Development of SOPs and a training package for the field immobilisation of large herbivores in Judas control programs

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Table of Contents

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1. Name of Project

Development of SOPs and a training package for the field immobilisation of large herbivores in Judas control programs

2. Project Aim and Objectives

2.1. Background

Introduced large herbivores, such as feral donkeys (Equus asinus) and feral camels (Camelus dromedarius), cause significant and undesirable impacts on the Australian landscape. These impacts can be economic, environmental and/or social. The challenge is to reduce these impacts to a manageable level. This objective is usually achieved using population reduction programs.

For large herbivores, the optimum method of removing them from the landscape is by aerial shooting. This has been successfully applied to rapidly reduce populations (e.g. the Bovine Tuberculosis Eradication Campaign 1970-1997, achieving disease freedom in 1989). The effort associated with aerial control increases as animal density declines. Consequently, the Judas technique was initially developed to improve the efficiency of feral goat control efforts at low density populations and has since been extended to large herbivore control.

2.1.1. Control of Large Herbivores using a Judas Approach

The Judas technique is used to assist in the location and control of gregarious animal species. Individuals are fitted with telemetry devices (radio collars) and tracked. In this way they 'betray' the presence of their companions. Some of the first successful applications of the Judas technique were in programs to eradicate remnant populations of feral goats, Capra hircus (e.g. Henzell 1987, Taylor and Katahira 1988, Keegan et al. 1994). It has since been successfully applied to the management of other large mammal pest species including feral pigs, Sus scrofa (McIlroy and Gifford 1997), feral donkeys (A.G. Johnson and M.G. Everett, Western Australian Department of Agriculture and Food [DAFWA], unpublished data), Himalayan tahr, Hemitragus jemlahicus (Simmons 2002), red deer, Cervus elaphus, fallow deer, Dama dama (Nugent 2002) and even starlings (Woolnough et al. 2006). For large herbivores, one of the critical difficulties of any Judas program is the attachment of the telemetry collar (either UHF satellite or VHF radio beacons) to the animal. This generally involves immobilisation of the animal in remote field locations. In operational control programs this field immobilisation is routinely conducted by a non-veterinarian field operator.

2.1.2. Need for SOPs for the immobilisation of large herbivores

In Western Australia, a successful Judas program has been undertaken since 1994 for feral donkeys. At any one time, there are more than 400 'active' Judas donkeys. Each of these animals has been immobilised by darting (from a helicopter) with suxamethonium chloride. Whilst this muscle relaxant has been proven to be safe and effective, there are general concerns about the welfare associated with this neuromuscular blocker, since no sedation occurs. Since the original procedure was described for the use of S4 drugs by authorised non-veterinary Agriculture WA staff in April 2000, advances in equine anaesthetic protocols have been developed that

may be more appropriate for large herbivores generally. The optimum equine immobilisation tool needs to be field tested and, if appropriate, developed into a Standard Operating Procedure for use. Edwards et al (2004) highlighted the potential for the Judas technique in camels. The merits of the Judas techniques for camels are being investigated (Woolnough et al. DAFWA pilot study involving control; Lethbridge et al. Flinders University assessing new technologies) and will contribute to the Australian Feral Camel Management Project (AFCMP) funded by Caring for Our Country. As with Equids, there is a need to develop a SOP, appropriate for non-veterinarian operators, for the field immobilisation of camels.

2.2. Links with APAS

To meet the actions of the Australian Pest Animal Strategy (APAS), and consequently community standards, Standard Operating Procedures (SOPs) need to be developed to ensure that control methods are humane, safe and efficient. For aerial control programs, national competencies, Codes of Practices (COPs), SOPs and training standards have been developed or are in the process of development. In contrast none of these have been developed for the Judas technique when used on large herbivores These SOPS are critical for the safe, efficient and humane immobilisation of the animals preceding collar attachment. Furthermore, these SOPs need to be species-specific because the physiology of a Perissodactyl (e.g. donkey) differs significantly from an Artiodactyl (e.g. camel) such that different drug regimes are required. Development of the SOPs requires assessment of potential drugs followed by the testing and documentation of the appropriate drug regime. Once developed, the SOP requires an appropriate training package to be developed and implemented so that the tool can be used by the field operatives. Importantly, the development of these two SOPs (donkeys and camels) will contribute to the National Model Codes of Practice and Standard Operating Procedures developed by the NSW Department of Primary Industry and Investment.

2.3. Project Objectives

The project was divided into two stages:

Stage 1: The objective of the first stage was to develop a standard operating procedure for the field immobilisation of feral donkeys and feral camels. The development of the SOPs required assessment, testing and documenting the appropriate drug regime for the humane, safe and efficient immobilisation of large feral herbivores (specifically feral camels and donkeys). Once developed, the SOPs contributed to the work of NSW DPI and the Vertebrate Pests Committee (VPC). Furthermore, the testing component for feral donkeys and camels will be published in a peer-reviewed journal.

Stage 2: The objective of the second stage was to develop and implement a training package to ensure that field operatives are competent to immobilise donkeys or camels for Judas control programs. The training package will be developed based on the SOPs. Once developed, the training will be delivered to field operatives in both South and Western Australia. The content of the training package will be made available to other jurisdictions.

3. Project Location

Donkeys:
The project work occurred in the Pilbara region of Western Australia. The operational work was based from Port Hedland.

Camels:
The project work was centred around Warburton in Western Australia, with field work occurring in north-western South Australia and central-eastern Western Australia.

Office-based work was done primarily in the population hubs of Perth, Adelaide and Orange.

4. Methodology

4.1. Immobilisation of Camels

Immobilisations were performed in the Warburton region and Gibson Desert of Western Australia in 2010 and 2011. Animals to be captured were chosen on the basis of suitability as Judas individuals. The methodology built upon immobilisations undertaken in the same region in 2008.

Feral camels were captured using a combination of medetomidine (Medetomidine, Kyron Laboratories, Johannesburg, South Africa) at a concentration of 20/40 mg mL^{1}, ketamine dry powder 1g (Ketamine, Mavlab, Queensland, Australia) and butorphanol 10mg/mL.

The drug combination was delivered by remote injection in 'C type' 6/7 mL darts, fitted with 1.5 inch wire barbed needles (Pneu-Dart, Pennsylvania, USA). They were fired from a Pneu-Dart gun (Pneu-Dart, Pennsylvania, USA), from a Robinson 44 (R44) helicopter (Robinson Helicopter, California, USA). All animals were darted at a distance of 5-15 m. Body weights of animals were estimated from visual examination.

Once animals had been darted, the helicopter would leave the immediate vicinity of the animal in an attempt to decrease excitation during the onset of sedation. Visual contact with the animal was maintained at all times. The helicopter would then return to the animal's vicinity and land when recumbency was achieved or when the animal was sufficiently sedated to allow roping down. Once recumbent, animals were placed and held in sternal recumbency and a blindfold was placed over the animal's eyes to reduce visual stress and stimulation. Forelimbs were tied to prevent the animal from standing. Anaesthetic monitoring consisted of recording heart rate, respiratory rate, rectal body temperature, pulse strength, capillary refill time and mucous membrane colour. Measuring oxygen saturation and heart rate was accomplished using a pulse oximeter.

Once the animal had been collared with a satellite tracking collar and the required data had been recorded, ropes were removed and atipamezole (Antisedan, Novartis, NSW, Australia), a specific antagonist to medetomidine, was administered intra-muscularly into the quadriceps muscle, at a rate of 3mg/mg of medetomidine. Naltrexone at 2.5mg/mg of butorphanol was also given intra-muscularly. The animal continued to be held in sternal recumbency until obvious signs associated with reversal drug was noted. Within five minutes, animals lifted their head, became more

alert and attempted to stand. Animals were observed until they stood and regained coordinated locomotion and walked away. Using the satellite tracking data the next day, all animals were noted to have moved from their original location. All recoveries were uneventful.

Results are presented as mean ± standard deviation unless otherwise stated.

4.2. Immobilisation of Donkeys

All immobilisations were performed on pastoral stations in the Pilbara region of Western Australia in November 2010. Maximum air temperatures in the shade were extremely high at the field site on all days of the study (44.9 ± 0.6 ℃; Bureau of Meteorology). Animals to be captured were chosen on the basis of suitability as Judas individuals. Mature, non-pregnant females, without young at foot are considered the most gregarious class of donkeys and were preferred for this reason. Animals with an estimated body weight of close to 200 kg were preferred to minimise the dart size required.

Fourteen feral donkeys were captured using a combination of medetomidine (Medetomidine, Kyron Laboratories, Johannesburg, South Africa) at a concentration of 20 mg mL^{-1} and ketamine (Ketamine, Mavlab, Queensland, Australia) at a concentration of 200 mg mL^{-1}. Initial dose rates for donkeys were extrapolated from the related species Przewalski's horse (Equus Przewalskii Przewalskii; Matthews et al., 1995) and other ungulate species (Jalanka and Roeken, 1990; Tyler et al., 1990). Initial dosages were then raised to allow for the completely wild, free-ranging nature of the donkeys in this study (Matthews et al., 1997) and the need for recumbency, not just sedation, in all cases.

The drug combination was delivered by remote injection in 'C type' 6 mL darts, fitted with 1.5 inch wire barbed needles (Pneu-Dart, Pennsylvania, USA). They were fired from a Pneu-Dart gun (Pneu-Dart, Pennsylvania, USA), from a Robinson 44 (R44) helicopter (Robinson Helicopter, California, USA). All animals were darted at a distance of 5-15 m. Body weights of animals were estimated from visual examination.

Once animals had been darted, the helicopter would leave the immediate vicinity of the animal in an attempt to decrease excitation during the onset of sedation. Visual contact with the animal was maintained at all times. The helicopter would then return to the animal's vicinity and land immediately after recumbency was achieved. Once recumbent, animals were approached on foot, manipulated into a lateral recumbency position and a blindfold was placed over the animals eyes to reduce visual stress and stimulation. Physical restraint consisted of light pressure being placed on the lateral neck. Anaesthetic monitoring consisted of recording heart rate, respiratory rate, rectal body temperature, pulse strength, mucous membrane colour, corneal reflex strength and muscle tone. Heart rates were measured by auscultation and body temperatures were measured using a rectal thermometer. Degree of sedation is categorised as light, moderate, deep or very deep based upon the strength of corneal reflexes, degree of muscle tone and pulse strength, as recommended by Matthews et al. (1997). Measuring tissue oxygenation was attempted using a Trusat pulse oximeter (Datex Ohmeda, Kentucky, USA) but proved unreliable due to battery life constraints.

Once required data had been recorded, atipamezole (Antisedan, Novartis, NSW, Australia), a specific antagonist to medetomidine, was administered intra-muscularly into the lateral neck, at a concentration of 5 mg mL^{-1}. Atipamezole was administered a minimum of 15 minutes after darting to minimise any residual ketamine effect.

Atipamezole dose rates were extrapolated from recommended dose rates for equids and other related species (Jalanka and Roeken, 1990; Matthews et al., 1995). Blindfolds were removed and animals released from physical restraint once reflexes had become strong and consistent and full muscle tone returned. The animals were observed until they stood and regained coordinated locomotion. They were then circled from a distance with the helicopter in a 'fly-over' procedure five minutes after standing to ensure recoveries were complete and uneventful. Ten of the 14 animals were then located using radio telemetry 24-48 hours after capture for visual examination. Results are presented as mean ± standard deviation unless otherwise stated.

4.3. Training Package Development and Delivery

The training package was developed based upon the SOPs, and delivered to field operatives from South Australia and Western Australia as a trial training program.

The training package comprised two components:

1. a face-to-face theoretical workshop and demonstration
2. a series of supervised practical exercises, in an ex-situ location.

The training package for camels is ready to be made available on-line, though we will await approval of the SOP by the Vertebrate Pests Committee (VPC). The draft SOP is to be submitted promptly. However, the on-line camel immobilisation training package will still need to be complemented by the demonstration and practical exercises.

The Adelaide-based workshop was held in the PIRSA Conference Room, Urrbrae, whilst the practical exercises were held on private property at Mylor.

Theoretical and practical components addressed:

- Camel natural history and behaviour
- Animal welfare considerations
- Legislation
- Occupational Health and Safety
- Operational Procedures
- Anaesthesia
- Emergency procedures
- Practical – drug handling and preparation
- Practical – dart rifle maintenance and operation
- Practical – camel anatomy, injections and collaring

5. Results

5.1. Immobilisation of Camels

Anaesthetising dromedary camels in the wild situation can be very variable. Initially a combination of medetomidine, ketamine and butorphanol was used to anaesthetise the animals effectively, but later medetomidine at higher doses and ketamine were as effective.

Young adult males and females and adult males and females were anaesthetised during 2008, 2010, and twice in 2011. The immobilisation procedure has been refined through the capture of camels under this project (2010-2011) and a previous exercise in 2008. 63 camels were anaesthetised in total over this time to attach satellite tracking collars.

Not all animals became recumbent even at very high doses. Some animals that were very ataxic would, when approached, move away steadily. Ropes were required to lasso the camel and immediately run around the camel, pulling on the rope to cause it to trip over. Once the animals were down they were placed in sternal recumbency, the head was covered, the front legs hobbled. None would attempt to stand.

All animal physiological parameters were measured and found to be within an acceptable range.

The drug doses were based on three categories: young adults, adult females and adult male.

The following table describes the doses used:

Chemical name	Conc	Route	Dose	Total dose for subadult male or female	Total dose for adult female camel	Total dose for adult male camel
Medetomidine	20 or 40mg/ml	IM	100-120mg	100mg	110mg	120mg
Ketamine	1g	IM	1g	1g	1g	1g
Butorphanol	10mg/ml	IM	15-25mg	15-20mg	15-20mg	20-25mg

Total recumbency times were variable, but generally 20-45 minutes. The majority of animals attained a moderate plane of anaesthesia appropriate to the fitting of telemetry collars.

All physiological parameters were measured immediately after recumbency and then at 10 minute intervals. No animals displayed apnoea, cardiac arrhythmia, or abnormal mucous membrane colour. Capillary refill times were 1-2 seconds in all animals during recumbency. Body temperatures ranged from 37.6 to 41.0℃

Once the procedures were completed, the ropes were removed and the reversal drugs given at the following doses.

Chemical name	Conc	Route	Dose	Total dose for subadult male or female	Total dose for adult female camel	Total dose for adult male camel
Atipamezole	5mg/ml	IM	300-360mg	300mg	330mg	360mg
Naltrexone	50mg/ml	IM	50-75mg	50-60mg	50-60mg	60-75mg

Recovery after administration of atipamezole and naltrexone was generally smooth and rapid. Initially the respiratory rate would increase, control of head movements were regained, eyes became more alert and the animal would attempt to stand. In almost all cases, this sequence was completed in a few minutes. Most animals displayed some ataxia, some would stand and shake and move slowly, others would stand and immediately walk away. Within 10-15 minutes of first standing, all animals assumed a normal gait and achieved relatively coordinated locomotion. When fly-over procedures were performed ten minutes post-recovery, most animals were returning to normal behaviour. No animals suffered any injury as a result of these procedures.

5.2. Immobilisation of Donkeys

Drug dose rates, time to recumbency and recovery and physiological variables recorded during recumbency are presented in Table 1. Two animals (#12 and #14; Table 1) did not become recumbent after a single dart was administered, and both required a second dart. These two animals had the highest body weights in the study, both estimated at 300kg. Inductions, from darting to recumbency, were observed to be calm and smooth in all cases, with no evidence of distress or injuries sustained. Induction time was consistently short (9 minutes ± 2.6 mins).

Table 1. Summary of immobilisation procedures
ID – individual animal identification; Time 1 – time from dating to recumbency; Time 2 – total recumbency time; Depth- depth of sedation; HR – heart rate; RR – respiratory rate; T – rectal body temperature.

Animal	Sex	Estimated Weight (kg)	Medetomidine (mg kg^{-1})	Ketamine (mg kg^{-1})	Atipamezole (mg kg^{-1})	Time 1 (min)	Time 2 (min)	Depth	HR	RR	T (℃)
1	F	180	0.22	5.55	0.55	6	27	Deep	56	34	39.5
2	M	250	0.12	3.20	0.30	12	10	Light	45	51	39.6
3	F	230	0.13	3.48	0.33	9	12	Light	60	54	38.4
4	F	220	0.14	3.64	0.34	10	15	Moderate	48	60	39.8
5	F	250	0.12	3.20	0.30	14	8	Light	54	57	39.1
6	F	210	0.14	4.76	0.36	9	54	Very deep	60	36	39.6
7	M	200	0.15	5.00	0.37	12	17	Moderate	72	36	40.0
8	F	180	0.13	5.55	0.42	6	47	Deep	75	38	39.3
9	F	240	0.15	3.33	0.31	12	10	Light	51	45	39.5
10	M	200	0.14	4.00	0.37	10	21	Moderate	60	39	39.5
11	F	220	0.13	3.64	0.34	8	23	Moderate	54	39	38.7
12	F	300	0.13	3.67	0.33	10	17	Light	48	66	41.3
13	F	230	0.13	3.48	0.33	5	19	Light	56	52	39.3
14	M	300	0.13	4.67	0.25	8	10	Light	60	30	41.6
Mean		229	0.14	4.08	0.35	9.4	20.7		57.1	45.5	39.7

Medetomidine doses used were 0.14 ± 0.03 mg kg^{-1}, ketamine doses 4.08 ± 0.85 mg kg^{-1} and atipamezole 0.35 ± 0.07 mg kg^{-1}. Three animals entered deep or very deep planes or sedation after darting, displaying weak palpebral responses and poor muscle tone. Dose rates of medetomidine received by these animals ranged from 0.13-0.22 mg kg^{-1} and doses of ketamine 4.76-5.55 mg kg^{-1}. These animals had longer recumbency times and were more ataxic at time of initially standing. Total recumbency times were variable, but generally short (21 ± 13.8 minutes). The majority of animals (n=11) attained a light-moderate plane of anaesthesia appropriate to the fitting of telemetry collars. In all cases, collar fitting took less than two minutes.

All physiological parameters were measured immediately after recumbency and then at 5 minute intervals. Heart rates ranged from 40 to 75 min^{-1} (57 ± 8.5). Respiratory rates ranged from 30 to 57 min^{-1} (45 ± 12.0). No animals displayed apnoea, cardiac arrhythmia, or abnormal mucous membrane colour. Pulse strength was weak-moderate with capillary refill times 0-1 second in all animals during recumbency. Body temperatures were uniformly high and ranged from 38.4 to 41.6 ℃ (39.7 ± 0.9).

Recovery after administration of atipamezole was smooth and rapid. The typical sequence consisted of pulses strength first increasing, then palpebral reflexes strengthened, muscle tone increased, animals lifted their heads, sat up in a sternal position and then attempted to stand. At this point animals were released from physical restraint. In almost all cases, this sequence was completed in a few minutes. All animals displayed some ataxia, moved slowly and appeared disoriented at their first efforts to stand upright. Within five minutes of first standing, all animals assumed a normal gait and achieved coordinated locomotion. When fly-over procedures were performed five minutes post-recovery, all animals were rapidly returning to normal behaviour. At visual examination 24-48 hours post-capture, all animals observed showed no signs of disability. No animals suffered any injury as a result of these procedures.

5.3. Training Package Development and Delivery

A face-to-face workshop entitled Field immobilisation of feral camels for use as Judas animals was held on October 25-26, 2011, delivered by Dr Mark Lethbridge and Dr Wayne Boardman. Eight field operators from across South Australia and Western Australia attended the two-day workshop.

The workshop comprised both theoretical and practical components, as detailed in the workshop agenda below. Participants were provided with course notes (Appendix 5) that further extended upon the information provided at the workshop. Participants also received the Field immobilisation of feral camels for use as Judas animals SOPs (as an appendix in the course notes).

Day 1

Time	Agenda Item	Deliverer
	Arrival – coffee/tea available	
9.00–9.15	Introduction and overview • Background to course • Course outline	ML

9.15-10.15	• OH&S issues
	  o Firearms/helicopter
	  o Drugs
	• Aerial operations and legislation
	• Dart rifles (class, licence)
		ML

10:15 – 10:45	• Camel natural history and behaviour • Animal welfare considerations	ML/WB
10.45-11.00	Morning tea	
11.00-12.15	Standard Operating Procedures • Overview • Roping techniques • Darting equipment	ML
12.15-1.30	Lunch	

1.30-3.00	Anaesthesia
	• Physiology
	• Pharmacology
	  o Ketamine
	  o Medetomidine
	  o Butorphanol
	  o Naltrexone
	  o Atipamazole
	• Health, safety and legislation
	  o Preparation and handling
	  o Responsibilities – licencing and storage
	  o Documentation
	• Monitoring and examination
	  o TPR
	  o Pulse oximeter
	  o Condition assessment
		WB

3.00-3.15	Afternoon tea	
3.15-4.00	Practical – drug handling and preparation	

Day 2

	Arrival – coffee/tea available	
9.00-10.00	Theory and Practical test from drug handling and preparation	ML/WB
10.00-10.15	Morning tea	

10.15-12.00	Emergency procedures
	
	• Complications and euthanasia
	  ○ Capture myopathy
	  ○ Injuries
	  ○ Disease
	  ○ Euthanasia technique
		WB

12.00-1.00	Lunch and travel to range	
1.00-4.00	Practical session • Darting practice • Camel collaring • Camel anatomy and injections	ML/WB

Learning outcomes were delivered through a combination of visual presentation and practical demonstration. A live camel was on-site to aid in some of the practical demonstrations.

Participants were tested on both theoretical and practical aspects, including the calculation of drug dosage rates, the preparation and handling of drugs, and the use of a tranquilising firearm.

Participants were asked to complete a course review questionnaire upon completion. Extension activities are proposed but only after the SOPs have been approved by VPC.

5.4. Addressing the Programme

5.4.1. Project Milestones and Performance Indicators

Table 2. Addressing the original milestones of the project and progress on their delivery.

Objective	Outcome	Performance indicator(s)	Delivery
(1) Stage 1. Development of a standard operating procedure for the field immobilisation of feral donkeys and feral camels	1) Review of immobilisation methods and determination of appropriate methods. This information is incorporated into separate Animal Ethics Application for camels and donkeys	1) Approved Animal Ethics Applications to undertake field work.	1) Approved Animal Ethics Applications were obtained from the Western Australian Department of Agriculture and Food and the Western Australian Department of Environment and Conservation (see Appendix 3)
	2) Field immobilisation of donkeys.	2) Number of donkeys used to obtain field measurements.	2) 14 donkeys were used to achieve stable and repeatable results of the protocol (see 5.2)
	3) Field immobilisation of camels.	3) Number of camels used to obtain field measurements.	3) 63 camels were used to define the anaesthetic procedure and provide repeatable results
	4) Development of SOPs	4) Two SOPs drafted	Both SOPs have been drafted and will be submitted to the VPC Animal Welfare Technical Working Group for consideration and progression to the VPC.
	5) Endorsement of SOPs	5) SOPs appear on NSW DPI website as part of the series.	Not Completed to Date. Publishing of the SOPs will not occur until they have been approved by the VPC.
	6) Extend the results of the project.	6) A pastoral memo article on the work is produced and a peer-reviewed article is	An article has been submitted to the WA Pastoral Memo for publication.

		produced on the field immobilisation of donkeys.	A journal article on the field immobilisation of donkeys has been submitted to the Journal of Wildlife Diseases.
(2) Stage 2. Develop and implement a training package to ensure that field operatives are competent to immobilise donkeys or camels for Judas control programs.	1) Write course structure and develop notes and assessment. Develop on-line delivery mechanism.	1) Course notes online.	On-line component will be put on the WEB once SOPs are approved.
	2) Invite review	2) Review documentation. Final notes and assessment.	Course notes have been compiled and completed (Appendix 5), and were distributed to participants at the workshop.
	3) Run pilot practical course. Invite participant review.	3) Participant review.	Each participant completed a review questionnaire (accompanying report).
	4) Panel to review and amend course, present to other agencies and submit report.	4) A review document. A pastoral memo article on the work is produced and a peer-reviewed article is produced.	At this stage, the training package has not been circulated to other jurisdictions.

5.4.2. Outstanding Tasks

The project completed the majority of tasks in a timely manner. However, there are several key exceptions, along with some additional tasks that have been identified.

Outstanding Milestones
The outstanding milestones are associated with the Vertebrate Pests Committee (VPC). Whilst the SOPs have been submitted for endorsement by the VPC, the process for endorsement takes time. This is because the internal process of VPC are well-considered but not rapid. Flow-on impacts are that the SOPs will not be published on the NSW DPI website until they have been endorsed by the VPC.

Additional Tasks
This work has developed a safer, more cost-effective and humane method for immobilising donkeys and camels in the field. Transitioning the concept from the development phase to an ongoing field technique used by non-veterinarian practitioners has presented some problems.

Because the drugs are scheduled substances, special permissions need to be granted from the appropriate agencies that administer poisons (licences to buy, store and use scheduled products) and veterinarian authorities to administer the drugs by non-vets. This has presented several challenges because some of the drugs are Schedule 8 substances. This imposes important restrictions on the purchase, storage and use of the products. More work still needs to be done to ensure that the techniques can be used by non-veterinarian practitioners.

5.4.3. Media

This project deliberately did not seek out media attention because of the potential sensitivities associated with the type of work. However, the work has been promoted through the rural community via the Pastoral Memo. For camels, the project has close links with the AFCMP which has also increased the awareness of the work.

6. Discussion of Results and Implications for Future Management

6.1. Immobilisation of Camels

There is very limited information in the literature on the immobilisation of wild camels. The routine practise of using xylasine and ketamine in the captive situation (Blyde, 1994) is not effective in remote areas because of the markedly variable effect and excessively large volumes required. Remote injection of wild camels at the above dose rates proved a reliable method for immobilisation. A single 7 mL dart was sufficient to produce immobilisation in the majority of animals, though some animals required ‘top-up’ doses. All 63 animals darted were immobilised without injury. Times to recumbency were variable and could be as long as 45 minutes, though most animals were recumbent within 15 minutes. Depth of sedation achieved was reasonably variable as were recovery times.

The degree of variability in response to drug doses was in part thought to be due to a lack of accuracy in observed body weight estimation and the effects of circulating adrenalin. Long (1 ¼ inch) needles were chosen for this study to maximise the

probability of injection into deep into the muscle sites. However, darting a fast moving, mobile species from a helicopter can result in some variability in administration sites. In all cases, drug leakage from darts, and absorption from darts that bounce off the animal or dislodge is unknown. The effect of the drugs on the animal's level of sedation was observed and supplementary drug administration was at the discretion of the veterinarian.

No animals were anaesthetised above an ambient temperature of 33^{o}C and most animals were anaesthetised between 18^{o}C and 25^{o}C

Due of the limit on the size of darts available, high concentrations of medetomidine levels were used with dry ketamine and butorphanol to obtain an effective volume of 7mL.

Although medetomidine is readily reversible with the antagonist atipamezole, the irreversible nature of ketamine may prolong recovery times. Often some residual ketamine effect was encountered after reversal drugs were administered. Timing of antagonist administration is important to ensure that the ketamine drug levels are as low as possible. Animals were reversed usually 30-40 minutes post-initial recumbency.

In conclusion, the combination of medetomidine, ketamine and butorphanol with reversal of atipamezole and naltrexone proved to be a reasonably effective anaesthetic regime for the remote capture of feral camels.

Alternative drug combinations using A3080 and a sedative such as azaperone or detomidine or the use of the 'BAM' combination – butorphanol, azaperone and medetomidine should be considered in the future in order to reduce time to recumbency and because of the improved reversal drug opportunities.

Due to the overwhelming welfare issues and the dangers associated with use of muscle relaxants, suxamethonium should never be used under any circumstances for the immobilisation of camels or indeed in any animals.

6.2. Immobilisation of Donkeys

Remote injection of wild donkeys with dose rates in the order of 0.14 mg kg^{-1} medetomidine and 4.1 mg kg^{-1} ketamine proved a reliable method for immobilisation. A single 6 mL dart was sufficient to produce immobilisation in the majority of animals. All fourteen animals darted were immobilised without injury with consistently short times taken to attain recumbency. Depth of sedation achieved was moderately variable as were recovery times, though donkeys, as a species, are known to exhibit relatively long anaesthetic recovery times (Matthews et al., 1997). The initial doses administered to animal 1 were unintentionally high owing to difficulties in estimating body weight, and may not have been appropriate as a first test of medetomidine/ketamine in feral donkeys.

The degree of variability in response to drug dose rates was thought to be due to a lack of accuracy in body weight estimation and the inherent variability of remote darting systems in delivering a known quantity of drug. Long (1 inch) needles were chosen for this study to maximise the probability of injection into optimal deep muscle sites. However, darting an extremely fast moving, mobile species from a helicopter entails a high degree of variability in administration sites. In all cases, drug leakage

from darts, and absorption from darts that bounce off the animal or dislodge is unknown, and was assumed to be zero in this study.

Signs of cardio-pulmonary depression were minimal. Heart rates and respiratory rates were all moderately raised from normal levels (heart rate range 36-68; mean 44 and respiratory rate range 12-44; mean 20; French and Patrick 1995), despite high doses of medetomidine. Alpha-2 adrenergic receptor agonists commonly cause some degree of bradycardia but the animals in this study had exerted themselves running from the helicopter immediately prior to darting. This exertion, combined with very high environmental temperatures very likely contributed to the relatively high heart and respiratory rates observed. Although high doses of medetomidine were employed, and two animals entered a state of deep sedation, cardio-pulmonary performance was uniformly stable. This is consistent with the relatively unreactive nature of the donkey cardio-pulmonary system to anaesthesia (Matthews et al., 1997). All animals in the study were considered to be at minimum risk of anaesthetic complication or injury.

All animals had body temperatures far above the normal resting range of 36.2-37.8°C; mean 37.1°C in domestic donkeys (French and Patrick, 1995). Two individuals (animals 12 and 14) recorded body temperatures above the critical limit of 41°C. These values can be explained by the extremely high air temperatures during the study and the exertion experienced by the animals immediately before and after darting from helicopter pursuit. Due to timing and logistical constraints, some animals were regrettably pursued and captured throughout the hottest parts of the day in this study. Centrally mediated disruption of thermoregulatory mechanisms by medetomidine, an Alpha-2 adrenergic receptor agonist (see Jalanka and Roeken, 1990), may have also contributed to the hyperthermia observed. Immobilised animals with rectal temperatures above 40°C are generally considered to be at high risk of injury, while temperatures exceeding 41°C constitute a medical emergency, requiring aggressive efforts to cool the animal. Rapid reversal of immobilisation reduced these risks. We would recommend that in future operations, when maximum air temperatures exceed 35°C, animal capture should be restricted to early morning and late afternoon to minimise hyperthermia risks. Capture operations should also be planned to avoid the months of most extreme heat (November-February in northern Australia) where possible. Upon reflection, conducting the field work for this study in the month of November was a flaw in our study design. Atipamezole should be administered as a reversal agent as soon as possible when hyperthermia is a high risk.

Very high medetomidine levels were used in this study. The vast majority of studies employing the medetomidine-ketamine combination for wildlife capture in a variety of species have employed medetomidine dose rates in the range of 0.06-0.10 mg kg^{-1} (Jalanka and Roeken, 1990). Medetomidine has, however, repeatedly been shown to be safe at much higher dose rates that those commonly employed (e.g. Tyler et al., 1990; Fournier-Chambrillon et al., 2003). High doses of medetomidine were needed in this study for two main reasons. Firstly, the temperament of the animals made them refractory to the effects of sedation, being completely wild and free-ranging. Secondly, fast recovery times were a priority for this study. The use of high medetomidine doses allows concurrent ketamine doses to be lowered, and thus higher dose of atipamezole to be administered sooner after initial sedation, reducing recumbency times.

Although medetomidine is readily reversible with the antagonist atipamezole, the irreversible nature of ketamine prolongs recovery times. By administering relatively high doses (0.25-0.55 mg kg^{-1}) of atipamezole relatively soon after ketamine

administration (15 minutes), recovery time was reduced to a minimum, but some residual ketamine effect was encountered. This effect concerns the situation where a drug that has been used in combination with ketamine is antagonised, leaving ketamine as the sole active drug present in the animals' system, and producing unsteady recoveries (Jalanka and Roeken, 1990). Owing to the perceived risks of residual ketamine effects in flighty species, antagonism is rarely employed in equids. Due to the steadier, more stoic nature of donkeys when compared to domestic horses, anaesthetic recoveries tend to be smoother, though longer (Matthews et al., 1997). As such, the risks derived from anaesthetic antagonism are diminished in the donkey when compared to the horse. Timing of antagonist administration is important to ensure that medetomidine effect is neutralised only as ketamine plasma levels are dropping due to endogenous metabolism. For this reason, intra-venous (IV) administration of atipamezole was not utilised in this study. We would strongly recommend against administering atipamezole to donkeys any sooner than 15 minutes post-sedation. If time constraints are not restrictive, atipamezole should ideally be administered 20-30 minutes post-sedation to further reduce risks of residual ketamine effect in recovering animals.

Cost effectiveness is a critical factor in wildlife management, especially in the case of pest animal species. As such, any capture protocol must be shown to be cost-effective for wide scale uptake. The current cost of the drugs used for a 229 kg animal is $4 for medetomidine, $7 for ketamine and $143 for atipamezole. The darts used in this study retail at around $4 each. The total cost for each 229 kg animal darted is therefore $158. By far the highest cost associated with this regime is the atipamezole at over ten times the cost per animal of the next highest component. Without the use of atipamezole, the cost per average Judas animal would be only approximately $15.

Reversal of sedation is not a necessity in all animal capture situations but is often desirable. Reversal agents allow more rapid recoveries, lower anaesthetic risks, and in this case, lower helicopter running costs. The use of atipamezole as a reversal agent may not be recommended in all situations for donkey capture. In most situations, the use of atipamezole as an antagonist will improve animal welfare but reduce cost-effectiveness. We recommend reversing donkeys when environmental temperatures are very high (>35ºC); when depth of sedation is excessive and results in significant cardio-pulmonary depression; and when time constraints necessitate fast recoveries. In all other situations, it may be acceptable not to reverse, provided recovering animals are closely observed and donkeys are only captured when air temperatures are relatively cool.

Existing Judas donkey control programs in Australia utilise the neuromuscular blocker suxamethonium (succinylcholine) as the sole chemical agent for capture (Walters, 2007). Despite their widespread use in the past, neuromuscular blockers have been very rarely employed over the past two decades. Owing to their extremely low safety margins, high mortality rates and lack of sedative or analgesic properties, neuromuscular blockers are now widely considered to be inhumane and unsafe for this purpose (Kreeger et al., 2002; Arnemo et al., 2007). Despite disadvantages of the medetomidine/ketamine combination including higher costs and some prolonged recoveries, this combination resulted in reliable, reversible, humane sedation. We recommend that suxamethonium should be replaced in feral donkey capture programs by the more humane, safer drug combination trialled in our study. There is considerable evidence to suggest that animal welfare standards for unwanted or unvalued species such as the feral donkey are falling behind advances in valued species (Littin and Mellor, 2005). We encourage the integration of modern,

humane approaches pioneered in the field of endangered species management into more pest animal management practices.

In conclusion, the combination of medetomidine, ketamine and atipamezole proved to be suitable for the remote capture of feral donkeys. The use of sedative drugs with analgesic properties represents a considerable improvement in animal welfare over the previous use of neuromuscular blockers as the sole capture drug. This new method allows a rapid, safe, cost-effective approach to the immobilisation of feral donkeys for use as Judas animals.

6.3. Training Package Development and Delivery

There are significant animal welfare issues related to the immobilisation of large herbivores. Moreover, the immobilisation of these animals involves the handling and administration of potentially dangerous drugs, and the discharge of firearms. That field operators (non-veterinarian and veterinarian) are applying nationally recognised techniques in these aspects ensures that feral herbivore control measures are humane, safe and efficient. Furthermore, standard operational procedures lend themselves to a more controlled and professional undertaking of the activity.

Participant feedback indicates that the training course was well structured, contained appropriate content, delivered clearly and in logical sequence and had adequate time set aside for practical demonstration and assessment. Moreover, most agreed that the course notes reflected the contents of the training package well.

6.4. Implications for Future Management

The results of this work represent a considerable improvement in animal welfare over the previous methods used for the capture and restraint of large feral herbivores. These SOPs will ensure that animal welfare is an important consideration in any Judas program and that ‘best practice’ will be followed. Further, by increasing the capacity of operators to use the technique, it enhances the delivery of Judas programs.

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12. Appendix 1 Draft Standard Operating Procedures

12.1. Draft SOP for the Immobilisation of Camels

Standard Operating Procedures

FIELD IMMOBILISATION OF FERAL CAMELS FOR USE AS JUDAS ANIMALS

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Background

Feral camels (Camelus dromedarius) are widespread throughout central Australia. They pose serious environmental and agricultural threats including degradation of soil, waterholes and native plant communities; competition with native animals and domestic stock; damage to infrastructure; erosion of waterways; and spread of weeds.

Large vertebrate pests are usually managed by culling or commercial harvest. However, at times they can be difficult to locate because of the vast area that they inhabit or because of the inaccessibility of terrain. Radio-collared 'Judas' animals can be used to enhance population control programs. The technique involves immobilising an individual, attaching a telemetry collar, and releasing the collared animal to re-join its herd. The collared individuals are subsequently tracked via GPS and communications satellites, and periodically other members of the animal's herd can be either mustered or shot. The technique is particularly useful when the target population occurs in medium to low densities, or are widely dispersed in remote areas. This technique is effective for camels because they are principally social animals and females in particular are known to locate another group if they become isolated. It should be noted that camels are not naturally aggressive animals and prefer to flee from the helicopter and personnel. However, if it is necessary to handle or lasso them, it should be done with great care as they are large and heavy animals.

The immobilisation technique we describe involves using Schedule 8 and Schedule 4 drugs to immobilise the camels with the use of darts discharged from a tranquilliser rifle operated from a helicopter. It is a high risk technique and restrictions apply under State and Federal legislation relating to Scheduled substances, firearms, aviation and animal welfare. This Standard Operating Procedure (SOP) meets the legislative requirements and maximises the safety of and the welfare of the staff and animals involved.

General considerations

The Judas technique should only be used in a strategic manner as part of a co-ordinated program designed to achieve sustained effective control.

- For safety reasons, darting from a helicopter cannot be undertaken in adverse weather conditions (e.g. strong wind, rain, low cloud).
- Darting is difficult and sometimes dangerous in heavily wooded areas; this situation should be avoided.
- Darting of feral camels should only be performed by competent, trained personnel who have been tested and accredited for suitability to the task and marksmanship and who hold the appropriate licences. Firearms accreditation must also cover firearms used for euthanasia of feral camels (e.g. .308 rifles).
- All non-veterinary staff required to use immobilising chemicals must be trained thoroughly in their safe and humane use by a veterinarian.
- Animal welfare standards must be strictly observed when capturing animals for use in Judas operations.
- Helicopter pilots must hold the appropriate licences and permits including approval from the Civil Aviation Safety Authority and be skilled and experienced in aerial shooting operations.
- Storage, use and transportation of firearms and ammunition must comply with relevant legislative requirements.
- Storage, use and transportation of veterinary chemicals must comply with relevant legislative requirements.
- Schedule 4 and Schedule 8 chemicals are subject to regulatory controls under State or Territory legislation and can only be obtained via a prescription from a registered veterinarian. It is ILLEGAL to be in possession of these drugs unless they have been prescribed by a veterinarian for a specific purpose, or the user holds a Schedule 4 and Schedule 8 drug license for this specific purpose. Under the Standard for the Uniform Scheduling of Medicines and Poisons (SUSMP), Schedule 8 drugs involve additional legal constraints relating to storage and recording of use.

Health and safety considerations

- Darting from a helicopter can be hazardous particularly in areas of rugged topography. The combination of low-level flight, close proximity to obstacles and the use of firearms and dangerous chemicals make this task extremely hazardous.
- Safety protocols must be strictly followed and the appropriate policy documents for aerial operations, chemical and firearms use should be adhered to.
- Camels are large, potentially dangerous animals. The risk of serious injury from being kicked by an uncoordinated sedated animal is high unless all staff position themselves safely.
- Personnel involved in this activity must hold a current Senior First Aid Certificate.
- Firearm users must strictly observe all relevant safety guidelines relating to firearm ownership, possession and use.
- When not in use, firearms must be securely stored in a compartment that meets State or Territory legal requirements.
- When not in use, Schedule 4 and Schedule 8 drugs must be securely stored in a compartment that meets State or Territory legal requirements.

- Adequate hearing protection should be worn. Repeated exposure to firearm and helicopter noise can cause irreversible hearing damage.
- Extreme care must be taken when handling Schedule 4 and Schedule 8 drugs that can affect humans. For example, medetomidine and ketamine are potent sedatives in humans and self-injection is extremely hazardous. To minimise self-injection risks, Schedule 4 and Schedule 8 drugs should not be handled while inside the helicopter. All darts, including back ups, should be pre-prepared on the ground and kept safely in an esky or equivalent dart holding equipment in the helicopter and not loaded into the dart gun. All staff should be trained and prepared to administer first aid or resuscitation as required.
- If veterinary chemicals come into contact with skin, immediately wash the area with soap and water.
- All used needles, syringes and darts should be placed into a 'sharp medical waste container' as soon as they have been used. Handling of needles and darts should be kept to a minimum.

Resources required

Helicopter

- Four-seater helicopter meeting the minimum safety guidelines for the State or Territory.
- Intercom helmets
- Full 'cameraman' or 'shoulder' safety harness and anchor point designed for this purpose

Darting rifles, darts and allied equipment

- Dart guns powered by explosive charge should be used (e.g. Pneudart 196). CO_2 powered dart guns may not be sufficiently powerful for helicopter darting.
- 6 - 7ml darts should be used with 20 gauge, 38mm barbed needles or similar. It is unlikely that telemetry darts would be required as the camels are seen in open terrain.
- The accuracy and precision of all firearms and users should be tested against inanimate targets prior to the commencement of any shooting operation.
- Lockable firearm box
- Lockable ammunition box

Drugs

- Dart container – upright container fixed to the user or helicopter, with individual compartments and snap-shut lid.
- Drugs required are medetomidine (20-40mg/ml), ketamine (1g vials), butorphanol (10 or 50mg/ml), atipamezole (5mg/ml) and naltrexone (50mg/ml)
- All drugs must be kept in cool conditions (8ºC) out of direct sunlight. During transportation, drugs should be kept in a solid esky or refrigerator.
- It is important to ensure that all drugs are within the expiry period specified by the manufacturer.
- Atipamezole should be administered using a 20 mL syringe and an 18 gauge, (1.25 inch needle) or similar.
- A drug register book must be carried to record amounts of ketamine used.
- Secure storage of Schedule 4 and Schedule 8 drugs

Other items

- Radio collars - the total weight (collar, transmitter, battery, aerial and bonding material) should be less than 5% of the animal's bodyweight.
- Device for collar activation (usually a magnet)
- UHF radio tracking receiver and antennae
- A handheld GPS unit should be used to record animal locations
- Rifle and ammunition suitable for euthanasia of injured animals – .308 calibre
- Binoculars/range finder
- Recording sheets
- Pulse oximeter for monitoring animal heart rate and oxygen levels during sedation
- 20 m x 12 mm rope for securing the camel
- Hessian sack for covering the camels head
- PVC or nitrile gloves
- Leather gloves
- Glasses for dart gun operator
- Stop watch
- Survival kit (including a first aid kit)
- Emergency locating beacon (EPIRB)

Preparation

Drug regime

Based on previous experiences with wild camels, standard zoo dose rates do not apply because the animal is usually more agitated and excited than in captivity. It has been noted that wild camels require three to four times the normal standard captive camel dose rates of xylazine and ketamine, which requires several darts because the volume becomes very large. Hence a new drug regime has been developed which reduces the volume to be administered to one dart only.

Concentrated medetomidine and ketamine are used with butorphanol to minimise volumes and induction times and atipamazole and naltrexone are used to reverse two of the drugs.

There may be a residual ketamine effect but this wears off quickly and appears to have a minimal effect on the animal once the reversal drugs are administered.

Anaesthetic drugs

Chemical name	Conc	Route	Dose	Total dose for subadult male or female	Total dose for adult female camel	Total dose for adult male camel
Medetomidine	20 or 40mg/ml	IM	100-120mg	100mg	110mg	120mg
Ketamine	1g	IM	1g	1g	1g	1g
Butorphanol	10mg/ml	IM	15-25mg	15-20mg	15-20mg	20-25mg

Reversal drugs

Chemical name	Conc	Route	Dose	Total dose for subadult male or	Total dose for adult female	Total dose for adult male camel

				female	camel	
Atipamezole	5mg/ml	IM	300-360mg	300mg	330mg	360mg
Naltrexone	50mg/ml	IM	50-75mg	50-60mg	50-60mg	60-75mg

NB: IM = intramuscular injection

Tranquiliser darts and darting rifle

- Personal protective equipment must be worn when loading darts (PVC or nitrile gloves, safety glasses).
- The number of animals to be immobilised (and hence the number of darts required) should be determined before each trip. Two darts per animal should be prepared.
- Darts must be prepared in a clean and quiet environment without interruption. It is important to let someone know that you are doing this procedure.
- Normally Pneudarts are used – 6ml or 7ml with 38mm length barbed needles.
- The amount of medetomidine required is added to the 1g vial of ketamine which is then shaken to improve solubility.
- The butorphanol is added too but you must ensure the total volume does not exceed 6ml or 7ml depending on the size of the dart being used
- Darting syringes are loaded in a vertical position. Using a 50mm 18/20G needle and 10 ml syringe the drugs are drawn up and injected slowly through the centre of the darting syringe needle. Avoid any spillage. A 50 mm length needle is essential to avoid spillage and back flow.
- Once the drug is placed in the darting syringe the end of the darting needle is 'sealed' using vaseline to avoid losing drugs.
- Ensure the dart rifle is cleaned and oiled
- The loaded darts are placed in the esky
- Ensure you have sufficient charges if using a Pneudart rifle – normally colour green charge is required and the setting on the rifle is 4 for this size of dart and the distance recommended.
- Update the drugs register when preparation is complete

Radio collar testing

- Test radio collars immediately before deployment by removing the deactivator and checking signal on a receiver.
- Fine tune the receiver frequency for maximum signal strength and record the frequency.
- Etch the transmitter with its frequency.
- Replace deactivator to turn the transmitter off.

Field Immobilisation Procedures

Pre flight

- Animals should not be tranquillised in temperatures greater than 33°C.
- A decision is made as to the sex and size of camels to be darted before leaving. It is important to avoid darting female camels with young calves at foot and very heavily pregnant animals.
- Darts are prepared immediately before the helicopter flight and should be based on the correct sex and size of animal being targeted. Two darts for each animal should be made in case of misfires.
- The darts are securely loaded in a container in the helicopter and not loaded into the breach of the dart gun.
- All belts and harnesses should be attached and the darters' door removed

- Ensure the dart rifle's safety catch is on.
- Ensure the intercom system between pilot and darter is working adequately
- Ensure all necessary darting equipment is available.
- Fill magazine with correct blank charges but do not insert into gun.

In-flight pursuit of camels and operation of dart rifle

- Shoot only under favourable weather conditions. Avoid adverse weather conditions such as strong wind, rain or low cloud.
- Shoot only in open areas where visibility is high. Avoid dense cover, such as vegetated creek lines, woodlands and forests.
- Once in the air and a group of camels has been sighted, they should be approached so that the age and sex of the group can be determined and a suitable candidate for immobilisation chosen.
- Once a target is sighted and has been positively identified, the pilot should position the helicopter as close as is safe to the rear of the target animal to permit the darter the best opportunity for a clean shot.
- Minimise the pursuit time to reduce the stress on the target animal in particular as this may have an adverse effect on the induction of anaesthesia and the smoothness of the anaesthesia.
- Continuous dialogue with the pilot is required to ensure the target animal continues to be sighted.
- Insert magazine into darting rifle – ensuring safety catch is still on and the barrel is directed outside the cockpit of the helicopter.
- While ensuring the dart rifle is pointing downwards carefully remove the prepared dart from the holding container and insert into breach of the dart rifle.
- When pilot agrees, get ready to aim.
- On final approach to darting position, communicate with the pilot "ready to dart"
- Ensure safety catch is off and the rifle is loaded.
- Continuous dialogue is required to ensure the pilot is in the correct position for darting. Sometimes trees cause the pilot to veer off-line in which case the pilot should communicate with the darter.
- The helicopter speed should be at the same speed as the running camel and the distance should be 5-15m from the darter.
- In this instance and using 6ml-7ml Pneudarts use 0.22 calibre medium (green) pneudart charges at pressure 3 i.e G3
- Once in the correct position, the camel is darted as quickly as possible.
- If correctly darted communicate this to the pilot.
- Preferred sites are the gluteal muscle mass or the hamstring muscle mass.
- If darted into solid muscle, then the contents of the dart should inject into the muscle mass.
- If the dart hits bone, i.e. pelvis, then it's possible the contents will not be fully discharged.
- If the dart bounces out immediately it is normally safe to assume the contents will not be discharged into the muscle.
- In either of the last two cases, another dart should be loaded and the pilot and darter prepare to dart the same animal again.
- The time of each dart injection explaining success or not is recorded on the sheet.
- Ensure dart rifle safety is on after successful darting.

12.1.1.1.

Induction of anaesthesia

- Once darted, the pilot should move away and take an advantage point about 1000m above the group to reduce the stress on the group. This clearance

may need to be adjusted in open areas; greater than 1000m may be necessary, but the darted camel must remain in sight.
- The group should slow down and the target animal will be seen to fall behind the group or start to show ataxia.
- Normally if the dose rate is correct and there has not been too much pursuit of the animal, induction should take 10 minutes ± 3 minutes.
- The normal process of induction is for the animal to slow down, become ataxic, start to sway and then stop – often recumbency will soon follow.
- On occasions, some camels will stop and not become recumbent preferring to stand legs apart. The camel should be lassoed around the neck and pulled to the ground by personnel following the Model Code of Practice for the Welfare of Animals (PISC 2006).
- Safety of all personnel is paramount at all times. If, after 15-20 minutes, the animal is not sufficiently sedated to be approached for lassoing, then the camel should be darted again either from the helicopter, or from the ground if the darter can approach sufficiently closely. Adjust the dart rifle power settings as required.

Assessment and approach
- All equipment including the dart rifle and drugs should be taken from the helicopter to the site of the animal.
- Once the camel is on the ground, if lying on its side, immediately place it in sternal recumbency to avoid regurgitation and inhalation of ingesta.
- The animal will then need to be restrained by ropes to provide safety. Roping, or hobbling the front legs together across the knees or ankles is recommended.
- The head and eyes should be covered using a hessian sack or similar material, and the camels' head must be held up to prevent if from falling into lateral recumbency. The person holding the head needs to be mindful of OHS procedures for heavy lifting.
- The dart should be immediately removed from the darting site and placed in a sharps container. The wound should be cleaned with diluted betadine and antibiotics (i.e. orbenin eye ointment or mastitis treatment, inserted into the wound).

Monitoring of anaesthesia and health assessment
- Once in sternal recumbency and the legs are tied, the animal should be monitored and assessed.
- Rectal temperature should be taken and noted – temperatures over 40°C require water to be poured over the head and between the hind limbs to improve evaporative cooling.
- Both the respiratory rate and pulse rate should be taken and pulse oximeter attached to the tongue to assess oxygen saturation and heart rate, which are recorded.
- Someone should be assigned to observe and record the respiration at all times.
- Assess the capillary refill time and mucous membrane colour by pressing the mucous membrane to blanch the skin and then releasing the pressure. Normally, skin should perfuse into the blanched area within 1-2 seconds. A longer time period may suggest poor tissue perfusion which maybe related to an excessively deep plane of anaesthesia.
- The overall condition of the animal should be assessed and in particular teeth wear should be noted.
- If a veterinarian is present, the pregnancy/lactational status should be checked and recorded.

- In the unlikely event the animal has sustained life threatening injuries during capture and restraint, it must be humanely euthanased. If there is doubt that the animal will have a full recovery even after giving reversal drugs, then it should be humanely euthanased.

Treatments

- Given the stress of the whole process it is incumbent on the team to ensure the health of the camel is optimised to guarantee the animal will travel with the tracking device for the longest time.
- The camel is treated with long acting antibiotics intramuscularly (i.e. long acting penicillins), vitamin E/selenium intramuscularly (Selvite) and anthelmintics subcutaneously at normal cattle dose rates by estimated weight. All treatments are recorded on the sheet.

Attachment and testing of radio collars

- Switch radio transmitter on by removing the deactivator and check the signal. Record the capture location using a handheld GPS.
- The collar must be fitted so that it can move up the tapered neck of the animal as it grows or gains weight. Tight collars will constrict the neck of an animal as it grows, while loose collars may come off or catch in vegetation. As a general rule, the collar should not be able to be pulled over the camels head.
- Test the backup UHF beacon with a UHF radio receiver.

Reversal

- Once the radio collar has been checked to be working and once all other procedures have been done, the ropes are removed from the animal. The camel continues to be held in sternal recumbency with head upright.
- Under no circumstances should any reversal drugs be given until the ropes have been removed.
- The reversal drugs are administered intramuscularly into the neck, biceps or triceps muscle. The head cover is kept on until the animal is standing.
- The success of the reversal drugs is illustrated by the increase in rate and depth of respiration, the tongue and lips have more motor control, the camel often eructates or belches and then will start to show muscle movement. Between 5 minutes and 10 minutes should elapse before the camel will attempt to stand – often only one attempt is needed. Personnel should stand at a safe distance in case the camel falls over when attempting to stand.
- The camel will then stand and start to shake and become alert to their surroundings. Sometimes the camel will walk away or stand for a short while before the full effects of the reversal drugs have taken effect. They are more responsive to activities in their immediate vicinity. Leaving the Hessian sack on the camels' head (if it stays without assistance) will not impede its recovery. In fact, it may prevent the camel from trying to escape before it is ready.
- The camel should be observed from a safe distance to see if it can walk safely and normally. Normally, an animal that is alert enough to be left, walks or trots steadily, looks back regularly and vocalises. The animal can then be left, under the assumption it will continue to recover uneventfully from the anaesthetic procedure.

Records

A record sheet is used to record all activities pertaining to the timing of darting, the anaesthetic procedure and reversal. This is useful information to know, both in the immediate sense if you have to dart the camel again, and for researching the

effectiveness of the anaesthetic regime. An example of a record sheet is attached as Appendix 1.

Animal welfare and euthanasia

It is not anticipated that there will be any adverse effects, however, in the case that the animal is under-dosed because the drug in the dart is not the optimal dose for the size of the animal, the induction process may be longer (up to 20 minutes) and may require a top up of anaesthetic drugs. In this case, it is possible during this induction period the camel may stumble into trees, possibly injuring its leg or brisket as it stumbles. In this event lassoing the camel and pulling it down may need to be incorporated.

As with all large animal anaesthetics where there has not been pre-anaesthetic withholding of food and water, there may be a possibility of regurgitation. This can be minimised by holding the head up while the camel is in sternal recumbency.

Over-dosing may lead to a very deep plane of anaesthesia leading to severe respiratory depression, cyanosis or adverse paleness of the mucous membranes. If this is the case, partial reversal maybe instituted to improve respiration and tissue perfusion.

Capture myopathy is a possible medium term sequela of a prolonged capture procedure. Camels appear to be less susceptible to this condition than other hoofed animals e.g. antelopes. Injection of vitamin E has been commonly used in a variety of species to attempt to prevent the onset of capture myopathy. Although there is no direct evidence to suggest it may work, it can be done for all tranquilised animals.

Any injuries, regurgitation or severe respiratory depression (or if future capture myopathy may be suspected), will be assessed in the context of the entire procedure and the ability to treat and manage the problem in desert conditions. Should the future long-term survival of the animal be compromised in any way, a decision must be made to euthanase the animal immediately.

Use of Judas Camels to improve efficiency of aerial shooting.

This document does not cover the aerial or ground shooting of feral camels in Judas operations. As a guide, see the draft COP's produced by NSW Department of Primary Industries entitled CAM001 ground shooting of feral camels' and 'CAM002 aerial shooting of feral camels', available at: http://www.dpi.nsw.gov.au

Further Information

Relevant Commonwealth, State and Territory government agencies for feral animal control, their web address, and legislation controlling veterinary chemicals:

Commonwealth
Department of Environment and Heritage
www.deh.gov.au/
Therapeutic Goods Act 1989

Australian Capital Territory
Environment ACT
www.environment.act.gov.au

Medicines, Poisons and Therapeutic Goods Act 2008

New South Wales
NSW Department of Primary Industries www.dpi.nsw.gov.au
Poisons and Therapeutic Goods Act 1966

Northern Territory
Parks & Wildlife Commission www.nt.gov.au/ipe/pwcnt/
Poisons and Dangerous Drugs Act

Queensland
Department of Natural Resources and Mines www.nrm.qld.gov.au
Health Act 1937

South Australia Biosecurity SA
www.pir.sa.gov.au/biosecurity Controlled Substances Act
1984

Tasmania
Department of Primary Industries, Water & Environment www.dpiwe.tas.gov.au
Poisons Act 1971

Victoria
Department of Primary Industries, Agriculture & Food www.dpi.vic.gov.au
Drugs, Poisons and Controlled Substances Act 1981

Western Australia
Department of Agriculture and Food WA
www.agric.wa.gov.au
Poisons Act 1964