014; Paterson, 2014; Walter & Gibson, 2020).

It is not recommended to conduct capture and transport at these temperatures (Arnemo *et al.*, 2014; Breed *et al.*, 2019; Ko & Krimins, 2014; Paterson, 2014).

However, as this was a conflict lion, the veterinarians and operations manager had been trying to capture it for at least a month, and for logistical reasons for the reserve and the MWA team, as well as pressure from the communities of the LNP, this opportunity had to be taken.

**3. Giraffe (Operation 3)**

Giraffe capture and immobilization presents some particularities and risks (mortality is estimated to vary between 25 to 35%) related to its anatomy (its long neck, which can cause subluxation of the cervical vertebrae if handled carelessly) and a very large dead air space. And because of the anesthesia, which consists of the use of strong opioids in high doses: 50/50 etorphine and thiafentanil (a high-dose opioid protocol requires in an adult bull 12 mg-15 mg of opioid, in this case it was used 7 mg of each). It is important to have two veterinarians present, one in the helicopter to dart the animal and another on the ground team in case the helicopter has difficulty reaching the animal (Burroughs *et al.*, 2021; Deacon *et al.*, 2022).

Giraffes are very sensitive to opioids, causing respiratory depression and consequently hypoxia, which can be severe if the opioid antagonists are not administered within a few minutes (ideally less than 5 minutes). An advantage of the high-dose opioid protocol was that the induction time was very fast, and the lead veterinarian was able to fully reverse the anesthesia in 4-5 minutes. Giraffes also have a limited tolerance to exercise, so higher doses are needed to shorten the induction time. In giraffes, there is a risk of falling backwards during induction because they start to run, oblivious to all obstacles, and raise their heads as if they were stargazing, and ropes can be used to prevent this. In this case, due to the rough terrain and dense vegetation, the team could not use ropes (usually two ropes are used, one for the chest and one for the legs, which requires an experienced team) (Burroughs *et al.*, 2021; Deacon *et al.*, 2022). So, the team just waited for the giraffe to fall on itself.

It ended up falling into a shallow river, which is a risk, but the animal was uninjured. Although it is a ruminant and therefore sternal recumbency is recommended, because of the length of the neck and the complete reversal of the anesthesia, it must be placed in lateral recumbency and the legs stretched out so that it doesn't become numb, which can make it difficult to stand up. Since giraffes use their neck to get up, there must be at least one person on the neck and another on the torso, always making sure that the head and the beginning of the neck are elevated (to prevent passive regurgitation), which was possible because the head was on the edge of the river and therefore there was a small slope. These animals are handled awake so it's crucial to reduce the stimulus (blindfold and earplugs) because they can become stressed and start to kick, which is a risk not only for the animal but also for the team, who must be positioned behind the torso (safety measure). Care must be taken to avoid excessive weight and any obstruction of the airways; the animal must be able to use the maximum capacity of its lungs and take deep, long breaths

In this case, the veterinarian, who was on top of the neck, was responsible for the intravenous reversal of the anesthesia and for controlling the frequency and depth of breathing through the air coming out of the nostrils (should be 12-20 deep rpm) (Deacon *et al*., 2022).

Gums can't be used to assess oxygenation, circulation, or cardiovascular function because these species' gums are dark blue, purple, or grayish. If they're white, dark red, or too dark, it's a sign of shock. If breathing is deep and regular, there are no major physiological changes *(*Meyer *et al*., 2021a).

Since the animal was in the river, it was decided to simply cut the wire around the leg without any major treatment as it would soon come out with the water. The team that was positioned behind the trunk for safety and to access the injured leg, a rope was used to pull the leg as close as possible to the lead veterinarian and then the trap was cut with pliers.

After the entire team had moved away, the veterinarian removed the blindfold and earplugs, walked away, and the giraffe stood up on its own without any major complications or effects from the manipulation and anesthesia.

**4. Rhinoceros (Operation 5)**

Dehorning operations follow strict protocols to minimize stress and respiratory complications, especially given rhinoceros' sensitivity to anesthesia. Procedures are coordinated to be as quick and efficient as possible.

All procedures after butorphanol administration and blindfolding can be performed at the same time, if the number of personnel available with qualification allows it.

Etorphine causes significant respiratory depression, hypoxemia, hypercapnia, acidosis, tachycardia, muscle rigidity and tremors in rhinoceros. It is therefore used in combination with azaperone (a sedative), which reduces hypertension and increases cardiac output and peripheral vascular resistance. To improve hypoxemia and respiratory depression, butorphanol (at a dose of 10-15 mg of butorphanol per milliliter of etorphine) should be given intravenously into an ear vein as soon as we approach the animal. There is no major changes in respiratory depression with butorphanol, but hypoxemia improves and another measure to reduce it is to give intranasal oxygen (Fahlman, 2014), which was done in almost all the animals except in Sabie Game Park as there was only one oxygen cylinder and two rhinoceros.

Respiration remains our main concern during the immobilization, so it is important to constantly monitor the respiratory rate and the amount of air leaving the nostrils (Van Zijll Langhout *et al*., 2016). The degree of oxygenation must also be monitored, which in these operations was done by observing the color of the blood (Meyer *et al*., 2021a). The anesthesia used will also cause muscle hypertonicity and tremors, resulting in an increase in body temperature and accumulation of lactic acid. These tremors are very common to observe in anesthetized rhinoceros, but as they cause an increase in oxygen consumption and subsequent hypoxemia, the administration of a benzodiazepine may be considered (Burroughs *et al.*, 2021).

The most adequate position, and especially if the animal has run a long distance prior to induction is lateral recumbency to ensure leg blood circulation, and should be moved (change position), if possible, and placed in sternal recumbency prior to administration of the reverser to facilitate standing (Burroughs *et al*.,2021). During these dehorning operations, the rhinoceros remained most of the time in the sternal recumbency because hypoxemia tends to be less severe in this position (Fahlman, 2014) and facilitates the cut of the horn.

Rhinoceros are prone to subcutaneous abscesses because they have a very thick skin, and to avoid this infection, it is important to clean the wound with antiseptic and administer intramammary antibiotics inside, inserting the blunt nozzle into the wound as deeply as possible (Burroughs *et al.*, 2021). After the cut, the remaining horn must be sprayed with Terramycin to prevent infections too.

It is also crucial to control the body temperature. If environmental temperatures are very high, it is important to have jerry cans of water to pour over the animal to cool it down, the use of a leaf blower can also be beneficial.

For the dehorning in Massitonto, there were three teams: a ground team (the author, operation manager and rangers), a veterinary team (in the helicopter) and a spotting team. A support aircraft was needed to locate the rhinoceros. The operation manager had an approximate location, but the rhinoceros were spread out.

The helicopter must be as light as possible to make it easier to pursue and dart the animal. Dehorning requires at least a veterinarian, a competent person to assist in the procedures, who may or may not be a veterinarian, and a pilot. In this case, in addition to the pilot, the helicopter carried two veterinarians and essential equipment: a veterinarian's kit with medications and a basic surgical kit, a sampling kit, a chainsaw, a trimmer, and an oxygen cylinder.

The second animal was far from where the ground team was and therefore did not arrive in time to help as the anesthesia and dehorning were kept as short as possible due to severe respiratory depression. The pilot had some experience, so he helped the veterinarians with this animal.

At SGP we were faced with a cow/calf situation. So, the lead veterinarian decided to dart the mother first and then the offspring, even though the target was only the calf, which was not the case because mothers are very protective and can become aggressive or on the contrary run away, and the calf, being dependent, can be a big problem if it is abandoned.

During the Limpopo operation, it took the rangers several days to locate the rhino, as it was the only one in the area. When it was finally found, the veterinarian in charge, positioned in the helicopter, fired the dart. However, because the road where the animal was located was narrow, the helicopter was unable to land. As a result, the veterinarian threw the blindfold and butorphanol from the helicopter to the author (who was on the ground team) to administer. While the helicopter landed at the base (10–15 minutes away from the animal), the operations manager began placing the GPS ankle bracelet, while the author monitored the rhino's breathing. This highlights the importance of a ground team capable of managing such situations. Once the lead veterinarian arrived, the dehorning procedure began, and everything proceeded without major setbacks.

# V - CONCLUSION

The conservation interventions and anesthesia plans for certain species and different situations are quite well defined, but to reach this point there have been several attempts over the years, and even so, as in the cases described above, none of these procedures are free of risks and unexpected setbacks, given the number of variants both related to the animal and to the environment in which it is found.

Through careful planning, appropriate use of anesthesia, and response to medical emergencies, these operations underscore the importance of veterinary expertise in wildlife conservation. The document illustrates that conservation success relies not only on policy and habitat management but also on immediate, hands-on actions that safeguard both animal welfare and biodiversity.

In wildlife operations such as those described in this document, it is not always possible to monitor all vital parameters due to the need for rapid procedures. The primary approach is to reverse the anesthesia immediately if there is any indication that the animal is not responding well, such as signs of tremors, tachypnea or respiratory apnea. In practice, detailed measurements such as precise blood oxygenation (pulsoximetry), echocardiography or capnography are not essential, apart from the fact that the environmental conditions are usually difficult. Whatever the specific measurements, the protocol remains the same: if adverse reactions are observed, the priority is to reverse the anesthesia immediately in order to stabilize the animal.

Veterinary interventions are vital to sustaining wildlife populations in dynamic ecosystems, emphasizing the need for ongoing research, ethical practices, and resource allocation for effective wildlife conservation and protection of endangered species.

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## ANNEX A

**Value of the horn: Impact of poaching of Rhinoceros.**

The persistent demand for rhino horn explains why its value remains high. On the contrary, the value of many wildlife products on the black market, such as elephant ivory, has decreased, which ultimately reduces hunting by not compensating traffickers.

Table A1 - Average value of raw rhino horn (USD/kg) in seven African and Asian countries, 2016-2022 (Wildlife Justice Commission, 2022).

| Year | South Africa | Mozambique | Democratic Republic of Congo | Malaysia | Thailand | Vietnam | People's Republic of China |
|---|---|---|---|---|---|---|---|
| 2016 | | | | | | 22257 | 20132 |
| 2017 | | 10667 | | | | 18591 | 19723 |
| 2018 | 5514 | 6664 | | 8562 | | 16595 | 17545 |
| 2019 | 5687 | | | 7682 | 9398 | 11418 | 20881 |
| 2020 | 3382 | 3987 | 5250 | | | 10694 | |
| 2021 | 4968 | 4536 | 5250 | | | 13445 | |
| 2022 | 7529 | 4776 | | | | | |

The decrease in 2019 and 2020 is explained by the covid-19 pandemic.

The value of the horn increases from the point of origin to the point of transit and to the point of destination (China and Vietnam) because there are associated costs included in this price, which are labor, guns and ammunition, food, transportation (domestic and international), packaging and other materials to conceal the horns, warehousing/storage, and payments to corrupt officials at the airport. For example, the value of the horn in Mozambique in 2018, with shipping costs, was 7000-8000 USD/Kg, upon arrival at the destination it would already be 11500-13000 USD/Kg (Wildlife Justice Commission, 2022).

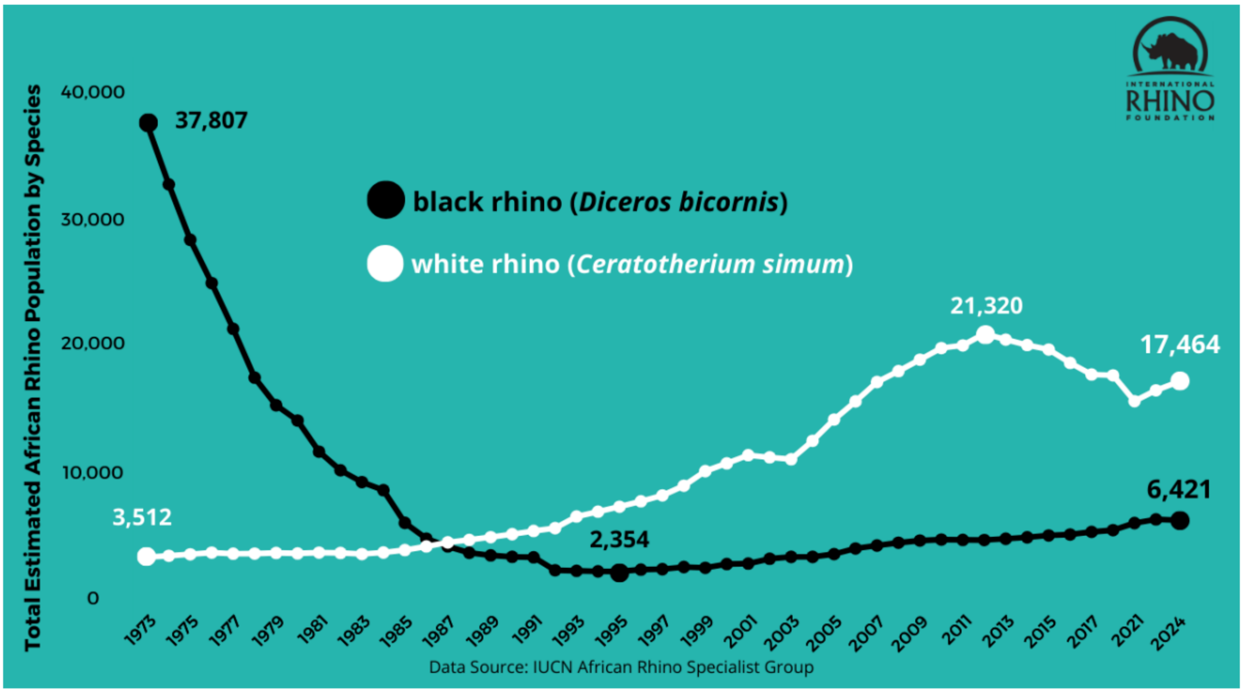


Figure A2 - African rhino population (International Rhino Foundation, 2024).

## ANNEX B

## Delivery term of rhinoceros 'horns in Mozambique.

REPÚBLICA DE MOÇAMBIQUE
MINISTÉRIO DA TERRA E AMBIENTE
ADMINISTRAÇÃO NACIONAL DAS ÁREAS DE CONSERVAÇÃO
SERVIÇOS DE PROTECÇÃO E FISCALIZAÇÃO

=TERMO DE ENTREGA=

No dia ............. o mês de ....................de.......... pelas ............ horas, foi por este termo feita a estrega de .............. CORNO(S) DE RINOCERONTE , com o peso total de ............. obtidos de acordo com o protocolo estabelecido pela Administração Nacional das Áreas de Conservação (ANAC) do MITADER, no ............................................ Distrito de .........................................., Província de ............................................,

Localização ............................

............................

| | Sexo | Idade | Corno frontal | Corno caudal |
|---|---|---|---|---|
| Rinoceronte Branco | | | | |
| Rinoceronte Preto | | | | |
| Observações: | | | | |

| Entregou (Operador) | Testemunhou (PRM) | Recebeu (ANAC) |
|---|---|---|
| | | |
| Nome | Nome | Nome |
| | | |
| Assinatura | Assinatura | Assinatura |

**ANNEX C**

**Poster made and presented by the author at the III Mozambique Congress: “Towards a more active profession in the promotion of global health” in Maputo, 24/11/2023**