Induction and Assessment of Velvet Analgesia

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Introduction

Growing velvet antler is innervated mainly through the zygomaticotemporal and infratrochlear branches of the trigeminal nerve (Adams, 1979). Other nerves (eg the cervical) may supply the posterior section of the pedicle antler in a small proportion of animals (Adams, 1979). Analgesia of the velvet prior to harvesting is achieved mainly by administration of lignocaine hydrochloride as a regional nerve or ring block (Wilson, 1989). The regional block is directed at the two major nerves close to where they emerge from the skull, while the ring block is injected around the base of the pedicle. Wilson (1989) suggested that the ring block may diffuse more rapidly than the nerve block and will block the two major as well as the cervical nerves. It seems likely, then, that the ring block will not only cause a more rapid but also a more complete induction of analgesia in a higher proportion of animals than the nerve block.

These hypotheses were tested in the experiments reported here. In addition, the duration of analgesia following the administration of local anaesthetic was determined. In order to make these measurements, it was necessary to develop a non-invasive, repeatable and relatively benign procedure for stimulating the velvet (thereby simulating velvet removal) and assessing velvet sensitivity. Such a procedure is reported in Phase I of Experiment 1. This involved stimulating the velvet with small electrical currents and recording the intensity of the behavioural avoidance reactions and cardiac responses. Changes in the behavioural and heart rate responses to stimulation were used to assess the efficacy of analgesic treatments. Our earlier studies (Matthews and Cook, 1991) have shown that avoidance reactions and changes in electrocardiogram parameters are sensitive indicators of pain in deer.

Methods

Experiment 1 - Assessment of Velvet Sensitivity

Animals and Apparatus

Ten red deer stags (five yearlings and five mixed age adults) with growing velvet were used. The stage of velvet development during the experiment was similar to that considered optimal for commercial harvest. The animals were kept on pasture and drafted off from the remainder of the herd on the morning of the study.

The animals were restrained in a pneumatically-operated drop-floor crush with padded sides during the experimental period.

A Grass Stimulator was used to deliver square-wave electrical pulses (frequency of 19Hz, 10m sec pulse duration and 0.1m sec delay between pulses) to the antler velvet via spring-loaded calipers that served as electrodes. The electrodes were positioned on

either side of the velvet about 20 mm above the pedicle. An electrolytic gel was rubbed into the velvet at the point of contact with the calipers. Variations in the magnitude of the electrical stimulus were arranged by altering the applied voltage in the range 0-100V. The stimulus was applied for two seconds during which time the current was measured. The maximum current delivered was 70mA (perceived by humans as a mild tingling sensation on moistened fingertips) and was usually in the range 5 to 30mA.

Cardiac cycle parameters were recorded in restrained animals via three sterile electrodes implanted subdermally (in a triangular pattern behind the left shoulder) on a Sony two-channel tape recorder.

Procedure

Individual stags were drafted from the remainder of the penned animals and restrained in the crush. The ECG apparatus was attached and the velvet antler prepared for stimulation.

Phase I - Sensitivity Testing Procedure. Following a baseline period (no experimental intervention) of behavioural observation and ECG recording, the responses of animals to first an ascending and then a descending series of electrical stimuli were recorded. The first stimulus was about 5 V (1 - 2mA). Subsequent stimuli applied to the velvet were applied at minute intervals, with stimulus increments of about 10V, until an upper threshold response was seen (behaviour score of eight or nine, see Results section). On average every second stimulus from the ascending sequence was used in the descending series. The same procedure was followed with each antler.

Phase II - Sensitivity following Ring and Nerve Blocks. A sensitivity testing procedure similar to that in Phase I was repeated after the administration of a local anaesthetic to induce analgesia of the velvet. Two different routes of administration were tested. Lignocaine hydrochloride (2%) was applied either as a ring block (15 ml) or nerve block (10ml). Each animal received both treatments (one per antler in random order).

The stimuli applied during sensitivity testing were those that had been shown to induce behaviour scores of seven or eight during Phase I (see Results section). The testing procedure continued for 10 minutes or until no response was shown to the stimulus (whichever occurred soonest). Insensitivity to the applied stimuli was checked by testing reactivity to currents up to 50% higher than those used in Phase I. Animals which continued to react at 10 minutes post-anaesthetic administration were given additional lignocaine and the testing procedure was repeated.

Phase III - Sensitivity to Velvet Removal (Ring versus Nerve Block). Animals that were insensitive to electrical stimuli in Phase II had their velvet removed by saw in the standard commercial manner. The behavioural and ECG responses were monitored (as outlined for Phase I) for five minutes before, during and five minutes following velvet removal.

Experiment 2 - Assessment of the Duration of Velvet Analgesia

Animals and Apparatus

Seven red deer yearlings with growing velvet were used. The stage of velvet development, animal management procedures and apparatus used were as described in Experiment 1.

Procedure

Individual animals were restrained in the crush and prepared for the recording of ECGs and electrical stimulation of the velvet. During the first 15 to 20 minutes in the crush baseline behavioural and ECG recordings were obtained and the sensitivity testing procedure (see Phase I Experiment 1) was conducted. This was followed by administration of local anaesthetic (lignocaine hydrochloride, 15ml) as a ring block and retesting of sensitivity at various intervals (five minutes, 30 minutes, two hours and 24 hours post-ring block administration). The animals were released from the crush after the 30 minute test and re-crushed for both the two hour and 24 hour tests (the animals were at pasture between these latter two tests). The standard behavioural and cardiac cycle measures were recorded during each test.

Results

Experiment 1

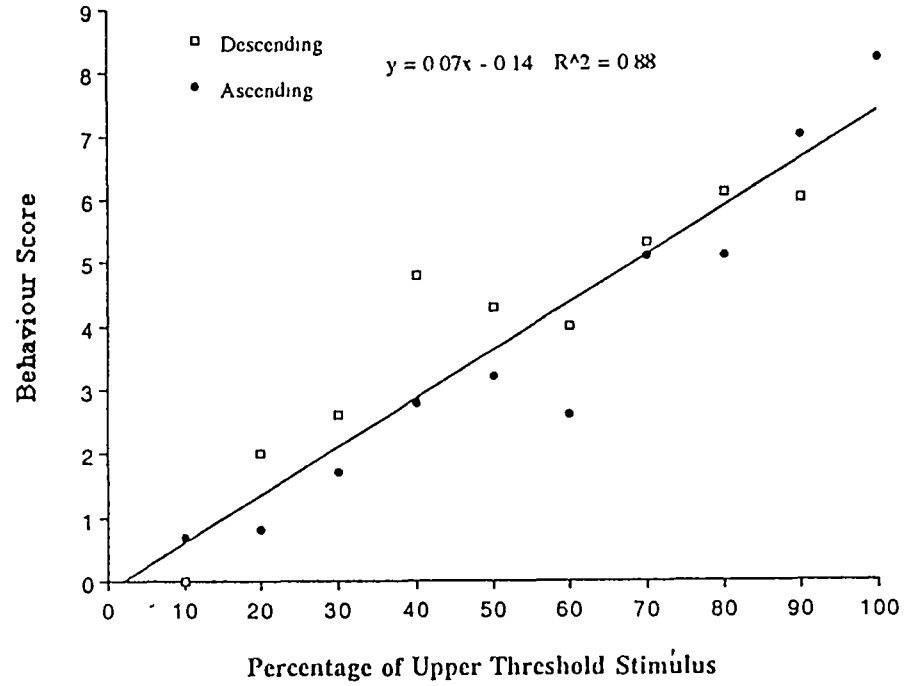
Phase I - Sensitivity Testing

The magnitude of the stimulus that elicited the minimal behavioural response (ie score of one) varied widely between individuals (1-30mA). However, increases in stimulus intensity above this lower threshold resulted in an orderly hierarchy of avoidance reactions in all animals. These responses included head movements alone (scores one and two), and head movements in combination with neck and shoulder displacement (scores three to seven) or body displacement (scores eight and nine). Current levels eliciting scores of eight or nine were defined as the upper threshold stimuli.

The relations between stimulus intensity and behaviour and stimulus intensity and heart rate are shown in Figure 1. Because of the variation between individuals in sensitivity to particular stimulus magnitudes the percentage of the upper threshold stimulus (rather than mA) is presented on the x-axis.

The behavioural data are well described ($r^2 = 0.88$) by the best fit straight line fitted by the method of least squares. Although the relation between stimulus intensity and heart rate is somewhat curvilinear, the overall trend is for heart rate to increase monotonically with current level.

There were no systematic differences between behaviour scores at equivalent stimuli on the ascending and descending series but heart rates tended to be higher during the descending series.



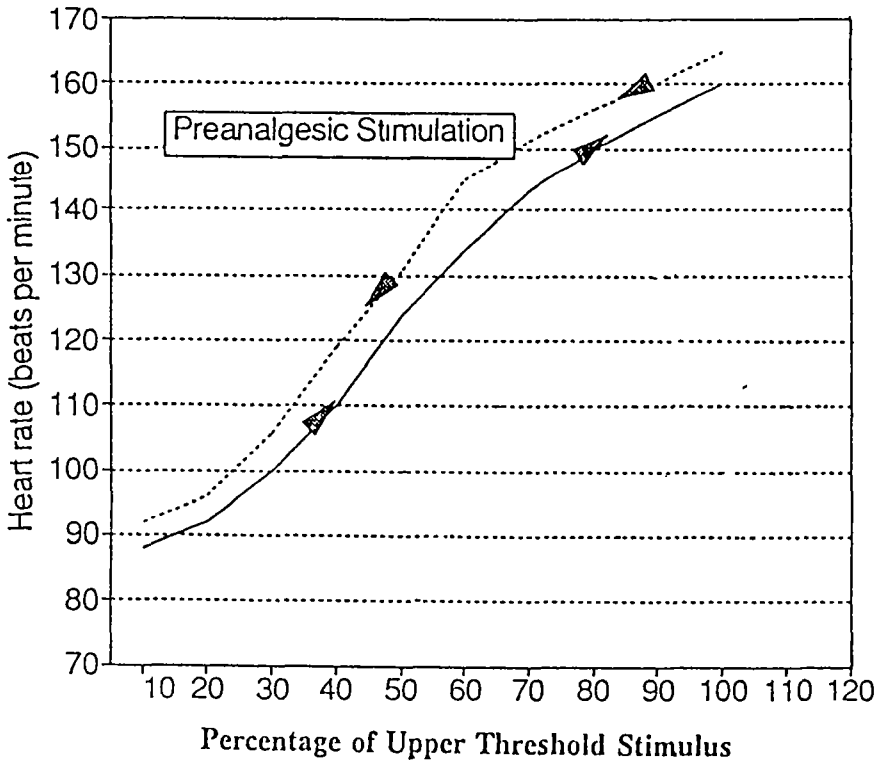


Fig 1 Behaviour scores (upper panel) and heart rate (lower panel) are shown as functions of increasing stimulus magnitude (percentage of upper threshold stimulus). The straight line of best-fit, its equation and r^2 value are also shown on the behaviour function.

Phase II - Sensitivity following Ring and Nerve Blocks

Table 1 shows that a higher proportion of animals did not react to the stimuli following the ring block (92%) than following the nerve block (67%). The table also shows that the average heart rates were higher in the nerve block treated group.

Table 1: Proportions of Animals not Responding to Electrical Stimulation, and Average Heart Rates

Anaesthetic Proc	Not Responding	Heart Rate (b.p.m.)
Ring block	0.92 (11/12)	84
Nerve block	0.67 (8/12)	100

For those animals not reacting to the stimulus, the onset of analgesia occurred within two to five minutes for the ring block and four to six minutes for the nerve block.

Phase III - Sensitivity to Velvet Removal (Ring vs Nerve Block)

The behavioural and cardiac responses to velvet removal are shown in Table 2 for those animals not reacting to the electrical stimuli in Phase II.

About two-thirds of the animals showed no behavioural reaction to velvet removal under both anaesthetic treatments with most of the remainder showing a slight reaction for less than a second. The average heart rate tended to increase during velvet removal and decline soon afterwards. The magnitude of the increase tended to be greater for the nerve block group.

Experiment 2

The average behavioural responses (± s.d.) during baseline and pre- and post-administration of local anaesthetic are shown in Table 3. The behaviour score increased from zero during baseline to 9.0 during the initial sensitivity test. Following the administration of local, the behaviour scores declined to zero for all animals at both the five and 30 minute tests. Six of the seven deer had regained some sensitivity at the two hour test (average score of 5.6, range 0 to 9), and all had regained complete sensitivity at 24 hours.

The changes in heart rate during the sensitivity tests conducted before and after anaesthetic administration are shown in Figure 2. The average basal heart rate was 79 b.p.m. and maximal rates (about 125 b.p.m.) were seen during the initial and 24 hour sensitivity tests. Heart rates were at intermediate levels (103 b.p.m.) during the five minute and 24 hour tests and at basal levels (83 b.p.m.) during the 30 minute post-administration test.

Heart rate but not behaviour changed in response to administration of the ring block alone. Average heart rate increased from 83 b.p.m. (± 16) pre-ring block to 94 b.p.m. (± 11) during the minute period after injection before declining to 89 b.p.m. (± 16) in the fourth minute after injection.

Table 2: **Proportions of animals showing various behavioural responses (a) and average heart rate (b) to velvet removal under ring block and nerve block anaesthesia**

(a)

Anaesthetic Proc	Behavioural Response		
	None	Slight[1]	Moderate[2]
Ring block	0.67 (8/12)	0.25 (3/12)	.08 (1/12)
Nerve block	0.63 (5/8)	0.38 (3/8)	0.00 (0/8)

[1] Behaviour score ≤ 5 for < 1 sec
[2] Behaviour score ≤ 5 for > 1 sec

(b)

Anaesthetic Proc	Heart Rate		
	Pre (2 mins)	During	Post (2 mins)
Ring block	84 (8)	103 (8)	96 (5)
Nerve block	81 (8)	118 (9)	101 (8)

Table 3: **Behaviour scores to sensitivity tests prior to and following ring block anaesthesia (time zero = anaesthetic administration)**

	Pre-anaesthesia		Post-anaesthesia			
	No stimulus	-5 mins	5 mins	30 mins	2 hrs	24 hrs
Behaviour score	0.0 (0.0)	9.0 (0.0)	0.0 (0.0)	0.0 (0.0)	5.6 (3.6)	9.0 (0.0)

General Discussion

A non-invasive, repeatable procedure for modelling the effects of noxious stimulation of growing antler velvet was developed. This involved applying mild electrical stimuli to the antler velvet and scoring the intensity of the avoidance behaviour of the animal. Threshold stimuli were selected for each animal and changes in the responses of the stags to these stimuli were used to assess the efficacy and duration of various analgesic treatments.

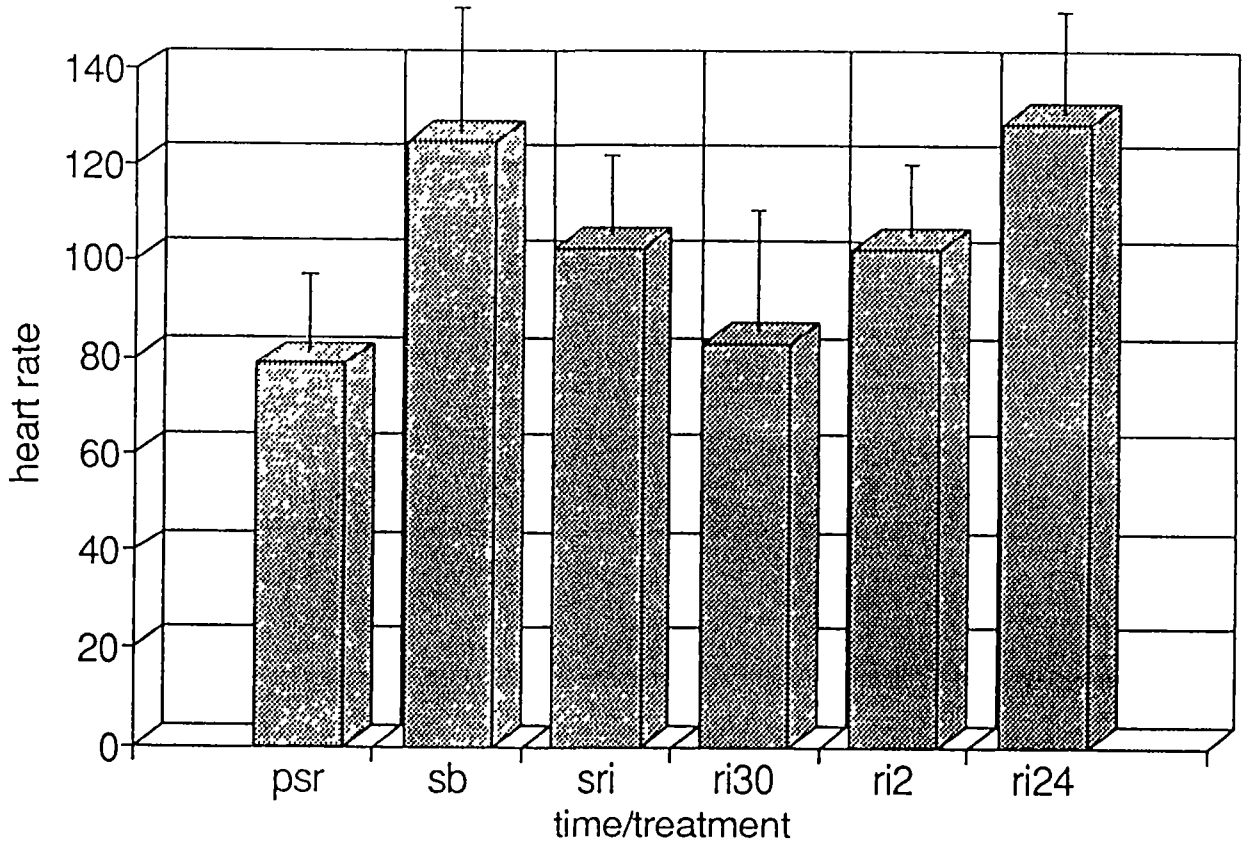


Fig 2 The average heart rates (± s.d.) during sensitivity tests administered before and after injection of local anaesthetic (prs = pre-stimulation heart rate; sb = first sensitivity test; sri = 5 minute post; si 30, 2 and 24 = 30 minute, 2 hour and 24 hour post, respectively).

A higher proportion of animals showed no reaction to the threshold stimulus following ring block anaesthesia in comparison with nerve block anaesthesia. Similarly, heart rates were lower for animals tested under ring block analgesia. Thus, administration of the local anaesthetic by a ring block would be the preferred method for maximising pain relief during velvet removal. This is supported by the results of Phase III of Experiment 1 - fewer animals showed behavioural reactions and heart rates were lower under ring block analgesia. The higher degree of pain suppression with the ring block is most likely due to the greater accuracy in the placement of the anaesthetic around the target nerves. In addition, any nerve branches supplying the pedicle but originating from non-trigeminal nerves would be anaesthetised by the ring block but not the nerve block.

A further advantage of the ring block arises from the more rapid onset of analgesia compared with the nerve block, thereby increasing the efficiency of the harvesting process. The results of Experiment 2 showed that pain relief was at maximal levels for at least 30 min but had diminished somewhat in most animals by 120 min post-

administration. Recent studies (Pollard, 1992) indicated that stags may be experiencing pain for some hours after velvet removal. In order to protect the welfare of the animals it may be necessary to administer analgesics that are longer acting than lignocaine hydrochloride.

The technique developed here for modelling stimulation of the velvet offers considerable potential for evaluating a range of novel analgesic treatments without the need to subject the animals to invasive procedures.

References

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