Title

Assessing the efficacy of medetomidine and tiletamine-zolazepam for remote immobilisation of feral horses (*Equus caballus*).

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Abstract

Context. The study of any wild animal's home range requires the collection of spatiotemporal data, obtained independently of climatic conditions or time of day. This can be achieved by the attachment of Global Position System (GPS) data loggers, which, in large species, is best achieved by remote immobilisation. Feral horses (*Equus caballus*) usually occupy remote areas of Australia, however a considerable population increase has been observed in a close proximity to metropolitan areas of the Australian east coast, creating increasing conflict with human interests.

Aim. The aim of this study was to investigate the efficacy of remote chemical immobilisation of feral horses with medetomidine combined with tiletamine-zolazepam to facilitate placement of satellite GPS collars.

Methods. Nine feral horses were darted from the ground with 60 mg of medetomidine and 1500 mg of tiletamine-zolazepam. The effects of medetomidine were reversed with 50-100 mg of atipamezole 30-40 minutes post induction (IV/IM). Physiological variables monitored during anaesthesia were heart rate, respiratory rate, temperature and oxygen haemoglobin saturation (S_pO_2).

Key results. All horses were successfully immobilised with between one and three darts (n = 9). The mean dose of medetomidine was 0.15 ± 0.01 mg kg^{-1} (SEM) and tiletamine-zolazepam was 3.61 ± 0.16 mg kg^{-1}. Mean time from darting to lateral recumbency was 13 ± 2.7 min, and mean recumbency time was 54 ± 13 min. Vital signs for all anaesthetised animals remained within normal range during anaesthesia, with the exception of one animal displaying a transient drop in S_pO_2. No mortalities were encountered.

Key conclusions. The combination of medetomidine and tiletamine-zolazepam provided adequate anaesthesia in feral horses in the field for application of GPS collars.

Implications. Although a limited number of horses were immobilised, this study shows that medetomidine and tiletamine-zolazepam provides effective short-term anaesthesia for feral horses, providing a practical and field-accessible capture technique. This method could also be applied to other management actions requiring safe and humane capture of feral horses.

Additional keywords: feral horse, remote immobilisation, medetomidine, tiletamine-zolazepam, atipamezole.

Introduction

To safely and humanely place GPS collars on wildlife, reliable capture methods are essential (Geschke and Chilvers 2009). In the case of feral horses, a reliable method of remote immobilisation is necessary to facilitate safe and humane capture and subsequent handling of the subject animal (Kaczenski 2010). 2006). For field anaesthesia to be effective, it should be fast, smooth, reversible, and pose minimal safety risks to the target animal and personnel involved in the anaesthetic regimen (Walzer *et al*. 2006). Remote immobilisation of wild equids in the field is often perceived to be difficult (e.g. Walzer and Kaczensky 2004) despite a large number of demonstarted techniques for wild herbivore species with similar body size (e.g. Jalanka and Roeken 1990; Tyler *et al*. 1990; McMahon and Bradshaw 2008; Boardman *et al.* in press).

The most commonly used agent to remotely immobilise non-domesticated equids is the potent opioid, etorphine hydrochloride (Matthews 1993; Walzer *et al*. 2006; Hampson *et al.* 2010; Rosu *et al*. 2012). Despite its high potency and availability of an antagonist that enables rapid and complete reversal, etorphine is restricted for use in many countries, including Australia, and difficult to import (Woolnough *et al*. 2012; Australian Government, Department of Health and Aging, 2013).

Investigations of alternatives to etorphine have led to use of combinations of α-2 adrenergic agonists (xylazine, detomidine, romifidine, medetomidine) with cyclohexamines (ketamine, tiletamine) (Barasona *et al*. 2013; Matthews *et al*. 1995; Walzer *et al*. 2006; Rosu *et al*. 2012). In particular, the potent α-2 adrenergic agonist medetomidine, in combination with the cyclohexamine ketamine, has demonstrated reliable and reversible remote immobilisation of a diverse range of ungulate species, including forest reindeer (*Rangifer tarandus fennicus*; Jalanka 1989), ibex (*Capra i. ibex*; Jalanka and Roeken 1990), Przewalski's horse (*Equus ferus przewalskii*; Matthews *et al*. 1995), donkeys (*Equus asinus*; Woolnough *et al.* 2012) and dromedary camels (*Camelus dromedarius*; Boardman *et al. in press*). The anaesthetic effects of medetomidine can be reversed, or antagonised, by the α-2 adrenergic antagonist atipamezole, with the effects of cyclohexamines dissipating over time (Woolnough *et al*. 2012).

Medetomidine is an α-2 antagonist with significant sedative and analgesic properties which provides muscle relaxation and allows smooth induction and recovery from anaesthesia (Bettschart *et al*. 1999; Muir and Hubbell 2009). Ketamine and the closely related tiletamine, cause dissociative anaesthesia characterised by catalepsy, amnesia, and analgesia (Muir *et al*. 2000; Muir and Hubbell 2009). Zolazepam is a benzodiazepine-like drug with sedative and muscle relaxation effects (Muir *et al*. 2000). Tiletamine is commercially available combined with zolazepam (Zoletil® or Telazol®), a benzodiazepine-like tranquiliser (Muir *et al*. 2000).

The advantage of the medetomidine and tiletamine-zolazepam combination is that it acts synergistically, with lower required doses, offers broad anaesthesia safety margins, well-preserved cardiovascular function and muscle relaxation (Jalanka and Roeken 1990). These effects, however, sometimes result in prolonged recovery and there is no readily available antagonist, or reversal agent (Matthews *et al*. 1991; Muir *et al*. 2000). The solubility of the concentrated ketamine preparations is insufficient to allow dosing darts with a capacity restricted to 3ml. In contrast, the advantage of using the tiletamine-zolazepam combination over ketamine is its superior solubility, permitting very high drug concentrations in minimal volumes (Matthews 1993), which in turn permits usage of darts of smaller capacity (such as the Pneu-dart tracker dart of a capacity of 3.0 ml used in the present study). In addition, the combination improves the reliability of sedative properties of either drug alone (tiletamine or zolazepam) without adding extensively to further vital organ depression (Booth and McDonald 1988).

The combination of medetomidine and tiletamine-zolazepam has not previously been tested in remote immobilisation of feral horses in field conditions. Therefore, the purpose of this research was to investigate the efficacy of medetomidine in combination with tiletamine-zolazepam as a case study for remote immobilisation of nine feral horses for the placement of GPS collars. Anaesthetic and physiologic data was collected in order to evaluate efficiency and safety of this drug combination, to provide rapid and smooth induction by remote intramuscular injection, and be easily reversible, which will provide an effective form of anaesthetic for shorter field procedures performed on feral horses.

Materials and methods

Study area

This study was conducted in the Tuan and Toolara State Forest (TTSF), located on South-East Queensland in Australia (25^{o}53’S and 152^{o}50’E; Figure 1) between August and

November 2013). The mean temperatures during the study were in a range of 20.4 - 27.0°C (Australian Government, Bureau of Meteorology, 2013). High environmental temperatures need to be considered when performing general anaesthesia in the field, with regard to potential hyperthermia of immobilised animals (Geschke and Chilvers 2009; Berger *et al.* 2010; Woolnough *et al.* 2012).

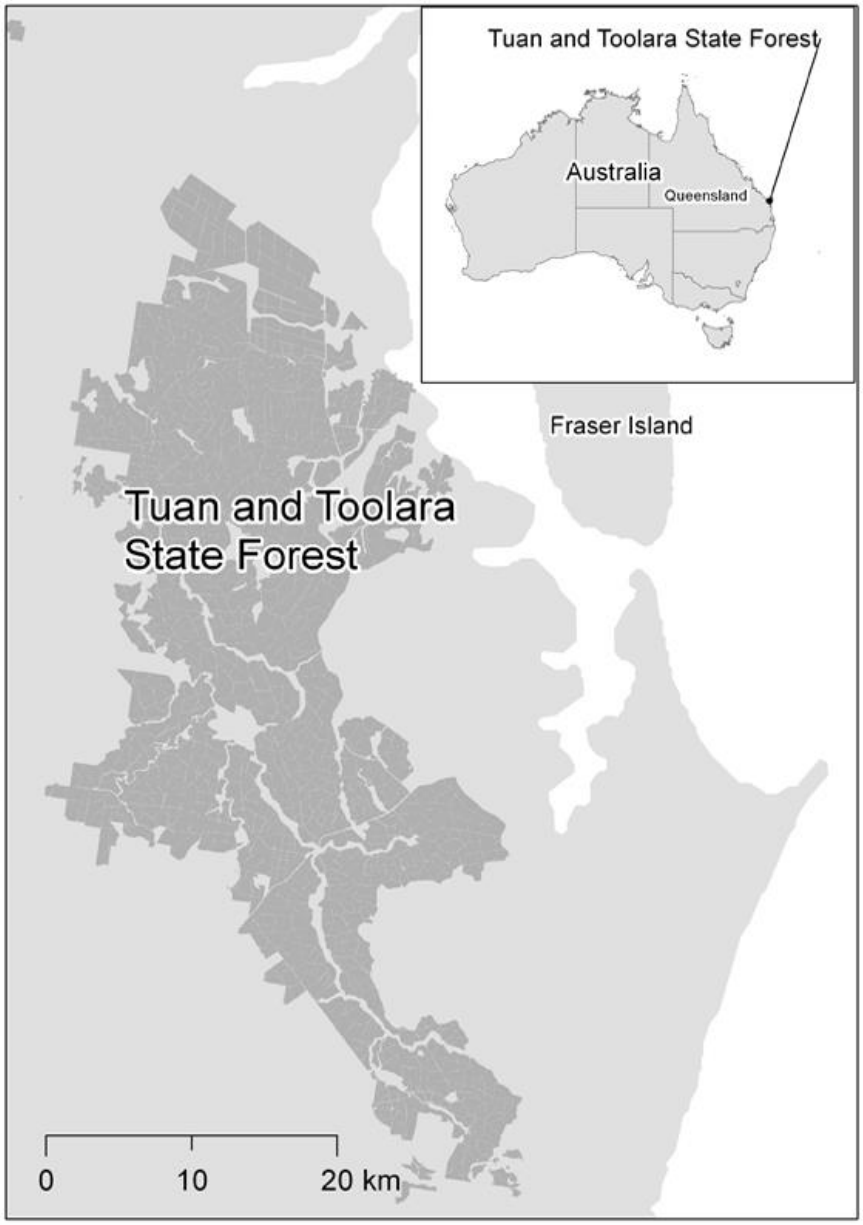

Figure 1: Map of Australia showing Queensland, Fraser Island and the location of the Tuan and Toolara State Forest (TTSF) on the central east coast.

Animals

Horses involved in this study were members of established breeding groups (n = 9), which were a part of a larger observational study. Individual horses were selected randomly and included mature males (n = 7) and females (n = 2). Selected horses were healthy in appearance with an estimated body weight based on visual appraisal of 400-500 kg. Selected females were not obviously pregnant and were without dependent foals.

Immobilisation procedure

All horses in the study were immobilised with medetomidine hydrochloride (Bova Compounding, New South Wales, Australia), and toletamine-zolazepam (Zoletil; Virbac, Queensland, Australia), which is a soluble powder consisting of equal parts of tiletamine and zolazepam. All horses received the same drug dosage which was approximated for 450 kg animal. Medetomidine (60 mg, at concentration of 40mg/ml) was mixed with 750 mg of tiletamine powder, 750 mg of zolazepam powder, and 0.5 ml of saline. Following several attempts to solubilise the tiletamine-zolazepam powder using only medetomidine, it was ascertained that 0.5 ml of sterile saline facilitated the solubilisation process, as well as providing a balanced dart volume. Remote injection of the anaesthetic agents was facilitated by 3 ml C-type explosive-powered metal darts equipped with VHF transmitters (Pneu-Dart, Pennsylvania, USA) which enabled location of the darted animals in dense forested vegetation using a Yagi antenna (Sirtrack Ltd, Havelock North, New Zealand). This requirement limited the available dart volume to 3 ml because of the commercial availability of tracking darts. Darts were fitted with 3.8 cm wire twin-barbed needles (Pneu-Dart, Pennsylvania, USA) and were delivered using an x-calibre® CO_2 powered dart gun (Pneu-Dart, Pennsylvania, USA). As transmitters added considerable weight to the dart, the shooting range to non-habituated to human presence horses was reduced to 40 meters.

Remote immobilisation was performed by a professional shooter and supervised by a veterinarian.

All animals were approached on foot and were darted while standing or grazing and the chosen darting site was the lateral shoulder, neck or rump and the intended injection route was intramuscular (IM). Distance travelled by each horse was measured by a GPS (Garmin Oregon 550, Garmin International, Kansas, USA) and reported distances are from the last successful dart. Immobilisation was deemed to be achieved when the darted animal was observed to be in lateral recumbency (as per Walzer *et al*. 2006). Once immobilised, horses were quietly approached from behind and sometimes repositioned to avoid rocks and vegetation, or to reduce visceral pressure on the diaphragm secondary to head- down-hill positioning. Animals were blindfolded with a blanket to reduce visual stimulation and to diminish potential injury to their eyes.

Anaesthetic monitoring of physiological parameters was performed immediately after lateral recumbency was achieved and then every 15 minutes until the animal was standing. Heart rate (HR) was recorded by auscultation; respiratory rate (RR) by counting chest excursions; pulse strength by digital pressure of the facial artery and body temperature by a thermometer placed in the rectum. Mucous membrane colour (MM), capillary refill time (CRT), palpebral reflex response and anal tone were also evaluated. Haemoglobin saturation (S_pO_2) was measured by a battery powered c-clamp pulse oximeter (Edan, California, USA), placed on the tongue. Oxygen supplementation via nasal insufflations at 10 L min^{-1} was administered when S_pO_2 fell below 90%. Oxygen was delivered from a portable high pressure cylinder (BOC Australia Ltd, NSW, Australia) fitted with a regulator flow meter and connected to the horse by 3 m of 14 mm internal diameter plastic tubing.

Body weight was calculated while the animal was anaesthetised and in lateral recumbency using the formula of Carroll and Huntington (1988):

$$\text{Weight (kg)} = \frac{girth^2 x\ length}{Y}$$

The perpendicular distance from the dorsal midline immediately caudal to the withers and the ventral midline was doubled to provide the girth measurement. The distance from point of hip to point of shoulder was measured as being representative of body length (Milner and Hewitt 1969), and the divisor 'Y' equalled to 11900 (Carroll and Huntington 1988). This calculation allowed approximation of drug administered per kg of horse. Age was approximated by dental examination (as per Baker and Easley 1999).

Time to lateral recumbency was measured as the time from first dart placement to the time the horse became recumbent (as per Woolough *et al.* 2012). In horses darted multiple times, some darts bounced off or embedded in superficial tissues. In horses darted with more than one dart, time to lateral recumbency was measured from the successful delivery of the last dart to lateral recumbency. Drug absorption from these ineffective darts was assumed to be zero (as per Woolough *et al.* 2012) and they were not included for calculation of final drug dosage. Total recumbency time was measured from initial recumbency to standing in minutes.

Immobilisation was reversed with an initial dose of 50mg of atipamezole (Illium Atipamezole, Troy Laboratories, NSW, Australia, concentration of 5mg/ml) intravenous (IV) and/or intra-muscular (IM) 30-40 minutes post induction. If the recovery was prolonged, then an additional dose of atipamezole equal to 25mg (IV) was given 25 and 60 minutes after the initial dose. Recovery time was measured in minutes as the time from first administration of atipamezole to the time the horse stood and remained standing.

Further observations were performed from a safe distance to ensure recovery was complete, which was expressed as sufficient muscular strength and coordination of movements to remain standing (Clark-Price 2013). Within 24-48 hours of recovery, all horses were

reassessed to see if they were of normal demeanour and that they had returned to their harems.

Results are presented as mean ± SEM and range.

Results

Immobilisation

Drug doses, animal details, induction, anaesthesia and recovery data for all horses are presented in Table 1. Tabulated drug doses were calculated retrospectively after estimation of body weight post darting. Five horses (animals 1 - 5) became laterally recumbent after administration of one dart, three horses (animals 6, 7, and 8) required two darts to become recumbent and one horse (animal 9) required three darts to achieve lateral recumbency. The mean dose for medetomidine for all nine animals was 0.15 ± 0.01 mg kg^{-1} and for tiletamine-zolazepam was 3.61 ± 0.16 mg kg^{-1}. In all horses, a stilted gait was observed within 2-3 of darting, followed by progressive ataxia and lateral recumbency within 13 ± 2.7 min. Distances travelled by horses after a successful dart varied from 60 – 813 m, and averaged at 194 ± 79.6 SEM meters.

Anaesthesia

On average, all horses were laterally recumbent for 54 ± 13 minutes. All measured variables were within normal ranges for the duration of the anaesthesia in all horses (Table 2) with the exception of one horse (animal 1) displaying a transient drop in haemoglobin saturation.

Recovery

Following the administration of atipamezole at a mean of 37 ± 1.6 min post induction, all horses stood within 31 ± 13 min. In one horse, where 75% of the calculated dose of atipamezole was given IM and 25% IV, totalling 100 mg, the recovery was prolonged and lasted 115 min. In the second horse, where 25 mg atipamezole was given IV and 25 mg IM, the recovery was rapid and lasted five min. Subsequently, the remaining seven horses

received 50 mg atipamezole IV. Amongst six horses the average recovery length was 9.3 ± 3 min. One horse experienced a longer recovery; therefore, it additionally received 25 mg of atipamezole (IV) 25 minutes from the initial dose and recovered in 37 min. One horse did not recover from the initial dose, so subsequently it was given 25mg of atipamezole (IV) at 25 minutes and 25 mg of atipamezole (IV) at 60 minutes from the initial dose totalling100 mg. The recovery length of this horse was 70 min.

Most horses (*n* = 7; 77.8%) had a smooth recovery, which started with head-lifting and progressed to sternal recumbency, followed by less than three attempts to stand. Two (22.2%) horses had shorter recoveries characterised by three attempts to stand before standing. Despite remaining standing, all horses appeared moderately sedated, and, if not stimulated, moved very little for the next 3-4 hours. If stimulated to move, horses were ataxic, but the full control of body movements returned after two hours of standing.

Eight individuals eventually returned to their harems. One horse re-joined his harem on the same day, five horses the following day; and two horses remained by themselves for more than two days before re-joining their harems. One horse was euthanised within 16 hours of recovery because of an injury sustained during anaesthetic induction. The post-mortem examination revealed that while the horse fell to the ground, its body weight had driven the dart into the chest cavity causing a pneumothorax and lung collapse.

Discussion

The combination of medetomidine and tiletamine-zolazepam produced adequate short-term immobilisation of all feral horses in field conditions. This is the first known study, to have used this drug combination to remotely immobilise free ranging horses. A single 3-ml dart was sufficient to produce immobilisation in 55.6% horses, with consistently short times to lateral recumbency. Depth of anaesthesia in these horses was variable but anaesthesia was generally short, and all measured physiological parameters were within normal ranges

(Coumbe 2001). The recoveries varied in time, but were smooth and resulted in no visible injuries to immobilised horses. Similarly, 44.4% of horses that required more than one dart to become recumbent exhibited short times to lateral recumbency after the administration of the final dart. The stability of lateral recumbency in these horses was more variable as were the average recovery times. The overall recumbency time produced by this combination was longer than for many similar studies (e.g. Woolnough *et al.* 2012; Boardman *et al.* 2014).

In four horses, which were not immobilised with one dart, the initial dart bounced off or embedded in the target tissue subcutaneously. As a result, two horses in which the dart bounced off, showed a lack of response to the initial drug dosage, and in the other two instances, responses to the drugs were muted despite at least one of the subsequent darts embedding in the targeted animal's tissues. This procedure agitated the horses, and caused them to move, potentially bypassing the sedative effect. It is possible to conclude from these observations that where the dart did not initially lodge, or embed in the subcutaneous tissue, it may not have impacted with adequate force to inject a sufficient volume of drug to cause immobilisation, or the drug was subcutaneous and, therefore, had a slower effect (Rosu *et al.* 2012). Residual drug present in darts that bounced off the animals was observed but was not measured in the current study. Individual variation of anaesthetic responses varies between animals of the same species, and differences in age, gender, body condition, physiological state of the animals at the time of drug delivery may potentially affect drug absorption rates (Geschke and Chilvers 2009; Roelle and Ransom 2009).

Despite the differences in body size between the individual horses, it was not possible to constitute and deliver individual drug doses under the field conditions in which the study was conducted. The use of standardised total drug doses, rather than tailored individual doses, is reflected in the variability in drug dosages seen in Table 1. Measurement of body weight after immobilisation in the first four horses indicated that the drug combination dose selected was

more appropriate for male horses with a more uniform body weight of around 450 kg, hence the preponderance of males in this study.

In the current study, all animals were darted while standing or grazing, but numerous factors potentially influenced dart performance. For example, thick ground vegetation made it easier for the shooter to approach the horses, but the vegetation impeded progress of the dart. Observations made by the shooter revealed that wind speed affected dart trajectory which deviated from the target in two instances. Sudden movement of two horses also resulted in darts not embedding in the target tissue correctly.

The dose of medetomidine used in the current study was higher than the dose used in a previous study on use in Przewalski's horses (0.07-0.10 mg kg^{-1}; Matthews *et al*. 1995), and slightly higher than that used to immobilise feral donkeys (0.14 mg kg^{-1}; Woolnough *et al*. 2012). Other studies have shown that comparable doses of medetomidine to those used in the current study have been administered to large ungulates previously without lethal side effects (Tyler *et al*. 1990; Haulena *et al*. 2000; Woolnough *et al*. 2012; Boardman *et al.* in press). Heart and respiratory rates were within normal ranges, but S_pO_2 values showed that haemoglobin saturation decreased with anaesthesia and was of sufficient concern in one horse (11.1%) to warrant the administration of oxygen by nasal insufflation. If nasal oxygen is not available in the field then anaesthetic duration should be minimised by administering atipamezole as soon as possible to reverse medetomidine. The risk of early atipamazole use, however, could lead to residual effects of tiletamine and zolazepam, such as prolonged ataxia and distress to the animal (Muir *et al*. 2000). Greater dosing accuracy of medetomidine and tiletamine-zolazepam is also likely to reduce unwanted effects of anaesthesia, such as decreased haemoglobin oxygen saturation (Muir and Hubbell 2009).

Sedative and anaesthetic agents depress thermoregulatory function and both hypo-and hyperthermia can be of significance depending upon the ambient temperature and the

duration of anaesthesia in the field (Delvaux *et al*. 1999). The metabolic effects associated with the escape response in wild animals may significantly raise the core and therefore rectal temperature of captured animals (Woolnough *et al*. 2012). Despite moderately high ambient humidity and temperature during the period over which the darting study occurred, the rectal temperature of immobilised horses remained within the published normal range (Coumbe 2001).

The use of reversal agents is desirable in feral and wild animal field anaesthesia, as it diminishes the risks associated with anaesthetic procedures (Walzer *et al*. 2006). In wild animal capture studies involving α-2 adrenergic sedatives, atipamezole has been successfully employed to accelerate animal recovery and reduce the costs of anaesthesia monitoring (Matthews *et al*. 1995; Ramseyer *et al*. 1998; Hubbell and Muir 2006). However, timing of atipamezole administration is important irrespective of whether an α-2-antagonist is the only drug administered or if it is combined with other sedatives or anaesthetics. In field anaesthesia, atipamezole administered subcutaneously (SC) and IV at doses of 0.17-0.23 mg kg^{-1} 30 minutes after remote delivery of medetomidine and ketamine did not result in complete reversal and was associated with variable recovery times in Przewalski's horses, which was believed to be due to persisting effects of ketamine (Matthews *et al*. 1995). Larger doses of atipamezole administered 15 minutes after medetomidine and ketamine, significantly shortened recovery time but did not eliminate residual effects of ketamine in feral donkeys (Woolnough *et al*. 2012).

There is no readily available antagonist for tiletamine-zolazepam (Muir and Hubbell 2009). Administration of atipamezole in this study was deliberately delayed to 37 (± 4 SEM) min post induction to ensure that when the effect of medetomidine was neutralised, the residual effects of tiletamine-zolazepam were reduced. Earlier administration of atipamezole would have meant that the level of α -agonist reversal would have been influenced by the persistent

of the tiletamine-zolazepam sedation and arousal would have been diminished. As a result, rapid and smooth recoveries and return to standing was obtained in 77.8% horses. The approach was similar to that of Woolnough *et al*. (2012), where α-2 adrenergic antagonist administration to 30-40 minutes post induction, avoiding residual ketamine effects and enhancing the smoothness of recoveries.

Anaesthetic time of wild equids should be reduced to a minimum (Walzer *et al.* 2006; Woolnough *et al*. 2012) but our study reported an extended mean time in lateral recumbency of 54 (± 13 SEM) min. For example, the first horse received 75% of the calculated dose of atipamezole by IM injection. Time to standing in this horse was slow (115 min), which could have been influenced by the route of administration. Subsequent horses were given 50% (n = 1) or 100% (n = 7) of the calculated atipamezole dose IV, which considerably shortened their recumbency and recovery times (Table 1). When atipamezole was administered intravenously, the recovery was considerably more rapid, was associated with a moderate degree of ataxia, and in general involved a lower dosage. Extended recovery time of the last horse could have been a result of a larger dose of anaesthetic agents received by three consecutive darts. The amount of drug injected from darts which dislodged and/or bounced off was unknown and was assumed to be nil when calculating dose rates, however some absorption could have occurred. To reduce recumbency times, further research could investigate the combination of the shorter-acting but less soluble ketamine with medetomidine (as per Mathews *et al.* 1995) in contexts that permit larger dart sizes (helicopter darting, trapped animals). Investigation of adding the enzyme hyaluronidase (as per Cattet and Obbard 2010) may also be warranted to reduce induction times.

Legislative requirements surrounding the use of the potent opiate etorphine are prohibitive in Australia (Australian Government, Department of Health and Aging, 2013). The occupational hazards posed by etorphine make it very difficult to acquire licenses to use the drug for

operational immobilisation programs (Woolnough *et al.* 2012). Less potent opiates, such as butorphanol, are often added to the medetomidine–ketamine combination (e.g. Miller *et al.* 2009; Boardman *et al.* in press). However, opiates are Schedule 8 drugs in Australia (Australian Government Department of Health and Aging 2013), reducing their accessibility for field techniques (see Woolnough *et al.* 2012). In addition, the high cost of butorphanol, and its antagonist, naltrexone, render such regimes relatively expensive when compared with methods not including an opiate. For these reasons, an opiate was not included in the immobilisation regime in the current study. In contrast, the use of medetomidine and tiletamine-zolazepam offers an accessible and practical option for operational control programs of feral animals in the field.

Conclusion

The combination of 60 mg of metedomidine and 1500 mg of tiletamine-zolazepam allowed safe, partially reversible and cost effective remote immobilisation of nine feral horses in their natural environment of the Tuan and Toolara State Forest. This approach was practical for the study operators as it only involved the use of three drug preparations and did not require the use of restricted substances. The ability to safely immobilise feral horses for the attachment of telemetry equipment or collection of health and physiological data is important for the understanding of the biology of the species. The practicality of capture techniques is an important consideration for managers to facilitate live removal or euthanasia of feral horses during management operations where lethal methods are not acceptable (Chapple 2005; Nimmo and Miller 2007). The ability to capture feral horses in the TTSF and similar land tenures by chemical immobilisation will advance current non-lethal management options which are primarily based on mustering and trapping (Berman 2013). This technique will be of particular importance in the forestry areas located near major public roads, where mustering of animals may increase risk of collisions with vehicles. Future research should be

aimed at optimising dose rates and delivery mechanisms for medetomidine and tiletamine-zolazepam, comparing with medetomidine-ketamine, and providing additional information on the safety, efficacy, and physiological responses of horses immobilised with this drug combination.

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Table 1.

Summary data detailing animal characteristics, drug dosages based on calculated horse weight, number of delivered darts; and anaesthetic time effects in nine feral horses remotely immobilised with medetomidine and tiletamine-zolazepam in the Tuan and Toolara State Forest; LR – lateral recumbency; SEM – standard error of the mean.

ID	Sex	Age (years)	Body weight (kg)	Medetomidine (mg kg^{-1})	Tiletamine-Zolazepam (mg kg^{-1})	Atipamezole (mg kg^{-1})	No. of darts	Time to LR (min)	LR time (min)	Recovery time (min)
1	F	6	434	0.15	3.44	0.23	1	6	139	115
2	F	15	320	0.20	4.69	0.15	1	5	46	19
3	M	11	474	0.13	3.16	0.10	1	10	28	5
4	M	5	430	0.14	3.49	0.12	1	28	26	7
5	M	7	414	0.14	3.60	0.18	1	9	62	37
6	M	6	481	0.17	3.12	0.10	2	25	18	5
7	M	6	432	0.15	3.47	0.12	2	15	46	18
8	M	4	387	0.16	3.88	0.13	2	8	29	2
9	M	5	446	0.14	3.63	0.22	3	14	92	70
Mean		7.2	424	0.15	3.61	0.15	2	13	54	31
± SEM		1.18	16.12	0.01	0.16	0.02	0.24	2.73	13.04	12.74

Table 2.

Measured parameters of remotely immobilised feral horses (n = 9) with medetomidine and tiletamine-zolazepam in the Tuan and Toolara State Forest; HR – heart rate; RR – respiratory rate; Temp – body temperature; S_pO_2- haemoglobin saturation, and CRT-capillary refill time.

Parameter	Mean ± SEM	Range
HR (min)	43 ± 1.4	35 - 48
RR (min)	19 ± 1.6	14 - 30
Temp (^{O}C)	38.4 ± 0.2	38.2 - 38.7
S_pO_2 (%)	87 ± 2.2	79 - 94
CRT (sec)	2.3 ± 0.2	2 - 3