Velvet antler removal from red deer

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For my family

My fiancé,
Paul Chambers
and my wonderful children,
Malina, Niko, Jessica, Robert, William and Thomas.

Short Abstract

Antlers are unique structures specific to deer that are cast and regrown annually. The harvest of velvet antler is a surgical procedure requiring analgesia and haemostasis. Analgesia is provided by lignocaine ring blocks around the base of the antler in adult stags or compression analgesia with a rubber (*Natur*O™) ring in yearlings. Stags are often sedated with xylazine for velvet removal. This thesis covers four topics requiring refinement or further understanding: variability in local analgesia using lignocaine; the efficacy or noxiousness of *Natur*O™ rings; lignocaine residues in antlers; and post- xylazine stag death.

In a video observational study of antler harvest on commercial velvet farms, successful analgesia was characterised by fewer "gaps" in the ring block, greater volume of lignocaine per antler, greater time taken to inject lignocaine, greater number of injections, lower stag age, and other stag factors. There was significant confounding in the data and multiple variables are likely to be important.

In a series of studies investigating the use of *Natur*O™ rings, the rings prevented behavioural responses and partially prevented EEG responses to antler removal. On application of the *Natur*O™ ring, some animals demonstrated behavioural and EEG responses indicative of noxious sensation. *Natur*O™ rings provide analgesia during antler removal and may cause discomfort on application.

It is believed that lignocaine reaches the antler via the blood stream, resulting in tissue residues. Blood flow to the antler was investigated using acrylic models, fluorescent microspheres and cineangiography. Different tourniquet types were tested to determine whether they could prevent lignocaine residues. The arterial supply to the antler is elaborate and tourniquets minimised arterial flow at tensions less than 2kg but did not prevent lignocaine residues.

Occasionally, stags die within 48 hours of sedation with xylazine. In an epizoological survey, this was not related to drug or environmental factors. Reactions involved either acute respiratory distress or delayed death with severe pulmonary oedema. During observations of yearlings sedated with xylazine most demonstrated hypoxaemia that could be reversed by oxygen supplementation or yohimbine administration.

This work provides indicators of how best practice in velvet antler removal may be improved.

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Ethics Approval

The experiments contained in this thesis have received approval from the Massey University Human Ethics Committee and the Massey University Animal Ethics Committee.

Contents

List of abbreviations

		Chapter
ACVM	Agricultural Compounds and Veterinary Medicines	1, 5
AP	Antlerogenic Periosteum	1
AWAC	Animal Welfare Advisory Committee	1
BW	bodyweight	1
C	Close-up video recordings	2
cAMP	Cyclic adenosine monophosphate	1
CI	Confidence interval (statistics)	2
CNS	Central Nervous System	1
coeff	coefficient	2
CSF	Cerebrospinal fluid	1
DINZ	Deer Industry New Zealand	1
DMA	di-methyl-analine, also refered to as 2,6-DMA, DMHA or 2,6-xylidine	1,4
DRU	Massey University Deer Research Unit	3,4,5
EA	Electroanalgesia	1
EEG	Electroenchephalography, electroencephalogram	1,3
ESR	Environmental Science and Research (Laboratory)	1
ET	End Tidal (as in ET halothane concentration)	3
F50	Median Frequency (of a power-frequency EEG spectrum)	3
F95	95% Spectral Edge Frequency (of a power-frequency EEG spectrum)	3
faf	Focal Analysis File	3
fl	Flinch: Small sharp movement	2
fmf	Focal Master File	3
FMRC	Fluorescent Microsphere Resource Centre	4
GCMS	Gas Chromatography Mass Spectrometry	1,4
gdf	Global definition file	3
GLP	Good Laboratory Practice	4
HA	Head Arch: Movement of the head and poll so that the nose moves backwards and the poll moves upwards	2
HCO_3	Bicarbonate (Blood gas analysis)	5
HD	Head down: Downwards displacement of the head	2
HPLC	High Performance Liquid Chromatography	4
HR	Head rotate	2
IARC	International Agency for Research on Cancer	4
IJEACCM	Interim Joint Expert Advisory Committee on Complementary Medicines	1
IV	Intravenous	1
IVRA	Intravenous regional anaesthesia	1
LC-MS	Liquid Chromatography-Mass Spectrometry	1,4

LPS	Lipopolysaccharide	5
MAF	Ministry of Agriculture and Forestry, New Zealand Government.	1
MEGX	Monoethylglycinexylidide	1
min	minutes	2
mL	millilitres	1,2,3,4,5
mm	millimetres	2
mmHg	millimetres of mercury - a unit of pressure, e.g. blood pressure	5
MPL	Maximum Permissible Level (synonyms MRL Maximum Residue Level, Maximum Residual Level, MPRL Maximum Permissible Residue Level)	4
MRI	Magnetic Resonance Image	1
NAWAC	National Animal Welfare Advisory Committee	1
NDLR	Negative diagnostic likelihood ratio	2
NPV	Negative predictive value	2
NSAID	Non-steroidal anti-infammatory drug	1
NumVelvYear	Number of stags velveted per year : The average number of stags that an operator velvets per year	2
NVSB	National Velveting Standards Body	1
NZDFA	New Zealand Deer Farmers Association	1
NZFSA	New Zealand Food Safety Authority	1,4
NZVA	New Zealand Veterinary Association	1
OR	Odds Ratio (statistics)	2
p	probability, statistics (as in p-value)	2,3,4,5
$PaCO_2$	Arterial carbon dioxide pressure	5
PaO_2	Arterial oxygen pressure	5
PDLR	Positive diagnostic likelihood ratio	2
pH	pH. A measure of acidity/alkalinity	5
PIM	Pulmonary Intravascular Macrophage	1,5
PPV	Positive predictive value	2
RNZSPCA	Royal New Zealand Society for the Prevention of Cruelty to Animals	1
TCM	Traditional Chinese Medicine	1
TNF	Tumour Necrosis Factor (as in TNF-alpha)	5
TP	Total Power	3
SaO_2	Arterial haemoglobin oxygen saturation calculated from blood gas analysis	5
SD	Standard deviation (statistics)	2
sec	seconds	2
sl	slight: A small movement of the head	2
SpO_2	Haemoglobin oxygen saturation (%)	5
stdev	standard deviation (statistics)	2
TCO_2	Total carbon dioxide (arterial blood gas analysis)	5
TNF	Tumour Necrosis Factor	5

USFDA	United States Food and Drug Association	1
vax	Vaccination. As in vaccination gun	2
Vol	Volume, usually in millitres	2
vs	versus	
W	Wide angle video recordings	2
YrsVelv	Year velveting - The number of year the operator has been personally velveting stags	2
ZT	Zygomaticotemporal. Injection site for lignocaine for antler analgesia, below the zygomatic arch.	2

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Long Abstract

Antlers are unique structures specific to male deer that are grown and cast on an annual cycle and are unlike the horns of other ungulate species. During the growth phase, velvet antlers have a well developed neurological and vascular supply and are sensitive to pain. Antlers are usually removed from deer, for commercial and management reasons, during the velvet growth stage, when they are sensitive to pain and therefore analgesia must be provided. The removal of growing velvet antlers is a controlled surgical procedure that can only be carried out by a veterinarian or a farmer that has been certified by a veterinarian. There is considerable legislation surrounding the removal of antlers and the New Zealand Deer Industry has a desire to continue its right to harvest antlers and wishes to ensure that methods used are safe, effective and humane. The experiments in this thesis examine some areas of velvet antler removal that may be refined in order to improve the quality assurance of the procedure. These include analgesia with lignocaine and compression bands, drug residues and sedation.

Chapter one of this thesis provides background information on the anatomy and commercial harvest of antlers and introduces and discusses concepts and methods relevant to the experimental chapters (2 to 5) that follow. The general outline is as follows:

- Method for applying local anaesthetic ring blocks and determining a pain response
  Introduced in Chapter 1.2, experiment in Chapter 2.

- Use of compression with the *Natur*O™ ring for analgesia in yearling stags
  Introduced in Chapter 1.3, experiments in Chapter 3

- Lignocaine residues and the development of a tourniquet to prevent residues
  Introduced in Chapter 1.4, experiments in Chapter 4

- Post xylazine stag death and the effects of xylazine on blood oxygen levels
  Introduced in Chapter 1.5, experiments in Chapter 5

Lignocaine ring blocks

Under current practice in New Zealand, analgesia is provided by subcutaneous lignocaine injections in adult stags or *Natur*O™ ring compression bands in yearling stags. Experiments have shown that lignocaine injected in a high dose ring block around the base of the antler provides superior analgesia compared to blocking nerve trunks more proximally. Limited data from field observations of farmers applying lignocaine and removing velvet suggests that the achievement of analgesia in the field may be variable, with some operators achieving better results than others. There is a need to describe the best practice for applying lignocaine ring blocks to maximise the chances of analgesia for all stags on commercial farms. In order to do this a method for determining whether analgesia has been achieved needed to be developed. Previous methods have used a behaviour grading scale based on the amount of the stags body involved in the movement. This method may have limited sensitivity and/or specificity and there was a need to better define a

withdrawal response caused by pain sensation from antler that were cut with insufficient analgesia. Methods for assessing a pain response in animals are reviewed in Chapter 1.2, while Chapter 2 consists of an observational study of farmers and veterinarians harvesting velvet antler in the field. A detailed behaviour analysis was done to develop the criteria for determining a withdrawal response to antler removal. Using this behaviour scoring system, operators were ranked according to the proportion of stags that showed a withdrawal response during antler cutting. Variables associated with the farm, operator, animal and injection method were analysed to determine which had a significant effect on the likelihood of a withdrawal response during antler removal. "Flinch" had a higher sensitivity for a withdrawal response compared to previously described movement of the head, neck or body. "Flinch", "Head arch" "Head down" and "Head rotate" had greater specificity for a withdrawal response compared to previously described movements and a combination of these specific head-related movements is likely to be a more accurate predictor of failed analgesia than previously described behaviours. The overall withdrawal response during commercial antler harvest was 35% and ranged from 0 to 76% between operators. The most important factor influencing the likelihood of a withdrawal response was the presence or absence of visible "gaps" in the ring block, whereby injection sites did not overlap. Other variables that were important included the number of injections, total volume injected and injection time. Factors relating to the stag including stag age, sedation and stage of antler growth also appeared to have an effect on behaviour during antler removal although there was a high level of confounding in the data. An interaction model was drawn and recommendations made for best practice injection method.

*Natur*O™ ring

Compression analgesia by the use of *Natur*O™rings is reviewed in Chapter 1.3 and four experiments relating to this topic are presented in Chapter 3. Compression analgesia has been investigated in deer and is currently legal in New Zealand for the removal of velvet from one-year-old stags using *Natur*O™rings. This method of analgesia provides a solution to problems concerning drug residues in velvet antler and transport of yearling deer following velvet removal. Compression causes displacement of myelin sheaths and hypoxia of nerves, causing them to cease functioning within a time period that is related to the level of pressure applied by the compression device. There are limited studies on the efficacy of compression for preventing a pain response to velvet antler removal or on whether compression is itself noxious to the animal. Chapter 3 of this thesis details four experiments using electroencephalography (EEG) and behaviour to help determine whether *Natur*O™rings prevent a response to antler removal and also to determine whether *Natur*O™rings cause a pain response when they are applied to the animal. When antler were cut from anaesthetised stags that had a *Natur*O™ring applied to the pedicle, the average EEG response was somewhere between that of stags that had been treated with lignocaine ring blocks and those that had no treatment. There was no difference in the behaviour of yearling stags during velvet antler removal that had been treated with either a *Natur*O™ring or lignocaine ring block prior to antler removal. When comparing responses to application of *Natur*O™rings and lignocaine ring blocks, there were significant differences in the EEG pattern following application of the different treatments and this was mostly due to changes in the lignocaine group. Overall, there was little effect on the mean EEG parameters in the *Natur*O™ring treated stags but on an individual animal basis, seven out of 10 stags treated with *Natur*O™rings showed some significant changes consistent with noxious somatic stimulus. Stags that were videoed for one hour following application of one of a combination of *Natur*O™rings, lignocaine or no treatment did not show differences in the majority of normal behaviours. Stags that were treated with *Natur*O™rings had a higher frequency of some specific head related movements such as head rotating, turning head in circles, arching the head up or down and head pressing. Overall, the *Natur*O™ring appears to offer analgesia during antler removal but may be perceived as noxious on application in some spikers but not others.

Lignocaine residues

Lignocaine use and safety is reviewed in Chapter 1.4 and the experiments relating to lignocaine residues are presented in Chapter 4. While compression analgesia ensures no residues are present in the antler, it is currently not an accepted form of analgesia for adult stags and lignocaine hydrochloride is used for analgesia in adult stags. One metabolic product of lignocaine, 2,6 dimethylanaline is classified as a potential carcinogen to humans after studies on the carcinogenic effects on rats. The maximum permissible level for lignocaine in velvet antler is set at 1mg/kg. This level is frequently exceeded in antler tissue so a method of preventing lignocaine residues was sought. It was believed that lignocaine reached the velvet antler via the blood stream and that a tourniquet placed prior to lignocaine injection would prevent lignocaine residues. Fluorescent microspheres, cineangiography and direct observations were used to determine the tourniquet tension required to minimise antler blood flow. In most cases tourniquets applied at a tension of 2kg or less prevented antler blood flow. Efforts to develop a consistent tourniquet for use in the field were unsuccessful at preventing lignocaine residues in the antler suggesting that either tourniquets are unable to fully prevent leakage of blood and lignocaine into the antler or that lignocaine is reaching the antler by another route.

Xylazine reactions

Stags often require sedation for velveting to ensure the safety of both the stag and the operator. The most commonly used drug for this is xylazine. Xylazine is prescribed and distributed to farmers that are licenced to harvest velvet from their own animals. Stags occasionally die up to 48 hours after administration of xylazine and this has generally been described as an anaphylactic or delayed anaphylactic reaction. Deaths are sporadic and variable from one year to another. Little is known about the factors that cause stag death following sedation with xylazine or the exact mechanism of the pathology. Chapter 5 of this thesis includes two main areas of research, an survey study or stag deaths and a series of experimental studies and observations of the hypoxaemic effects of xylazine in young deer. Survey data was limited and unable to identify specific risk factors although a number of potential causes were able to be excluded. Deaths were not related to any environmental factors including weather, temperature, time of day, facilities and method. The formulation and dose of drug administered was not a contributing factor, nor was the administration of the reversal agent, yohimbine. Deaths were sporadic in location and time, with some farms experiencing multiple deaths and others never experiencing a death. A limited number of postmortem samples were sent to Massey University for histopathology. The majority of these revealed pulmonary oedema with or without pulmonary haemorrhage. Yearling deer sedated with xylazine demonstrated marked hypoxaemia measured as reduced SpO_2 and PaO_2 levels. This was reversed after administration of endotracheal oxygen or reversal with yohimbine. It is hypothesised that xylazine causes hypoxaemia and pulmonary oedema in nearly all deer and that in most cases this is transient but a population of deer experience severe hypoxaemia from which they do not recover. Supplemental oxygen is recommended for all deer given xylazine or xylazine combinations and susceptible stags should be identified and alternative methods of restraint used.

Chapter 6 identifies some potential future research options that may help to further refine the methods used for velvet removal making the procedure safer and more humane for the animals and more predictable for the assurance of the general public. Potential options include the development of an automated needle-free drug delivery device, the use of a different local anaesthetic agent that does not produce carcinogenic metabolites and the use of peripheral alpha-2 antagonist agents to mitigate the hypoxaemic effects of xylazine in deer. These methods could also be extended to use in other ruminant species.