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**Assessment of Tail Docking and  
Disbudding Distress and its  
Alleviation in Calves**

A Thesis presented in fulfilment of  
the requirements for the degree of  
**MASTER OF SCIENCE**  
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## ABSTRACT

In this age of increasing awareness of animal welfare, the demand for scientific methods to quantify the welfare of animals maintained under different conditions and exposed to different husbandry procedures has also increased. The aim of the present study was to examine the acute distress involved in the procedures of tail docking and disbudding of Friesian dairy calves. Different methods of tail docking (rubber ring and docking iron) and disbudding (scoop and cautery), with or without the use of a local anaesthetic, have been assessed using changes in plasma cortisol concentration and some behavioural observation as indices of distress.

The practical objectives were to provide advice on choice of method and on the benefits or otherwise of using local anaesthetic to alleviate the pain associated with these procedures.

The innervation at the docking site of the bovine tail and the efficiency of two methods of local anaesthetic administration (epidural and ring block) in desensitising the tail were assessed. Epidural local anaesthetic was found to totally desensitise the entire tail whereas a ring block administration of local anaesthetic around the docking site only effectively desensitised an area immediately adjacent to the site of ring block administration. Hence, to ensure total loss of sensation in the tail, an epidural administration of the local anaesthetic was used in the tail docking experiments.

Tail docking, with or without a local anaesthetic, most three to four month old Friesian dairy calves was found to be no more distressing than control handling and blood sampling using both plasma cortisol concentration and behavioural indices of distress. However, there was a degree of between-animal variation in response - a small proportion of calves which received some treatments that were not expected to cause distress showed signs of mild distress. The reasons for these responses are unknown.

Disbudding six to eight week old Friesian dairy calves with a scoop caused a marked distress response which lasted for about five and a half hours, whereas the alternative method, the cauterising iron, was only slightly more distressing than control handling and blood sampling during the first one hour after disbudding.

Although administration of a local anaesthetic before scoop disbudding produced a marked reduction in plasma cortisol concentration during the first two hours after treatment there was little or no reduction in overall distress, as judged by plasma cortisol responses. However, prior administration of a local anaesthetic to calves disbudded by cautery effected a slight reduction in the distress response, decreasing it to near control levels.

The practical advice on method for these husbandry practices would be for tail docking, continued use of the rubber ring if tail docking is deemed necessary at all, and for disbudding, cautery alone or with local anaesthetic, if practically viable, would be recommended.

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## CHAPTER ONE: INTRODUCTION

### 1.1 ANIMAL WELFARE

Interest in the welfare of animals combines a philosophical debate as to what is acceptable to society with a scientific quantification of welfare. Animals may be kept for social or economic purposes (food, apparel, traction, guarding, rodent control, entertainment, sport or companionship) and it is usually in our best interests to ensure that the welfare of all animals is maintained at reasonably high levels. In livestock production systems good welfare often equates with good productivity and this has encouraged farmers towards good rather than poor welfare.

An animal experiences gains and losses in the trade-off of domestication. In the farming situation, humans exercise control over many aspects of the animal's life such as food intake, group size and composition, movement, reproduction, life expectancy and strive towards providing better health, adequate nutrition and protection from predators (Kilgour, 1984). As domestic animals contribute so much to the social, emotional and economic existence of humanity, it is not surprising that some of the current husbandry practices in agriculture should come under public scrutiny in this age of increasing awareness of animal welfare.

This increased awareness of animal welfare has resulted in the demand for scientific methods to quantify the welfare of animals maintained under different conditions and exposed to different husbandry procedures.

The following discussion is a synthesis of ideas from various publications that concentrates on farm animal welfare rather than a detailed review of all the facets of animal welfare.

Broom (1986) postulated that the welfare of an individual is its state with regard to its attempts to cope with its environment. In this definition the term environment refers to any factor which can affect the animal. Farm animals

encounter factors which challenge their homeostasis and with which they can or can not cope successfully. Broom's definition of animal welfare is rather general. A more comprehensive definition of animal welfare, and the five freedoms, formulated by the Farm Animal Welfare Council to assess the basic needs of livestock (Webster, 1986), has been further developed by Mellor and Reid (1994). Using the original definition (Webster, 1986), welfare is regarded as good when animals are;

1. free from thirst, hunger or malnutrition,
2. free from discomfort and exposure,
3. free from injury and disease,
4. free from restricted movement and to express most normal patterns of behaviour;
5. free from fear.

Mellor and Reid (1994) recast these "five freedoms" so that the major components of suffering (anxiety, fear, pain and distress) are included in freedom five. Using the original and the reconstructed five freedoms it is difficult to think of any area of farm animal life that can not be assessed in terms of welfare compromise. Therefore, good welfare is the state manifest in an animal when its nutritional, environmental, health, behavioural and psychological needs are met (Mellor and Reid, 1994). Welfare can vary on a continuum from good to poor.

In the past, although the primary motive for livestock research has been production orientated, the welfare interests of farm animals have been served through advances which promoted freedoms one and three and to some extent, freedom five. Much research has been undertaken to help insure that the nutritional requirements of farm animals are met (e.g. Agricultural Research Council, 1980; National Research Council, 1980) and that farm animals are free from injury and disease - much of livestock husbandry and farm animal veterinary practice is dedicated to those ends. In addition, some major improvements have been made with regard to freedom from fear, in particular fear at slaughter. Indeed, it could be argued that the large



Improvements in the areas of freedoms one and three during the past several decades have modified farm production systems so effectively that attention now has to be given to the areas encompassed by the remaining two (two and four) of the five freedoms.

Today there is increasingly strong public pressure towards minimising welfare compromise in every sphere of animal use (Blackshaw, 1986; Gee, 1986). The five freedoms provides scientists, farmers and the general public with general guidelines or objectives for welfare assessment and improvement. Since animal welfare is multidimensional it is not surprising that there is no single parameter that enables the extent of any animal welfare compromise to be assessed. However, for each of the five freedoms research has provided indices that help in the assessment of welfare. This is especially so in the first four of the five freedoms as recast by Mellor and Reid (1994).

1. Freedom from thirst, hunger and malnutrition. The nutritional requirements are known for a number of farm animals at different stages of life (growth and maturation) and under different circumstances (exercise, pregnancy and lactation) (e.g. Agriculture Research Council, 1980; National Research Council, 1980). In addition to physical parameters (weight or body condition and clinical symptoms), many biochemical tests have been developed to assess nutritional deficiencies, excesses and normal requirements.

2. Freedom from discomfort and exposure. Physiological and behavioural parameters can be used to assess the acceptability of environmental challenges imposed on animals when kept in hot, cold, wet or dry conditions. These parameters include factors such as body temperature, metabolic rate, body condition or weight, heart rate, respiration rate and character, sweating and shivering (Mellor, 1992). Advances in preference testing have allowed animals to make choices regarding some aspects of their environment such as housing conditions (Duncan, 1978; Dawkins, 1983).

**3. Freedom from injury and disease.** Injuries and diseases are diagnosed, and progress to recovery is monitored, using the cardinal signs and additional behavioural and clinical tests which form the basis of veterinary practice.

**4. Freedom from restricted movement and to express most normal patterns of behaviour.** Often it is a change in behaviour that gives the first indication that an animal's welfare may be at risk (Barnett and Hemsworth, 1990). The behaviours of farm animals experiencing conditions that restricts their movements and behaviour are being increasingly quantified (Matthews, 1993). The occurrence of "abnormal" behaviours such as stereotypies, anomalous reactivity, self-directed behaviour, behaviour directed to other animals or objects, failure of function and vacuum activities have been used as indicators of poor welfare (Fraser and Broom, 1990; Matthews, 1992).

**5. Freedom from suffering (anxiety, fear, pain and distress).** Animals experiencing thirst, hunger, malnutrition, discomfort, exposure, injury, disease, and behavioural restriction may also be suffering. Any anxiety, fear, pain or distress that is associated with compromise in the areas of the recast freedoms, one to four, or which arise in their own right, would be assessed as part of compromise within the fifth freedom (Mellor and Reid, 1994). The fifth freedom is possibly the most difficult to assess because of the subjective nature of suffering. While the perception of anxiety, fear, pain and distress in animals is unproven, by analogy with our own physiological and behavioural states when we have similar experiences, it seems reasonable to accept that animals can suffer. Therefore, although the different components of suffering are difficult to measure, that should not deter us from attempting to do so. Despite the fact that there are limitations to the measurement of different components of suffering because of their subjective nature, measurement can be attempted by reference to physiological and behavioural parameters.

This thesis is concerned with two common husbandry procedures, tail docking and dehorning, in cattle farming that are presumably painful and

potentially distressing because they involve injury. The intention is to assess the suffering (Freedom five) caused by these procedures and to seek ways to alleviate it.

## **1.2 ASSESSING FARM HUSBANDRY PROCEDURES INVOLVING TISSUE REMOVAL.**

Practices which may once have been deemed acceptable are now being reassessed and modified accordingly to new knowledge and changing attitudes. Husbandry practices which involve the removal of tissues are beginning to receive more attention as the urban community wants to know more about where their food and fibre come from. The farming community also realises that high standards of animal welfare are important legally and have direct economic benefits in ensuring continued access to international markets (Baddeley, 1992; Bavyel, 1992).

An animal attempts to cope with a challenge to its homeostasis by three major modes of response; changing behaviour, releasing catecholamines via activation of the autonomic nervous system and/or releasing corticosteroids which form the final step in the cascade of the hypothalamic-pituitary-adrenal system (Moberg, 1985). Fluctuations in behaviour, catecholamine levels or corticosteroid levels outside the normal range have been used to indicate that a stimulus is stressful. Tail docking and dehorning are potential stressors which challenge the homeostasis of an animal due to the physical trauma of tissue removal and the psychological response of the animals to an unfamiliar environment and handling.

These husbandry procedures are presumably stressful because the animals are conscious of the tissue damage and exposed to novel experiences which involve a psychological component. However, due to the primarily physiological nature of the term stress when it was developed originally (Selye, 1974), the terms distress or pain-induced distress will be used in this study to acknowledge the likely involvement of emotional or psychological

components in the total conscious experiences animals have when responding to noxious stimulation. Thus, although the emotional component of suffering will not and perhaps can not be measured directly, its existence in pain-induced distress is acknowledged.

### 1.3 MEASUREMENT OF DISTRESS

Direct neural stimulation following tissue removal which may cause pain-induced distress may result in other changes such as increases or decreases in heart rate, respiration rate, body temperature, blood composition, hormone levels and behaviour. Although each animal has the same basic repertoire of biological responses available to cope with a stressor, individual animals vary in their use of these different types of biological responses. The use depends on a variety of modulating factors, such as prior experience, genetics, age or physiological state (Stafford and Mellor, 1993).

The work of Hans Selye (1950) has been used as the basis for much of the understanding of stress. Although Selye knew of the potential importance of the entire neuroendocrine system during stress, he focussed primarily on the role of the adrenal cortex, emphasising the secretion of corticosteroids (Selye, 1950). Since there were no cases of obvious stress that did not include the adrenal gland, it was believed that corticosteroid release could be used as proof of stress (Moberg, 1985).

As the design of the experiments undertaken in this thesis involved the measurement of plasma cortisol concentrations as an index of distress, the uses and limitations of that index should be explored. Changes in plasma cortisol concentration have been monitored in many circumstances that correlated well with the expectation that plasma cortisol would increase during distressing situations. For example, transport of sheep, cattle and pigs (Purchas, 1973; Johnston and Buckland, 1976; Barnett *et al.*, 1984), surgical castration of cattle and sheep (Johnston and Buckland, 1976; Shutt *et al.*, 1988; Mellor and Murray 1989a,b; Lester *et al.*, 1991a,b; Wood *et al.*,

1991; Kent *et al.*, 1993; Molony *et al.*, 1993; Robertson *et al.*, 1993;), shearing sheep (Kilgour and DeLangen, 1970; Purchas, 1973), restraint of cattle, sheep and pigs (Kilgour and DeLangen, 1970; Becker *et al.*, 1985; Robertson *et al.*, 1993) and herding of sheep and pigs (Baldwin and Stephens, 1973; Thurley and McNatty, 1973).

There are limitations to the use of cortisol. A preferable method of distress measurement would involve monitoring more than one type of parameter (Dawkins, 1980). Rushen (1986) argued that plasma corticosteroids do not give a sensitive enough assessment of the distress experienced in a given situation. His reasoning comes from work by Friedman *et al.* (1967) who showed that in rats increasing the intensity of footshock was not accompanied by progressively higher plasma cortisol concentrations. It could be argued in this case that distress involved during the handling could be of similar magnitude to that experienced by the rats during low amperage footshocks. Further evidence to support Rushen's (1986) view comes from experiences that are not considered distressing, for example increases in plasma cortisol concentration were found during coitus (Szechtman *et al.*, 1974) and voluntary exercise (Sutton and Casey, 1975). Both of these examples could conceivably necessitate work of such intensity and duration that the animal's homeostasis is challenged enough to induce the release of corticosteroids. In addition during coitus, the psychological arousal could be of sufficient magnitude to induce the release of corticosteroids. So, it is important to be aware of other stimuli or activities that may influence the parameters used to assess distress. Provided the design of the experiment excludes or allows for unwanted environmental factors that could alter the cortisol concentrations and provided that one is cautious about interpreting plasma cortisol results, changes in cortisol concentrations may be used as useful indicators of distress in a variety of situations (Mellor and Murray 1989a,b; Lester *et al.*, 1991a,b; Kent *et al.*, 1993; Robertson *et al.*, 1993).

Behaviour was also used in this thesis as an indicator of distress after tail docking of dairy calves. As mentioned, it is often a change in behaviour that

gives the first indication that an animal's welfare is being compromised (Barnett and Hemsworth, 1990). The behaviours displayed after tissue removal or damage can give some indication that an animal may be experiencing pain and/or distress. In other studies, behaviours such as tail flicks, vocalisations, restlessness, escape-avoidance behaviour and body posture have been used in cattle to indicate pain and distress due to tissue damage (Macauley and Friend 1987; Robertson *et al.*, 1993; Taschke and Folsch, 1993).

#### Introduction

By combining changes in plasma cortisol levels with behaviour, the distress caused by the tissue removal can be assessed more comprehensively. Nevertheless, it will still not be possible to determine what contributions are made to such distress by nociception itself or by psychological components which include emotional responses to the conscious perception of nociception and to the novel environment and handling associated with the procedure. Prior administration of local anaesthetic may assist because it will abolish nociception when properly administered, so that the cortisol and/or behavioural responses observed after tissue removals involving local anaesthetic will be caused primarily by the psychological factors unrelated to pain. Thus, local anaesthetic used primarily to alleviate pain during and after husbandry tissue removals, may also help to clarify the contributions of non-painful stimuli of the distress response.

## 1.4 AIMS OF THE PRESENT STUDY

The aim of the present study was to examine the acute distress involved in the procedures of tail docking and disbudding of Friesian dairy calves. These procedures are routinely carried out on New Zealand farms for reasons outlined in the Introductions of the relevant chapters (Chapters Three and Five). Different methods of tail docking and of disbudding, with and without the use of a local anaesthetic, have been assessed using changes in plasma cortisol concentrations and some behavioural features as indices of distress. The practical objectives were to provide advice on the choice of method and

on the benefits or otherwise of using local anaesthetic to alleviate pain associated with these procedures.

## **1.5 OUTLINE OF THESIS**

This thesis has been divided into three main sections, the first deals with tail docking, the second with disbudding and the third a General Discussion. Each chapter, except Chapter Six (General Discussion), contains its own Introduction, which is followed by Materials and Method, Results and a Discussion.

### **1.51 Section One**

Three key issues should be taken into account in the tail docking debate:

1. Is there a need to tail dock dairy cows?
2. Does tail docking itself induce distress?
3. Are there any long-term welfare implications involved in tail docking?

The first issue will be dealt with in the Introduction of Chapter Three and in the General Discussion (Chapter 6), but the major contribution of this thesis will be towards answering the second question, does tail docking itself induce distress? This issue will be addressed in three chapters: first, the nerve supply to the tail has been described and the effectiveness of epidural as opposed to ring block local anaesthetic of the tail assessed (Chapter Two); secondly, the cortisol responses of calves to tail docking using two methods, with and without local anaesthetic, have been reported (Chapter Three) and thirdly, behavioural responses to tail docking using a ring, with and without local anaesthetic, have been outlined (Chapter Four). Some of the long-term implications of tail docking dairy heifers have been discussed in Chapter Six.

### **1.52 Section Two**

The second section involves assessment of the distress caused by disbudding male dairy calves. The distress experienced by calves undergoing this procedure was assessed with the expectation that

Improvements might be made through choice of method and the use of local anaesthetic. An investigation of the plasma cortisol responses to disbudding using two methods, with and without the use of a local anaesthetic, has been described in Chapter Five.

### **1.53 Section Three**

Finally, a synopsis of the main findings in both sections and a general discussion have been provided in Chapter Six.



# **SECTION ONE**

## **CHAPTER TWO:**

### **TAIL DOCKING IN CALVES; AN ANATOMICAL AND HISTOLOGICAL PERSPECTIVE AND A LOCAL ANAESTHETIC STUDY.**

#### **2.1 INTRODUCTION**

Tail docking using a tight rubber ring causes ischaemic necrosis of the tissue distal to the ring, and docking with a heated iron severs the tail by cautery. It may be presumed that the tissue damage caused by these procedures would lead to some pain which could be distressing for the animal. Accordingly, it is important to consider both the amount of pain-induced distress and methods of alleviating it. The present Chapter deals with observations related to the choice of methods for alleviating any pain-induced distress. It forms part of a general study to improve animal welfare with respect to tail docking of dairy calves, which it was proposed would involve injections of local anaesthetic to desensitise the tail, especially at the docking site. This obviously requires knowledge of the location of the sensory nerves to the tail and exploration of different local anaesthetic strategies.

The bovine tail is innervated by paired caudal spinal nerves that emerge through the intervertebral foramina. The caudal extremity of the spinal cord in cattle tapers to a point between the sixth lumbar (L6) vertebra and the caudal part of the first sacral (S1) vertebra (Habel, 1951; Getty, 1975), this point being referred to as the conus medullaris (Getty, 1975). From the conus a slender non-nervous filament of pia mater (the filum terminale) extends caudally. The caudal portion of the spinal cord and the roots of the caudal spinal nerves attached to the conus medullaris are referred to as the cauda equina (McLeod, 1965; Getty 1975; Dyce *et al.*, 1987).

Each caudal spinal nerve is connected to the spinal cord by dorsal and ventral roots. The roots unite and the division of the dorsal and ventral branches occurs in the subarachnoid space (Getty, 1975). These nerves then course caudally inside the spinal canal and emerge through the intervertebral

foramina caudal to the corresponding vertebrae (Habel, 1951; McLeod, 1965; Fig 2.1). Each of the dorsal and ventral branches, following emergence through the intervertebral foramina, connect with branches from the preceding caudal spinal nerves, thereby constituting a dorsal and ventral caudal plexus which extends to the tip of the tail (Getty, 1975; Nichel *et al.*, 1975). Both the dorsal and ventral plexuses supply the muscles, fascia and skin of the tail.

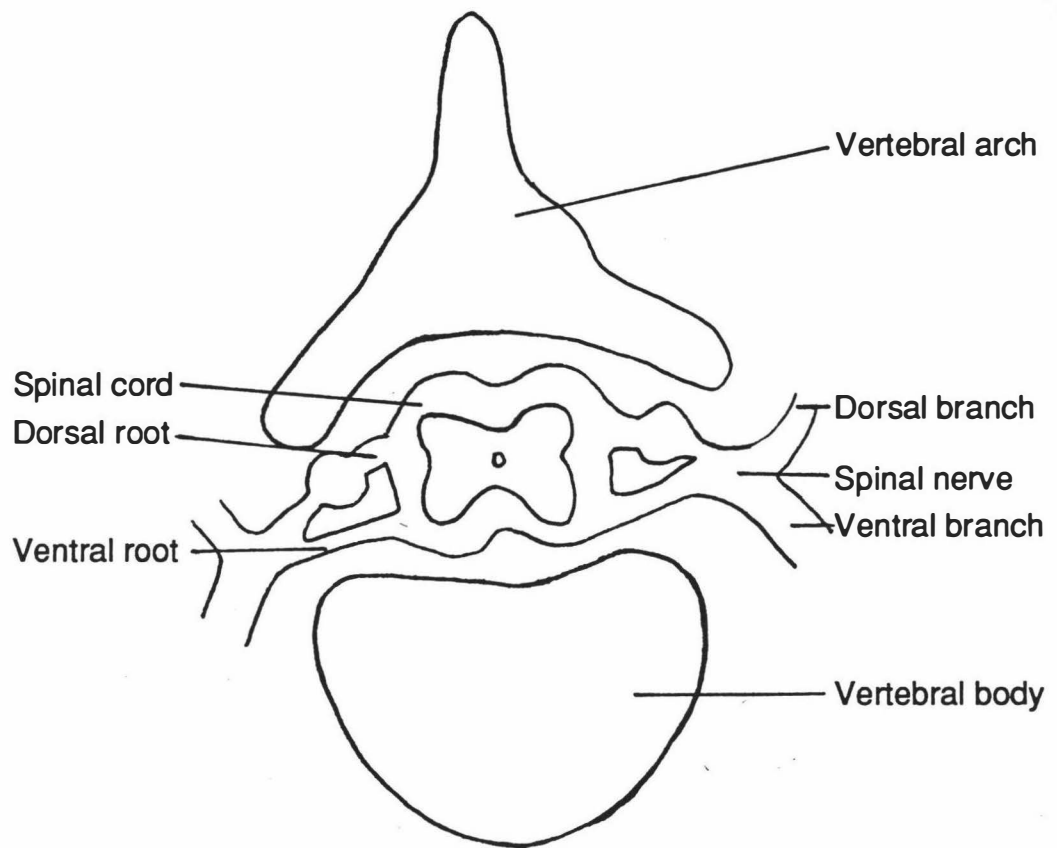
McLeod (1965) and Getty (1975) claim that there are five to six caudal nerves, whereas according to Schaller (1956) the bovine has seven paired caudal nerves.

Although the anatomy of the emergence of the caudal spinal nerves has been described in some detail, the exact nature of the dorsal and ventral caudal plexuses in the bovine have not apparently been described in the literature. The present study was therefore undertaken to define and describe the locations of the caudal nerves and their major branches (using gross anatomical dissection and histological examination) which would be affected by or be the target of local anaesthetic administration. In addition, a study was carried out to determine the effectiveness of epidural or ring block administration of a local anaesthetic in desensitising the bovine tail. The relevant anatomy and details of the local anaesthetic study are recorded here.

## **2.2 MATERIALS AND METHODS**

### **2.21 Anatomical Dissection**

The hind quarters from two adult female Friesian cows and five still-born female calves were obtained from Massey University farms. The hind legs and the pelvis were removed and the remaining tissues were skinned before being fixed in a 10% formalin solution (Pitman Moore, New Zealand Ltd). Each caudal spinal nerve was identified as it emerged from the intervertebral foramen. The caudal spinal nerves were then traced to where their branches



**Fig 2.1:** Schematic diagram of the formation of a spinal nerve and its division into dorsal and ventral branches.  
(Adapted from Dyce *et al.* 1987).

join with the dorsal and ventral caudal plexus. The plexus was identified as it ran down the tail until the size of the branches made identification impossible. Removal of the vertebral arches from the sacrum (S1-S5) to the eighth caudal vertebrae (Cd8) enabled the identification of the conus medullaris and the paired caudal nerves. The arrangement of the caudal nerves as they left the vertebral foramen and supplied the musculature of the tail was sketched.

## 2.22 X-rays

X-rays were taken of all the tail segments removed by the docking iron (n=18), and of the tail segments distal to the ring, after they had dropped off, in some (n=11) of the 3-4 month old calves docked with a rubber ring (Chapter Three). This enabled the identification of the docking site, the vertebral number at the site, and whether the rubber ring was positioned on a vertebra or between two vertebrae.

Further x-rays were taken of the sacral and caudal vertebrae (Cd1-Cd20) of 10 three to four month old calves tails', two weeks after the application of a rubber ring for docking or removal of the distal tail with the docking iron (Chapter Three), and of the three still-born calves used for the histological examination.

## 2.23 Histology

Tails (Cd1-Cd20) removed from three still-born calves obtained from Massey University farms were skinned and fixed in a 10% formalin solution (Pitman-Moore, New Zealand Ltd). The tails were then sectioned transversely about every 10mm along their length. Those sections from around the area of the site that would be used for docking, as identified by x-rays, were labelled and decalcified (Decalcifier I, Surgipath Medical Industries, Inc.) at room temperature over the following five weeks. After decalcification, the tissues were embedded in paraffin using an automatic tissue processor (SE400, Shandon Scientific Co. Ltd.). The tissues were then mounted in paraffin blocks. Sections 6µm thick were cut with a base sledge microtome and mounted onto P.V.A. coated slides. The section were stained with

hematoxylin, eosin and alcian blue (Culling, 1985), then mounted under a cover slip with DPX mountant (BDH Ltd., Poole).

## **2.24 Local Anaesthetic Study**

Three treatment groups of calves were used to assess the effectiveness of two methods of local anaesthetic administration; control (n=5), epidural (n=15) and ring block (n=15).

### **CONTROL n=5**

The tails of these calves were needle-pricked at the various predetermined sites along the tail (see below, Fig 2.2).

### **EPIDURAL n=15**

In each calf, 3ml of lignocaine (Techvet Laboratories) was administered as a caudal epidural injection made through the space between the arches of the first and second caudal vertebrae (Hall, 1971b). Prior to the injection the area was clipped and swabbed with hibitane solution (Pitman Moore, New Zealand, Ltd.) to provide asepsis. Ten minutes after local anaesthetic administration the responses of each calf to a needle-prick at predetermined sites along the tail (see below, Fig 2.2) were monitored.

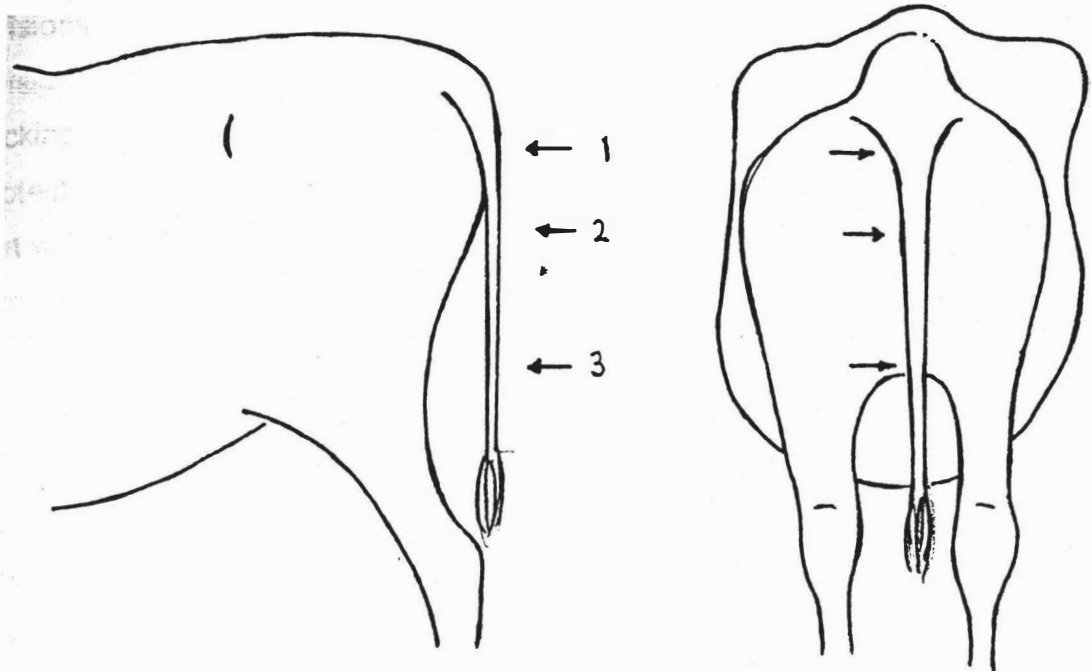
### **RING BLOCK n=15**

The area around the docking site was clipped (at least 2.5cm below the vulva) and swabbed with hibitane solution (Pitman Moore, New Zealand, Ltd.). In each calf, 1ml of lignocaine was administered subcutaneously in dorsal, ventral and lateral positions around the site that would be used for docking. Ten minutes after the local anaesthetic was administered the response to the needle-prick test was assessed in each calf (see below, Fig 2.2).

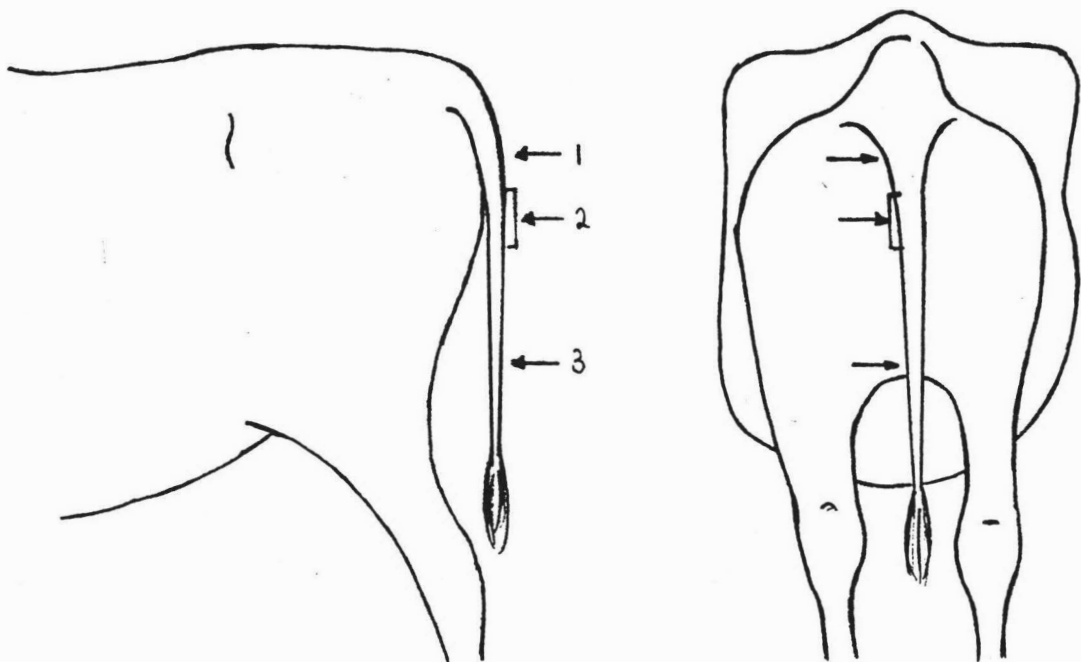
## **2.25 Needle-prick sites**

The tuber ischii of each calf were marked with tail paint and a point midway between them used as a reference point (tail head) from which the tail was

## EPIDURAL



## RING BLOCK



**Fig 2.2:** Positions on the calf tails where sensation was tested using a needle-prick. Arrows represents the position of the needle-prick.

measured. The tail length was then divided into three equal parts and these divisions were then used as sites for the needle prick test (Fig 2.2). The division between the proximal part and the middle part was the designated docking site (test site two), which was at least 2.5cm below the vulva (Animals Protection Act, 1960). The division between the middle part and the distal part was designated the distal test site three. In addition, a test site (one) was located halfway between the tail head and test site two.

The dorsal, ventral and lateral surfaces of each site were pricked with a needle and the calves' reactions were assessed. No response was taken to indicate that the calf was not conscious of the needle prick, whereas tail withdrawal, tail shaking, head turning and in some cases hoof stamping were assumed to indicate perception of it.

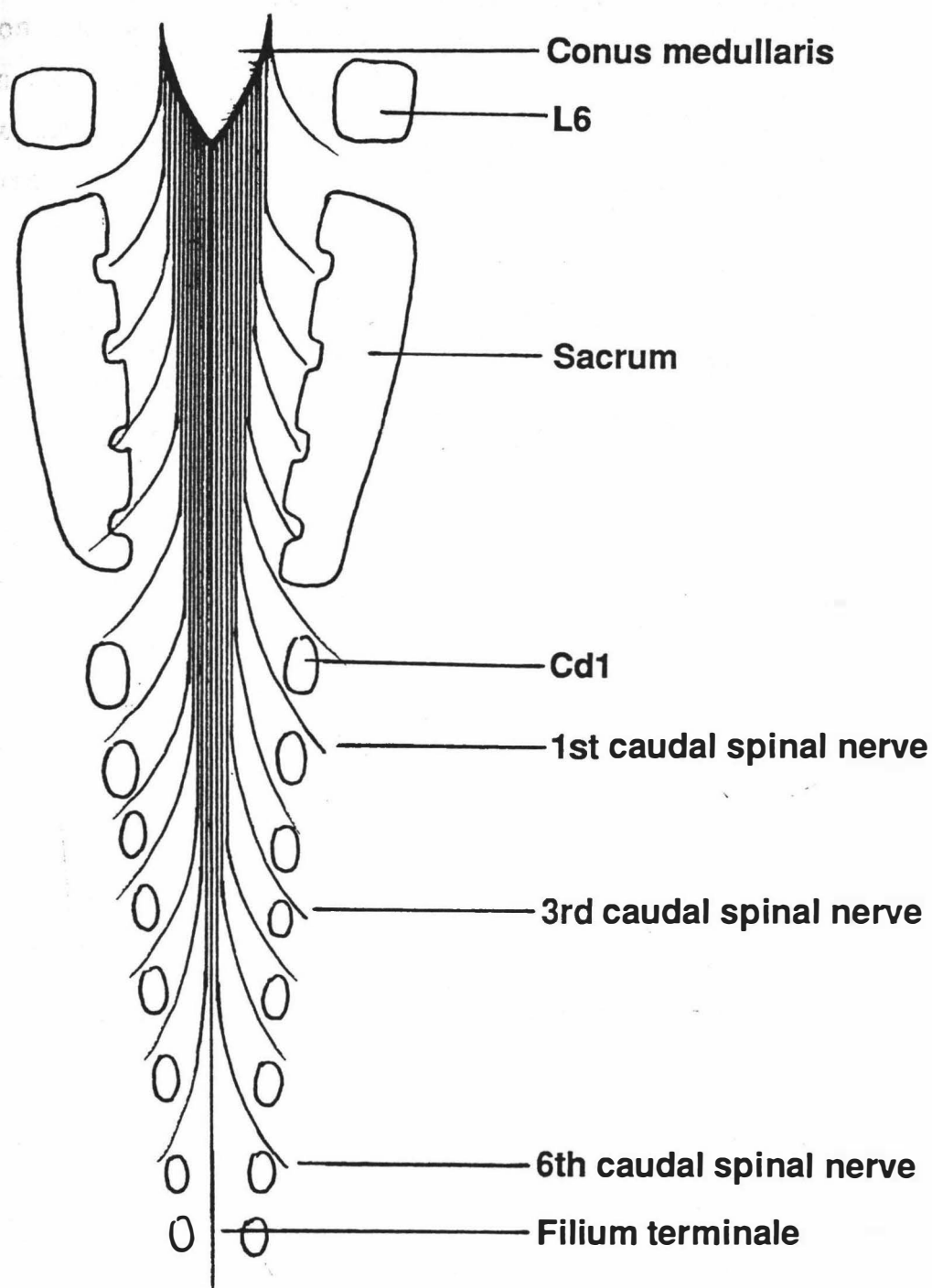
## **2.3 RESULTS**

### **2.31 Anatomical Dissection**

The cauda equina of the two adult cows was located at the junction the sixth lumbar (L6) and first sacral (S1) vertebrae within the vertebral canal, whereas the cauda equina of the still-born calves began between the second and third sacral vertebrae (S2-S3). In five of the specimens there were six paired caudal spinal nerves, while in the remaining two specimens there were seven paired caudal spinal nerves.

The arrangement of the caudal spinal nerves as they left the conus medullaris to form the cauda equina and then emerged through the intervertebral foramina is shown in Fig 2.3.

The dorsal and ventral nerve plexuses were identified on both sides of the tail in two of the still born calves. The dorsal branches emerged from the intervertebral foramina and ran caudally above the transverse processes between the sacrococcygeus dorsalis lateralis and the intertransversarii caudae muscles. The ventral branches ran caudally below the transverse



**Fig 2.3:** Schematic diagram showing the emergence of the caudal spinal nerves in the bovine.

L6 - lumbar vertebra number six

Cd1 - caudal vertebra number one.



processes between the intertransversarii caudae and the sacrococcygeus ventralis lateralis muscles. Along their course these branches anastomosed to form the dorsal and ventral plexuses (Fig 2.4). There was a degree of variation between the arrangements of the caudal plexuses within the specimens dissected. Between Cd6 and Cd7 the sixth caudal nerve emerged and thereafter presumably only the filium terminale continued down the dorsal surface of the remaining vertebrae. How far the filium terminale continued down the vertebrae is unknown because the anatomical dissection was not continued past the eighth caudal vertebrae and it was not identified in the histological sections. Further identification of the caudal nerves was made by histological examination.

### **2.32 X-rays**

The x-rays of the 29 calf tail segments docked with the rubber ring or docking iron revealed that the docking site in all of the calves was on either the ninth or the tenth caudal vertebrae. In the 27 of the 29 tail positions x-rayed, the docking site was on a vertebra rather than between two caudal vertebrae. In addition, in 22 of those 27 calves the ring or the docking iron acted on the transverse process of the vertebra.

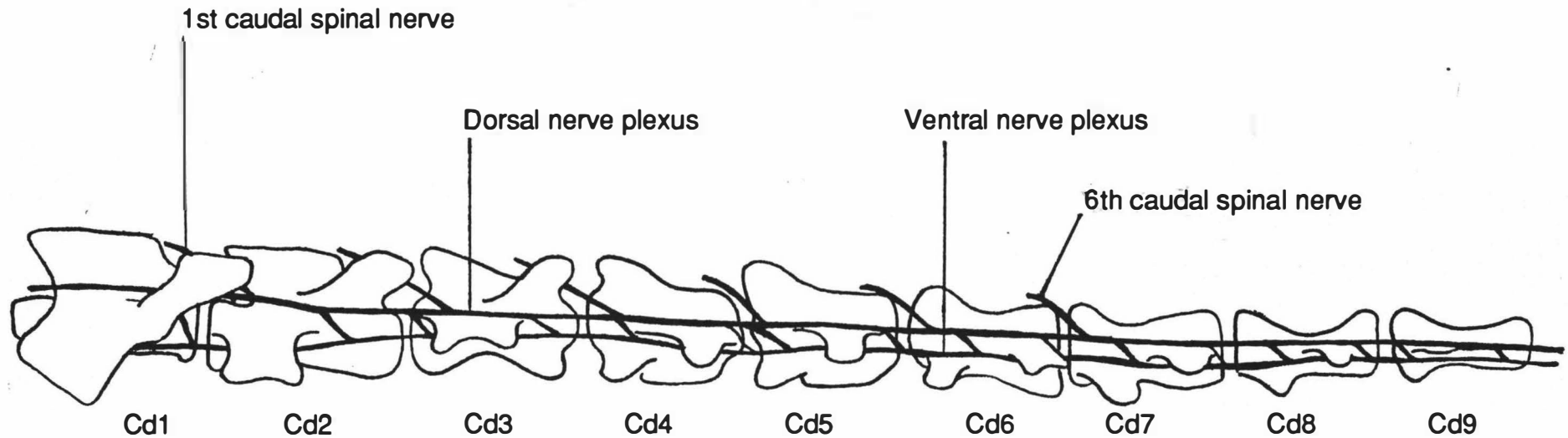
The same observation was seen in the 10 calves (from Chapter Three) x-rayed two weeks after rubber ring application or the removal of the distal tail with the docking iron. An example of where the rubber ring and the docking iron acted over the vertebra in the majority of calves is shown in Appendix A.

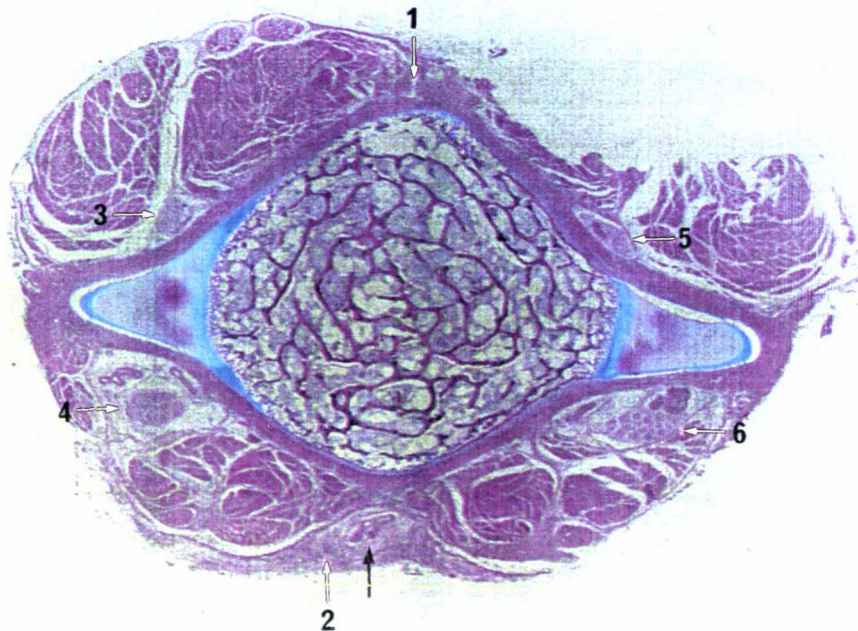
### **2.33 Histology**

Histological sections taken at the docking site were studied in detail. The distribution of the nerve bundles at the docking site, between the ninth and tenth caudal vertebrae is shown in Figures 2.5-2.8.

Histological examination of the docking site revealed nerve bundles dorsolateral and ventrolateral to the transverse processes of the caudal vertebrae. Also, two small bundles of nerves were found on either side of the

**Fig 24:** Diagram of the skeletal structure of a bovine tail (Cd1-Cd9). Lateral view, left hand side.  
Cd 9-Cd 10 - usual docking site (as determined from x-rays).  
Dorsal nerve plexus is seen above the transverse processes.  
Ventral nerve plexus is seen below the transverse processes.  
Anatomosing nerve branches occur cranially and caudally to every transverse process as far as Cd 10 - the arrangement of the nerves and branching is unknown after this point.





**Fig 2.5:** Transverse section through the 9th caudal vertebrae of a bovine. 40x magnification.

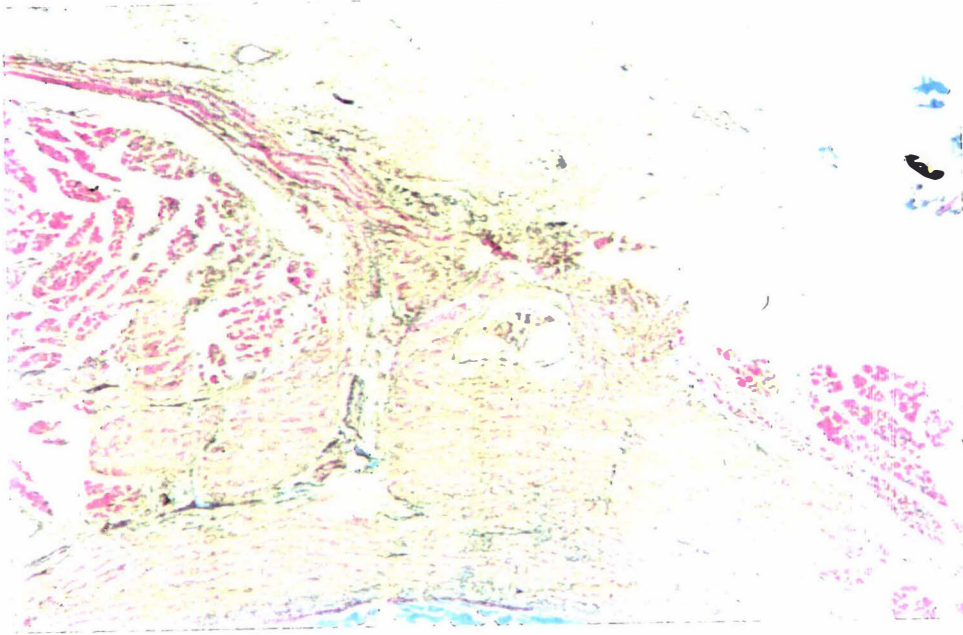
Stain: Hematoxylin and eosin and alcian blue.

Nerve bundles are identified with the white arrows.

The numbered arrows are shown magnified in Fig; 2.6, 2.7 and 2.8.

In the connective tissue surrounding the nerve bundles are arteries and veins. The median caudal artery is shown as an example with the black arrow.

1



2

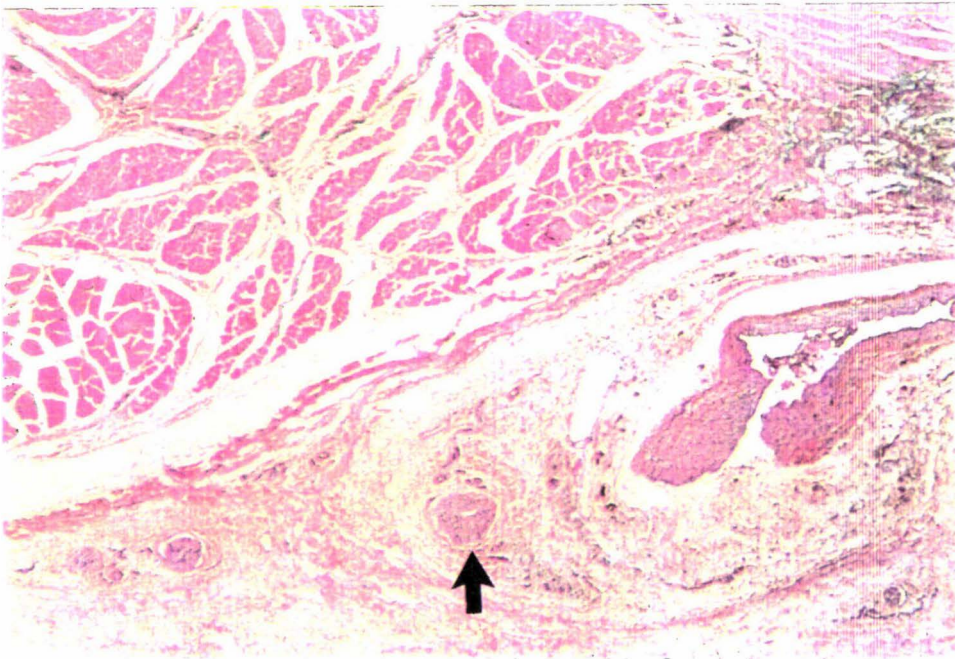
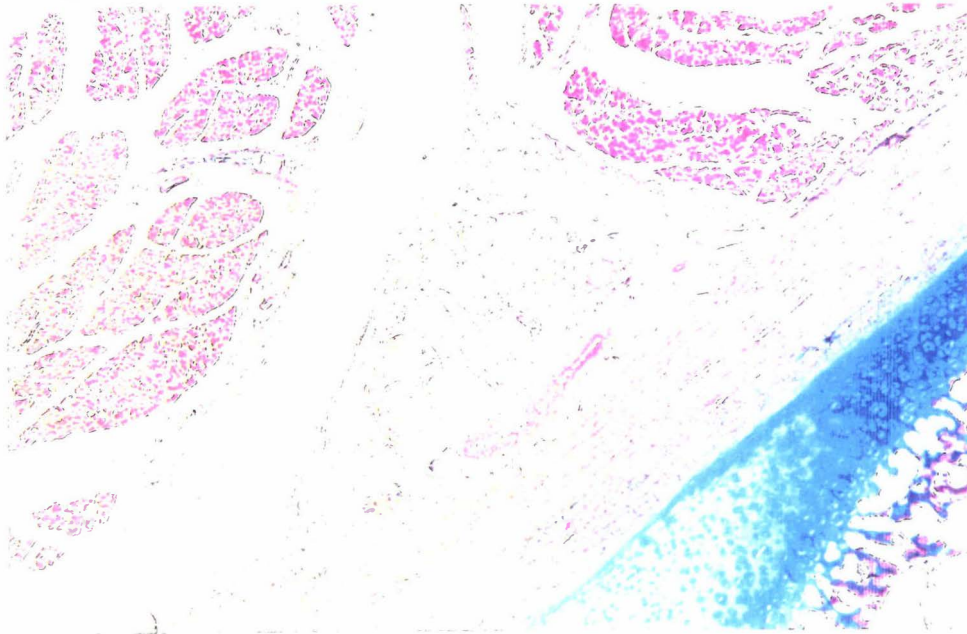


Fig 2.6: Magnification 100x of the nerve bundle sites.  
(1) Dorsal surface of the ninth vertebra, no nervous tissue.  
(2) Small nerve (indicated by arrow) on the ventral surface of the vertebra alongside the caudal median artery.



3



4

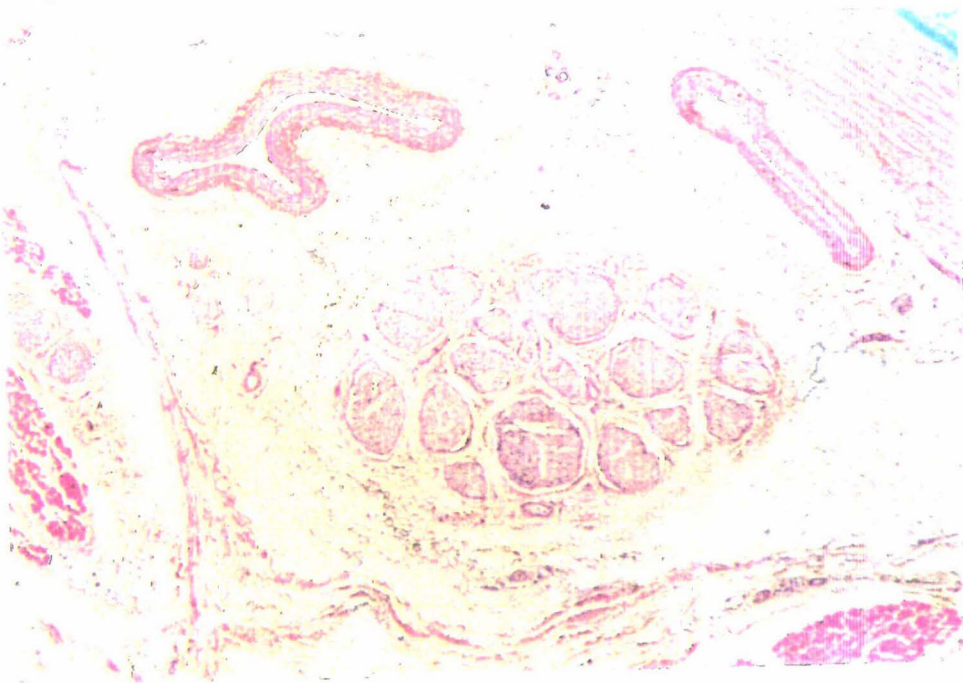
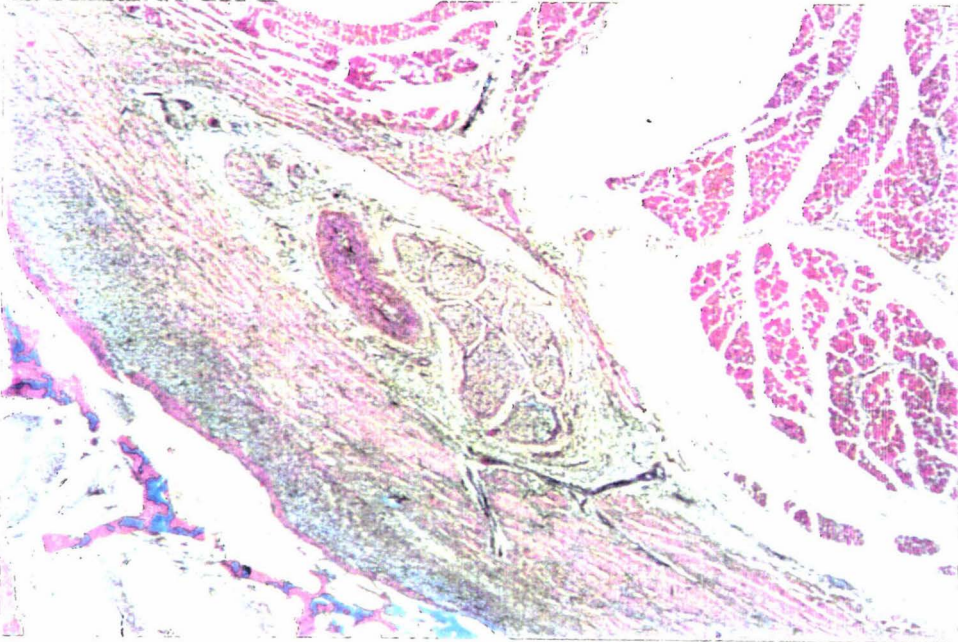


Fig 2.7: Magnification 100x of the nerve bundle sites.  
(3) Dorsal nerve bundle.  
(4) Larger ventral nerve bundle.

5



6

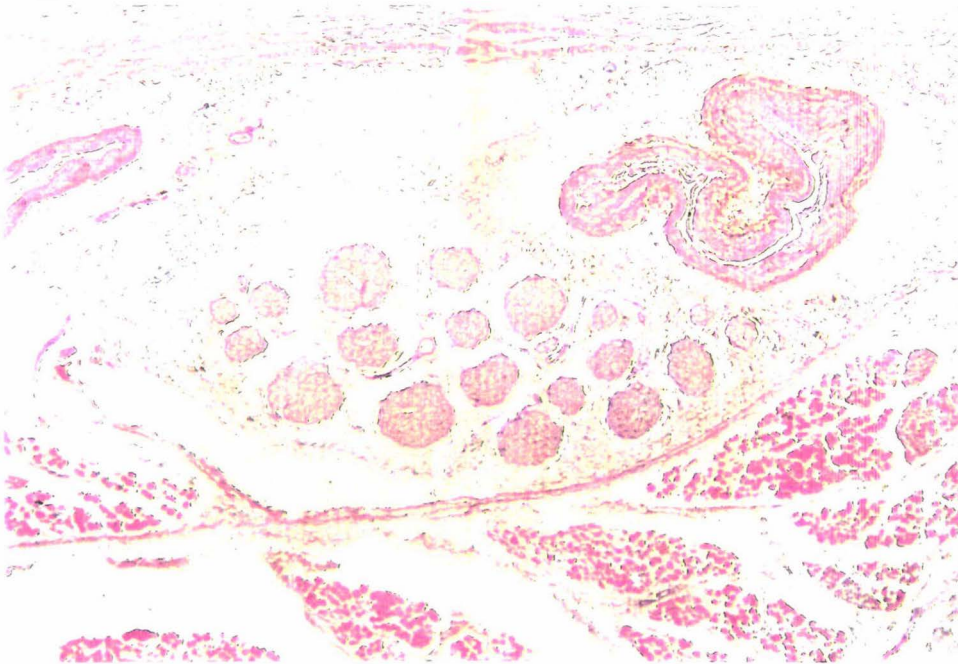


Fig 2.8: Magnification 100x of the nerves bundle sites.  
(5) Dorsal nerve bundle  
(6) Larger ventral nerve bundle

median caudal artery and vein, ventral to the vertebrae. The median caudal artery and vein near the base of the tail are protected by the hemal arches of the caudal vertebrae, however at the docking site only a slight indentation remains on the ventral surface of the bone. No nerve bundles were observed on the dorsal surface of the ninth or tenth caudal vertebrae. Small nerve bundles identified around the periphery of the section may have a role in supplying the fascia and the skin surrounding the tail.

The origins of the small nerve bundles running caudally with the median caudal artery and vein are unknown. It is possible that these nerve bundles were formed from branches of the caudal ventral nerve plexus.

## **2.34 Local Anaesthetic Study**

### **CONTROL**

All the control calves responded to needle prick stimulation of the tail in the following ways; trying to remove the tail from the noxious stimulation by pulling the tail between their hind legs, head turning, tail shaking and in some cases foot stamping.

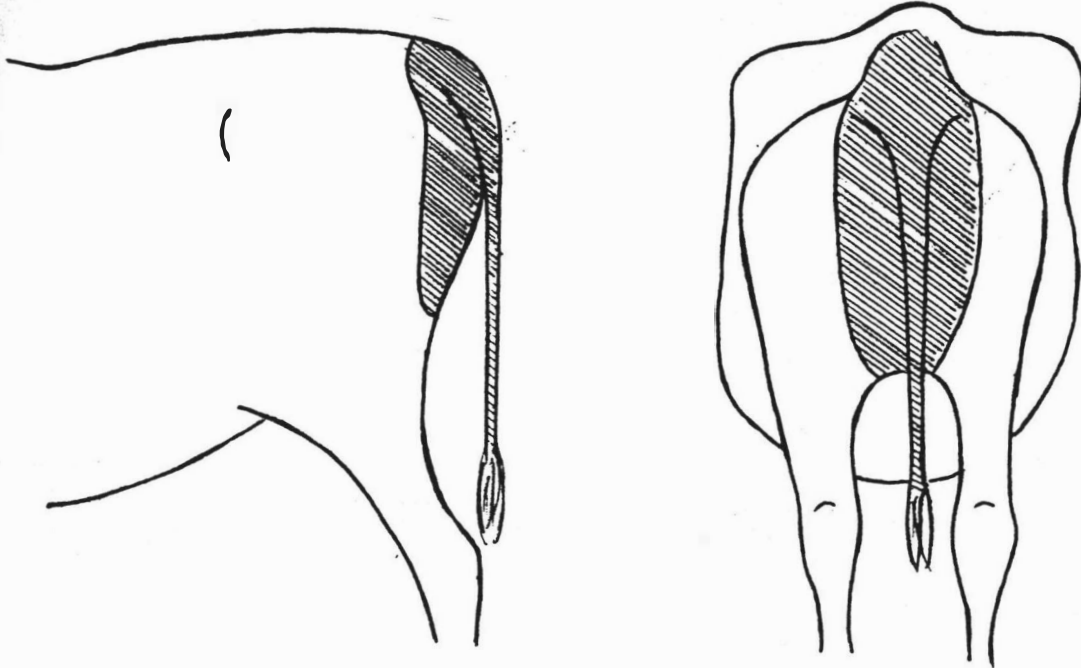
### **EPIDURAL**

Within two minutes after the administration of the epidural local anaesthetic the tail become flaccid, which indicated that the local anaesthetic had taken effect (Hall, 1971). There was no response of the entire tail to needle prick stimulation of the three sites in all of the epidural calves with one exception (Fig 2.9 and 2.10). This calf displayed a tail withdrawal response when the distal ventral surface of the tail was stimulated. After an additional 1ml of lignocaine was administered by epidural injection, that response was abolished.

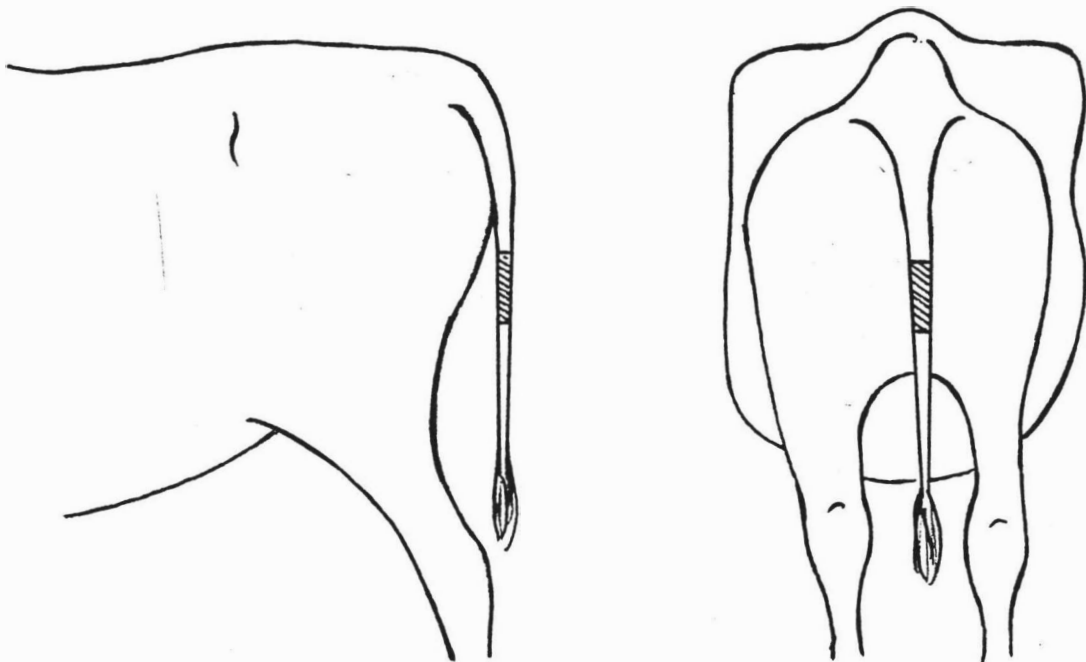
### **RING BLOCK**

Within two minutes after administration of the ring block local anaesthetic the tail became hard from about 3-4cm above to 3-4cm below the site of the ring block injection. That area was insensitive to needle-prick in all the calves (Fig

## EPIDURAL



## RING BLOCK



**Fig 2.9** The hatched lines represent the cutaneous areas affected by the epidural or ring block local anaesthetic.



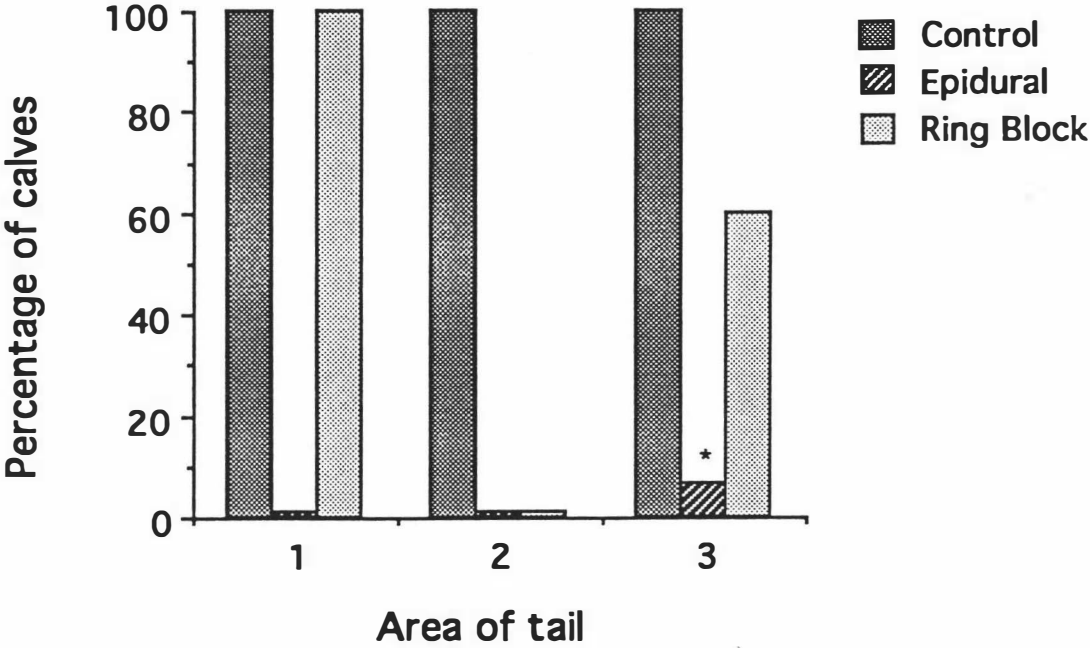


Fig 2.10: The percentage of calves that responded to needle prick stimulation at the three designated tail positions.  
\* - ventral tail only

2.9 and 2.10). In every case, test site one was responsive to the needle-prick. In contrast, the distal part of the tail (test site three) was responsive in eight of the 15 calves. The remaining seven calves were unresponsive to the needle-prick distal to the ring block site (Fig 2.10).

## 2.4 DISCUSSION

Observations made during this study have identified the docking site to be between Cd9 and Cd10 in 3-4 month old calves. The majority of the calf tails x-rayed after tail removal indicated that the docking site was on a vertebra rather than between two vertebrae. Wilson (1972) demonstrated that the swelling, produced above the site of application of a ring, was more marked in animals on which the ring was applied across the body of the vertebra than in those animals on which a ring was placed between two vertebrae.

Dissection revealed a significant neural input into the bovine tail. Dissection of the seven tails revealed that the animals had six pairs of caudal nerves in five of the seven animals, as reported by Nichel (1975) and Getty (1975), and seven pairs of caudal nerves in the remaining two as reported by Schaller (1956). Accordingly there appears to be natural variation in the number of caudal nerve pairs. Each of the paired caudal nerves emerge through the intervertebral foramina and passed behind the caudal arch of the same numbered vertebra as the nerve (Fig 2.2). The general disposition of the nerves was otherwise similar to previous reports.

Pasquini (1982) has shown that some cutaneous innervation of the proximal part of the bovine tail is supplied by sacral nerves four and five. This is in agreement with Nichel *et al.* (1975) who have observed branches of the caudal sacral nerves joining with the first few caudal spinal nerves to supply the base of the tail. In the sheep, innervation of the proximal portion of the tail has been demonstrated to arise from spinal nerve roots from S3, S4, Cd1 and Cd2 (Kirk, 1968; Lester, 1991). The dorsal and ventral nerve plexuses have been shown to innervate the dorsal, ventral and lateral musculature and skin

of the tail (Pasquini, 1982).

Histological examination confirmed the significant amount of neural input to the tail (Fig 2.4, 2.5). Histological sections through the vertebrae at the docking site showed no nervous tissue dorsal to the caudal vertebrae distal to Cd9. This indicates that innervation to the tail distal to this point is supplied by the branching of the dorsal and ventral nerve plexuses (Getty, 1975).

Application of a rubber ring will stimulate both the dorsal and ventral nerve plexuses of the tail in one or both of two ways. The physical stimulation/irritation caused by the rubber ring will continue causing nerve discharge until transmission of nerve impulses are blocked by pressure of the ring and/or neural stimulation from nerves distal to the rubber ring will cause nerve discharge until this discontinues due to progressing anoxia which will eventually render the nerves inactive. As the caudal spinal nerves have all emerged from the vertebral canal proximal to the normal site of tail docking, and in most calves the ring was positioned over a vertebra rather than between two vertebrae, the nerves would probably be rapidly compressed between the ring and the bone. However, some temporary protection of the nerves might be expected if the ring was placed on the transverse processes, as was the case in the 25 of the 29 of calf tails x-rayed, because the nerve bundles are adjacent to the bone.

In contrast, when tail docking is done with the docking iron all nerves and other tissues are severed by cautery at the docking site so there is no neural input from the distal part of the tail. However, neural stimulation at the site of cautery, both by the cautery itself and the subsequent chemical changes in the damaged tissue, would be expected (Gebhart and Ness, 1991; Handwerker and Reeh, 1991).

Total abolition of sensory input was achieved in 14 of the 15 calves by administering an epidural local anaesthetic. The one calf which did respond did so to the needle-prick distally on the ventral surface of the tail. That could

have been due to variation in the areas of the tail innervated by the spinal nerve plexuses, as was seen in the specimens dissected here. Administration of more local anaesthetic abolished the response, indicating either that not enough local anaesthetic entered the epidural space with the initial injection or that more local anaesthetic was needed to desensitise more cranial spinal nerves that might have been innervating the tail. Such variation in spinal nerves has been reported for the cat (Kuhn, 1953) but not the sheep (Lester 1991).

Ring block administration of the local anaesthetic did not adequately desensitise the tail distal to the site of ring block, presumably enabling sensory nerve transmissions to get passed the ring block. It would have been expected that the ring block technique would have been adequate enough to affect the superficial cutaneous nerves, sensory nerves not identified during the present histological examination may not have been accessible to the ring block and were not rendered insensitive. Assuming that the ring block did inactivate all superficial nerves of the tail, and in view of complete effectiveness of the epidural when adequate amounts were given, the persistent sensitivity of the tail distal to the ring block in eight of the 15 calves suggests that there is variability in deeper neural supply to the distal segments of the tail.

In view of these results the use of an epidural local anaesthetic was considered to be more effective than the ring block in desensitising the tail. That was the local anaesthetic method adopted for the study described in Chapter Three.

## CHAPTER THREE: TAIL DOCKING IN CALVES; EFFECTS ON CORTISOL RESPONSES OF TWO METHODS USED WITH OR WITHOUT LOCAL ANAESTHETIC.

### 3.1 INTRODUCTION

Tail docking of dairy cows is a farming practice carried out mainly in New Zealand and parts of Australia. An increasing awareness of the welfare aspects of our farming practices has motivated many scientists to assess not only production aspects of animal husbandry but also the health and well-being of the animals involved. This increasing awareness of animal welfare has raised many questions; 'Is there really a need to dock the tails of calves?' being one of them.

When tail docking of dairy cows was first introduced to New Zealand the major justification for this procedure was hygiene. That is still true today. The New Zealand climate and the dietary intake of its cattle, particularly in the spring, causes the faeces to become very fluid (Carsons, 1992). This can be a problem in the milking shed with respect to milk hygiene and for the cattle themselves who can become a target for flies (Carsons, 1992). The New Zealand Dairy Group of Companies cited in a submission dealing with the tail docking issue, claimed that the presence of dung flicked around by tails leads to higher coliform counts in milk. Their survey indicated that undocked herds have twice the levels of coliforms in milk than docked herds. Although it is argued that dung attracts flies (Carsons, 1992), which can irritate the cows (Thomas, 1957), the principle fly that worries cattle is the stable fly (*Stomoxys calcitrans*). Stable flies have been reported to be seen more often on docked cows than their undocked twins (Wilson, 1972; Phipps, personal communication). However, Todd (1964) has shown that stable flies prefer feeding on the surfaces of front legs, possibly because the skin is thinner and this would presumably occur whether the cow was docked or not.

Minimising the transmission of leptospirosis, a zoonotic disease spread by

urine of cattle (Fraser, 1991), was another suggested reason for the necessity to tail dock. However with the introduction of vaccines against this disease leptospiral shedding has been reduced and this argument has been largely negated.

Bacteria within the faeces and urine can be spread to the milker in the shed by the flicking of cows tails. This can lead to sores when bacteria come into contact with mucous membranes and recent cuts and abrasions of the skin. Even without the danger of infection, the slap of a wet, faeces-covered tail in the face is hardly pleasurable. Hemsworth *et al.* (1993) in recent studies have shown that the attitude and the behaviour of the stockpersons towards farm animals may affect their welfare. It is highly likely that the attitude and behaviour of the milker after being slapped in the face with a cow's tail will change for the worse and affect the cattle adversely.

The only method allowed for tail removal from dairy cattle by stock handlers is the rubber ring applied by an elastrator as stated in the Animals Protection Act 1960. However, a veterinarian may use alternative methods. The application of a rubber ring causes hypoxia followed by anoxia due to ischaemia in the tissues at the level of and distal to the ring. The part of the tail distal to the ring can be removed after seven days or the tail will eventually drop off just above the ring. In calves it is about 7 weeks from the time of application of the ring until the tail drops off (personal observation from the present study). Lester *et al.* (1991a) have shown in lambs that the docking iron, a heated scissor-like tool which severs the tail by cautery, causes no more distress as indicated by plasma cortisol and behaviour than does the rubber ring. The use of the docking iron was therefore evaluated in the present trial in the hope of identifying a less distressing alternative to the rubber ring.

Due to the tissue damage involved in tail docking there would presumably be some degree of pain-induced distress associated with this procedure. Two types of evidence can be used to help recognise when animals experience

pain, these being physiological and behavioural indices (Dawkins, 1980; Sanford *et al.*, 1986). This chapter deals with a physiological response to tail docking and the following chapter (Chapter 4) with behavioural responses.

Animals experiencing distress exhibit changes in neurochemical, endocrinological and metabolic processes (Moberg, 1985). Of these, the activity of the hypothalamic-pituitary-adrenal axis as represented by its hormonal components has often been used as an index of distress. The activity of the axis is indicated by changes in plasma concentrations of corticotropin releasing factor (CRF) which regulates the release of adrenocorticotrophic hormone (ACTH) from the anterior pituitary gland, which in its turn stimulates the secretion of cortisol by the adrenal cortex. A number of factors, including noxious ones, stimulate the activity of this axis. Studies of animal husbandry practices have identified a range of physiological changes such as the release of hormones, in particular cortisol, within the body when an animal is subjected to injury (Mellor and Murray, 1989a,b; Mellor *et al.*, 1991; Lester *et al.*, 1991a,b; Wood *et al.*, 1991; Molony *et al.*, 1993), extremes of temperature (Alvarez and Johnson, 1971), transport (Crookshank *et al.*, 1979; Kent and Ewbank, 1983, 1986a,b) and unfamiliar circumstances (Herd, 1989; Lester *et al.*, 1991a,b).

Provided that allowance is made for possible effects of physiological state and maturational changes on the dynamics of the responding system, physiological variables such as cortisol may be used validly to compare the response of members of the same breed and/or species to different treatments (Mellor and Murray, 1989b).

Studies of distress caused by tail docking have to date concentrated mainly on lambs. Early work by Filmer (1938) demonstrated that there were no significant changes in growth rates between lambs tailed with a knife or a docking iron. Attempts to develop bloodless emasculation techniques produced the rubber ring which initially was thought to be more distressing than the knife (Shutt *et al.*, 1988; Henderson, 1990). However, re-

interpretation by Mellor and Holmes (1988) of the work carried out by Shutt *et al.* (1988), suggested that their surgically tailed and castrated lambs had a greater distress response (using cortisol as an index) than did their ringed lambs. That suggestion was confirmed subsequently (Lester *et al.*, 1991a). Although it has been reported that tail docking of cows using rubber rings causes a small amount of distress which lasts for at least 6 but not more than 24 hours after ring application (Wilson, 1972), published details do not as yet allow a more precise evaluation of the immediate distress responses to this procedure.

The present study was therefore undertaken to help correct some of these deficiencies by comparing the cortisol responses, especially during the first eight hours after treatment, to tail docking using a rubber ring or a docking iron. The use of local epidural anaesthesia to alleviate any pain-induced distress caused by each method of tail docking was also evaluated.

### **3.2 MATERIALS AND METHODS**

Sixty three female Friesian calves three to four months old weighing between 62.5kg and 99kg (mean 79kg) were investigated for plasma cortisol changes during a tail docking study on a Massey University farm. All calves in this study were scheduled for tail docking according to the then usual farm practice. All calves provided for this trial were weaned at least two weeks before the first experimental day. The acute phase of the cortisol responses (i.e., the first 9 hours) to treatment were studied in the present calves over a three week period in May 1992.

The herd of calves was brought into a milking shed on the day before the experiment. Twenty to twenty four calves were separated from the herd and penned, the remainder being returned to the paddock. The penned calves were then sprayed with numbers for identification and those randomly allocated to be treated with local anaesthetic were clipped along the dorsal



aspect of the sacrum to the fifth caudal vertebra.

The calves were separated into four equal groups and penned overnight in four 3m x 4m pens with wooden slatted floors. Water but no food was available overnight. On the morning of the study the four groups of calves were reassembled and were placed as groups of equal size into two holding pens (3m x 4m).

Every calf was then blood sampled during the acute phase of the response and once daily for the next four days to test for evidence of chronic distress response to tail docking. At the end of each acute phase of the experiment the calves were returned to a paddock, separate from but near the rest of the herd. This allowed easy access for the continued blood sampling over the following four days. On those days calves were moved from their paddock and held in a shed for three hours to allow a period of habituation to their new environment before being blood sampled.

### **3.21 Treatments**

The 63 calves were randomly allocated into seven treatment groups (Table 3.1). Each treatment was conducted with the calf restrained against the wall of the holding pen by at least two people. Each treatment took no longer than one minute to perform. The blood sampling schedule was the same in all calves (see below).

#### **Control (*control*) n=9**

Calves were restrained and handled to simulate tail docking without any tissue removal occurring.

#### **Local anaesthetic control (*LA control*) n=9**

An epidural local anaesthetic (3ml lignocaine) was administered into the epidural space between the first and second coccygeal vertebrae 20 minutes before tail docking (Hall, 1971b). Strict asepsis was adhered to all times, the injection site being washed with hibitane (Pitman-Moore, New Zealand)

<b>TABLE 3.1:</b>			
Mean +/- SEM of the plasma cortisol concentrations, 45 minutes before treatment.			
<b>Treatment</b>	<b>n</b>	<b>Mean</b>	<b>S.E.M.</b>
		(ng/ml)	
Control	9	10.41	2.19
LA control	9	13.68	2.78
Ring	9	18.27	2.39
LA + ring	9	14.10	2.30
Iron	9	17.01	2.44
LA + iron	9	13.21	2.61
ACTH *	9	22.01	4.15
* Significantly different ( $P < 0.05$ ) from control calves			

<b>TABLE 3.2:</b>			
Separation of low and mild responders on the basis of integrated cortisol responses.			
<b>Treatment</b>	<b>n</b>	<b>Low responders</b>	<b>Mild responders</b>
Control	9	9	0
LA control	9	7	2
Ring	9	8	1
LA + ring	9	9	0
Iron	9	7	2
LA + iron	9	5	4
ACTH	9	0	9

before the local anaesthetic was administered. The effectiveness of the local anaesthetic was determined 10 minutes after administration by pricking the skin with a needle and assessing the presence or absence of tail withdrawal or any other behaviour indicative of pain/discomfort as described in Chapter Two. A limp tail and no response to the needle-prick was taken to indicate loss of sensation. These calves were then restrained in the same manner as the controls with no tissue removal occurring.

#### **Rubber ring (*ring*) n=9**

Calves were restrained as above and a tight rubber ring (Allflex New Zealand Ltd., Palmerston North) was applied to the tail at a point not less than 2.5 cm below the lower tip of the vulva. The tail was then left to drop off of its own accord rather than being removed seven days after application. The rubber rings commonly used (Allflex New Zealand Ltd., Palmerston North) are approximately 15 mm outside diameter and 5 mm inside diameter in their unstretched state. They were stretched over the tail with an elastrator (Fig 3.1A) before being released.

#### **Local anaesthetic plus rubber ring (*LA + ring*) n=9**

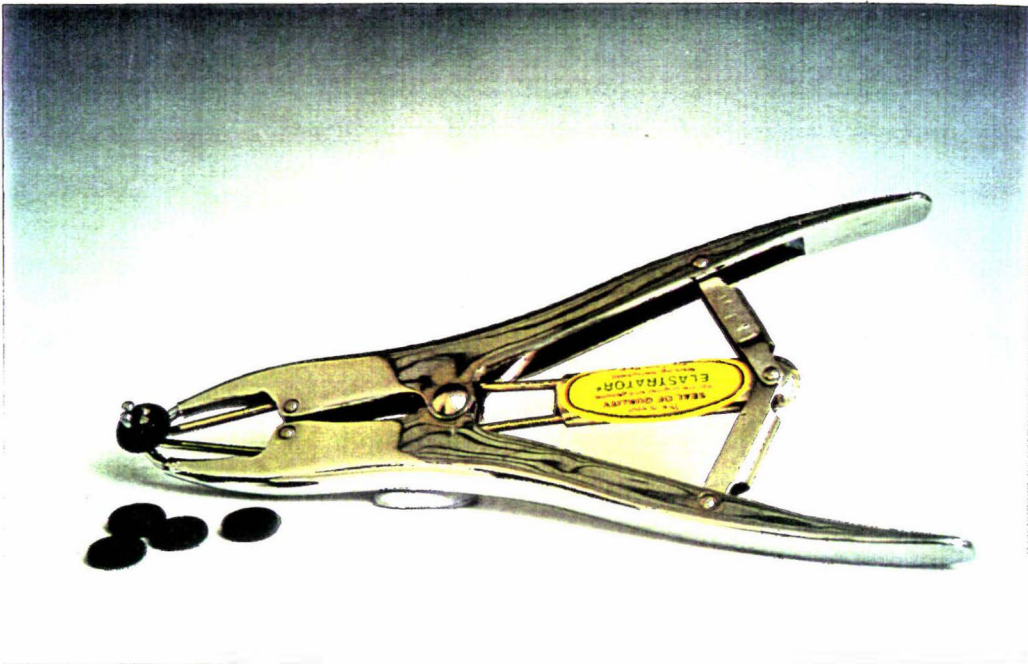
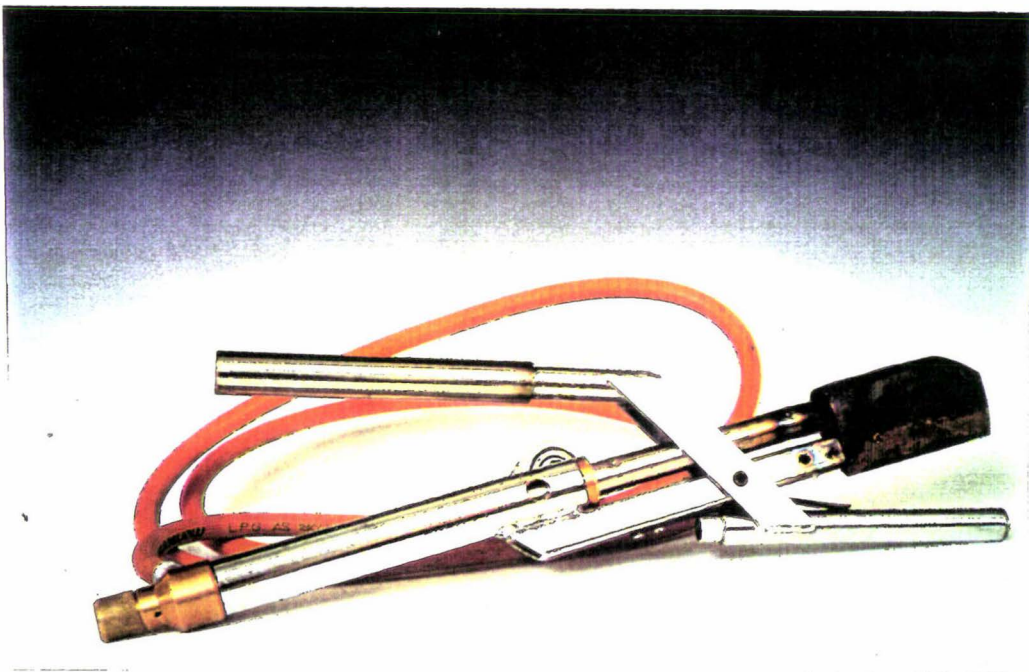
An epidural local anaesthetic (3ml lignocaine) was injected between the first and second coccygeal vertebrae 20 minutes before the application of the rubber ring as described above.

#### **Docking iron (*iron*) n=9**

Calves had their tails amputated with a hot anvil-scissor docking iron (Te Pari Products Ltd., Palmerston North, Fig 3.1B) at a point no less than 2.5 cm below the vulva. The docking iron cauterises the veins and arteries and all other tissues as it severs the tail, however cutting too quickly may result in bleeding (Te Pari Products Ltd, Palmerston North, Instruction sheet).

#### **Local anaesthetic plus docking iron (*LA + iron*) n=9**

An epidural local anaesthetic was injected 20 minutes before amputating the tail with the docking iron as described above.

**A****B**

**Fig 3.1:** Equipment used in this study to dock the tails of the calves.  
(A) Rubber rings and elastrator (Allflex, New Zealand Ltd.)  
(B) Gas heated docking iron (Te Pari Products, Palmerston North)

### **Adrenocorticotrophic hormone injection (ACTH) n=9**

ACTH (Synacthen; Ciba Pharmaceutical, Auckland) was injected into the jugular vein of calves at a dose rate (0.31mg) designed to elicit a substantial cortisol response (Alam *et al.* 1986; Verkerk 1993).

### **3.22 Blood sampling**

All calves were bled (5ml sample) by venipuncture from either jugular vein. Each animal was restrained against the wall of the holding pens by at least two people while a further person took the blood sample. One blood sample was taken from each calf 45 minutes prior to any manipulations (-45 minutes). A second blood sample was taken from all calves 10 minutes before treatment (-10 minutes) which was 10 minutes after the administration of the local anaesthetic in those calves that received it. Further blood samples were taken at 15, 30, 60, 90, 120, 150, 180, 240, 300, 360, 420 and 480 minutes after treatment. The whole procedure from restraint to completion of sampling usually took less than 30 seconds. Four further samples were taken at 24, 48, 72 and 96 hours after treatment.

Ten to 12 calves receiving all of the seven treatments were kept together in each of the two holding pens. The blood sampling times for each calf were related to the time of treatment as indicated above. Individual calves had to be identified prior to being restrained and bled within each holding pen. The order of bleeding of calves in each pen was the same on each occasion.

### **3.23 Plasma cortisol assay**

Blood samples were collected in lithium heparinised vacutainers, chilled immediately, centrifuged and the plasma stored at -20°C until required. Plasma cortisol concentrations were determined by radio-immunoassay, the lowest detectable concentration was 0.32ng/ml and the intra-assay and inter-assay coefficients of variation were 11% and 16.4% respectively.

The assay involved competitive binding of cortisol in the plasma sample to an antibody and radioactively labelled cortisol. After binding was complete the

ratio of the plasma cortisol to the radioactively labelled cortisol was used to determine the concentration of cortisol in the plasma sample.

The process used was as follows. Extraction of the cortisol from the plasma sample was performed by serial mixture with solvents (dichloromethane and ethanol). Once the cortisol had been extracted it was combined with tritiated cortisol (Amersham), cortisol antiserum (F3-314, 4301 Lost Hills Rd., Calabasas, CA 91301) and bovine gamma-globulin (Serva, Heidelberg) to allow competitive binding overnight at 4°C. Samples were assayed in duplicate. The bound cortisol was then separated from the free cortisol using polyethylene glycol 4000 (BHD Ltd., Poole) precipitation. The bound cortisol was then resuspended in water and mixed with scintillation fluid and the radioactivity was measured using a Beckman LS 8000 scintillation counter. The radioactivity within each tube was inversely proportional to the concentration of the cortisol in plasma and hence the concentration could be determined by comparison with a series of standard cortisol solutions (Lester *et al.*, 1991a).

### **3.24 Integrated cortisol response**

In order to give a single measure of both the magnitude and the duration of any increase in plasma cortisol concentrations after a treatment, the integrated cortisol responses were calculated. The integrated cortisol response is defined as the area between a horizontal line drawn through the pretreatment concentration (at -45 minutes) and the cortisol response curve during the period when the concentrations were greater than that pretreatment value (Mellor and Murray, 1989b).

### **3.25 Presentation of results and Statistical analyses**

Where applicable the cortisol results were expressed as the mean  $\pm$  standard error of the mean (SEM). To correct for individual variation of the pretreatment (-45 minute) cortisol concentration, this value was subtracted from the entire cortisol response curve. Hereafter all cortisol response curves have been expressed as the change from the -45 minute plasma cortisol

concentration. Significant differences between the means were determined by two-way analysis of variance with the Fisher probability of least significant differences (PLSD) coefficient to compare each treatment value at each time point (StatView +Graphics, version 1.03, Abacus Concepts Inc.). Two-way analysis of variance with the Fischer PLSD coefficient was also used to determine a significant change with time after each treatment and to detect differences between integrated cortisol responses.

### 3.3 RESULTS

The plasma cortisol responses of the *control* calves studied on each of the three experimental days were compared to check for differences between the three days. No differences were found so the results from all treatments were pooled. Furthermore, no significant differences were found between the plasma cortisol concentrations of the *control* calves and any other treatment with the exception of the *ACTH* calves, for the -45 minute blood sample (Fig 3.2, Table 3.1).

Bleeding order had no significant effect on plasma cortisol concentration. The relationship of bleeding order and cortisol concentration for the -45 minute sample is illustrated in Fig 3.3. Similar analyses of the effects of bleeding order on the cortisol concentration in later blood samples also resulted in nonsignificant outcomes.

Most of the mean cortisol responses of calves in the different treatments indicated that relatively benign stimuli had been applied because mean transient increases in cortisol concentration of no more than 18ng/ml were observed (Fig 3.4), except in the *ACTH* group which exhibited a protracted increase in concentration of about 25 ng/ml (Figs 3.12). However, there was a degree of variation within the groups such that the individual plasma cortisol versus time graphs revealed two populations of responses. One population had fairly uniform responses similar to the controls (low responders) and the other population, usually a minority of calves, showed

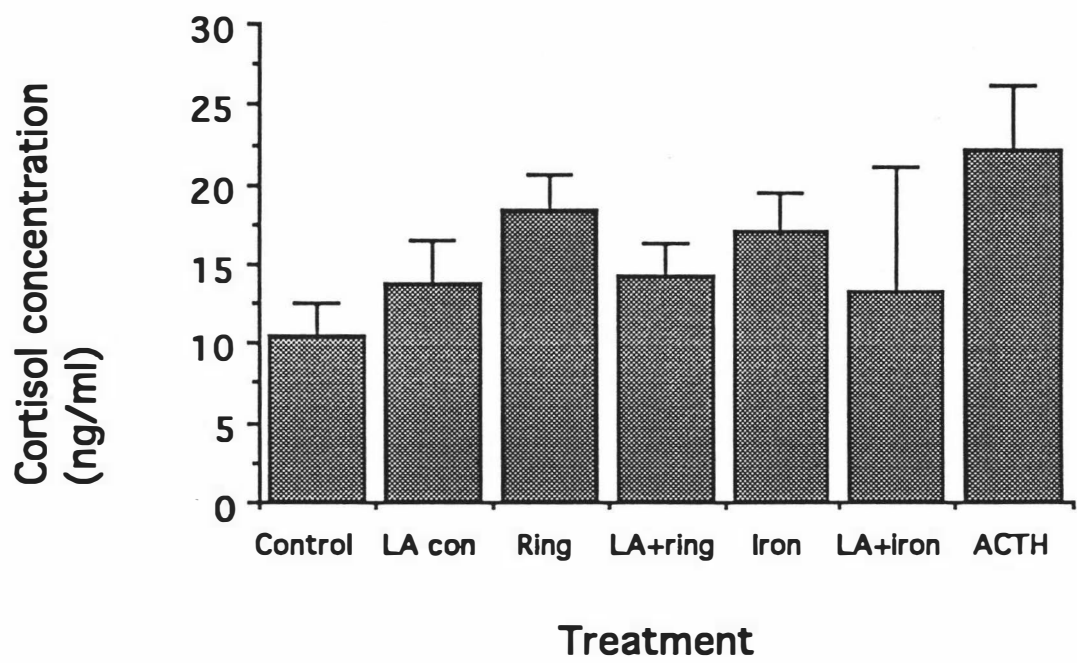


Fig 3.2: Pretreatment cortisol concentration of calves in the seven treatment groups (mean ± SEM). n=9.



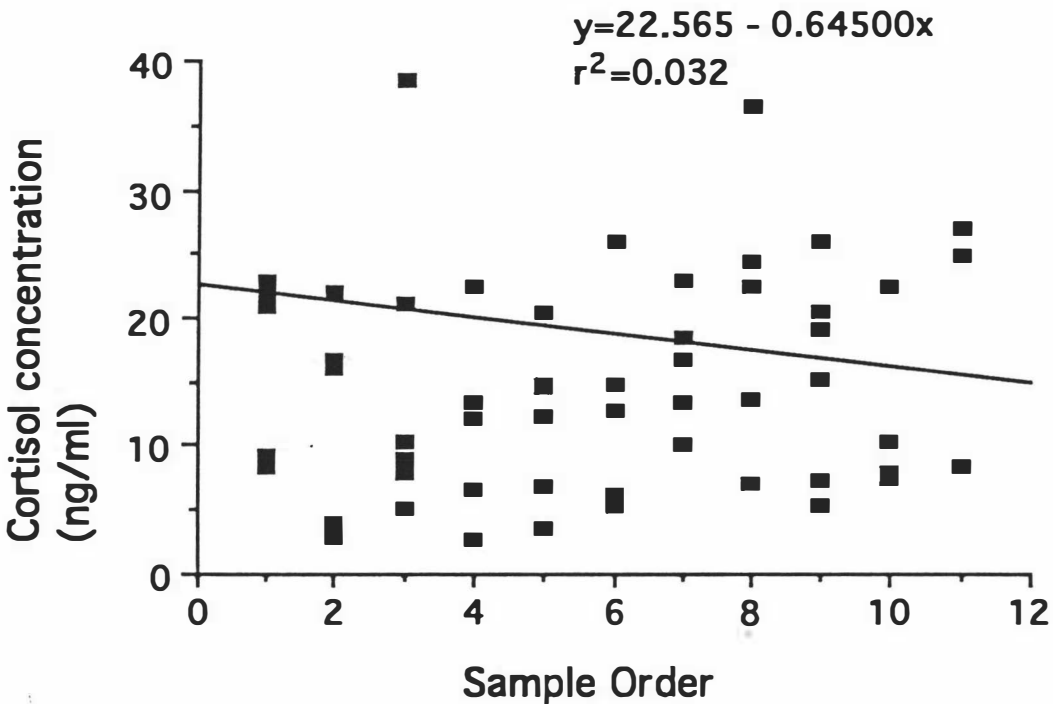


Fig 3.3: Relationship between plasma cortisol concentration and the sample order for the -45 minute blood sample.

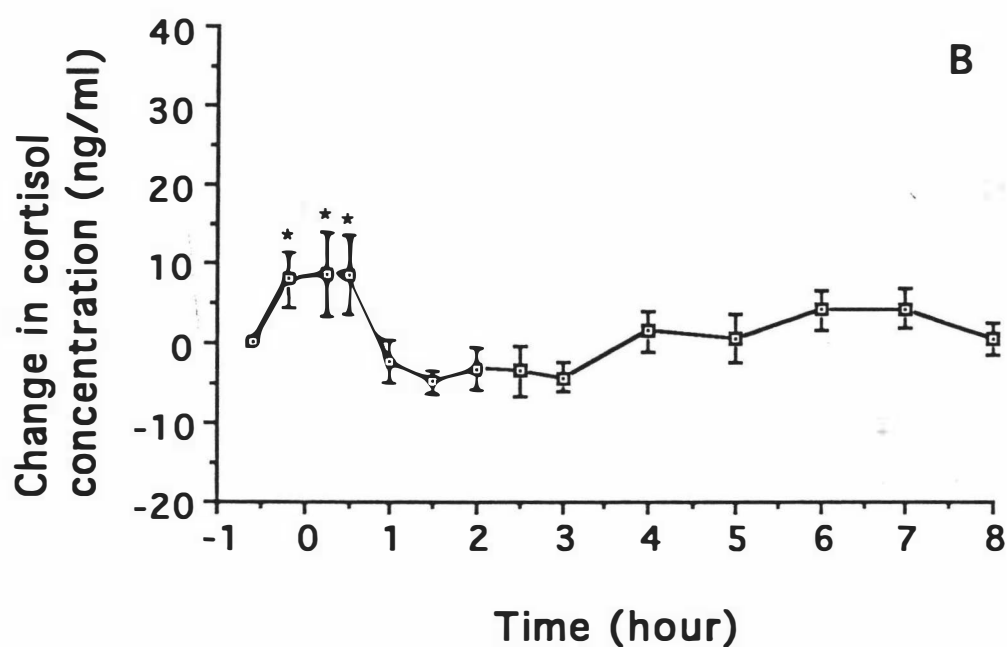
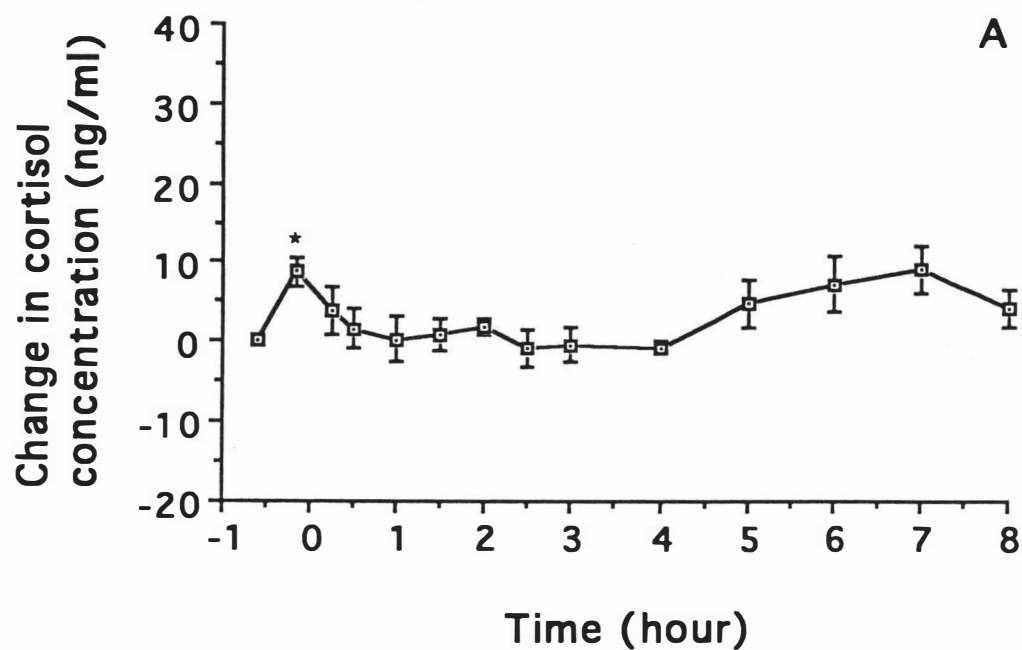


Fig 3.4: Change in plasma cortisol concentration of calves in response to control handling (A) and local anaesthetic administration (B), (mean  $\pm$  SEM).  $n=9$ . Time 0 represents time at tail docking .

\* significantly different from 0 ng/ml ( $P<0.05$ ).

either a low protracted cortisol response or an initial high but short-lived response (mild responders). Separation of low from mild responders was achieved using the integrated cortisol responses. Low responders were those individuals that had integrated responses equal to or below the maximum integrated response seen in individual *control* calves. Consequently, mild responders were those which exhibited responses above that maximum. The cortisol data for each group have therefore been presented as mean concentrations for the whole group and, where appropriate, the means for low responders together with individual results for the mild responders (Table 3.2).

### ***Control***

Restraint and simulated tail docking were preceded by a significant but small transient rise in plasma cortisol concentration that returned to starting levels within 15 minutes of treatment (Fig 3.4A). Thereafter, no significant change in plasma cortisol concentration occurred. The individual calves exhibited a similar pattern of change in cortisol concentration to that of the mean *control* values; thus, all *control* calves were low responders.

### ***LA control***

Restraint and the administration of an epidural local anaesthetic resulted in a significant transient rise in cortisol concentration of 8.7ng/ml; concentrations returned to pretreatment levels by one hour after the simulated tail docking (Fig 3.4B). However, two *LA control* calves showed a marked increase in plasma cortisol concentration (Fig 3.5B). The cortisol concentrations in these calves reached a peak of 35ng/ml returning to pretreatment values 1.5 hours after treatment. The remaining seven calves showed no significant change in plasma cortisol concentration over the entire observation period (Fig 3.5A).

The needle-prick test on the tail throughout the cortisol study allowed some indication of when the effect of the local anaesthetic was wearing off. In the *LA control* calves, sensation returned to the entire tail within two to two and a half hours. However in the *LA + ring* calves sensation never returned to the

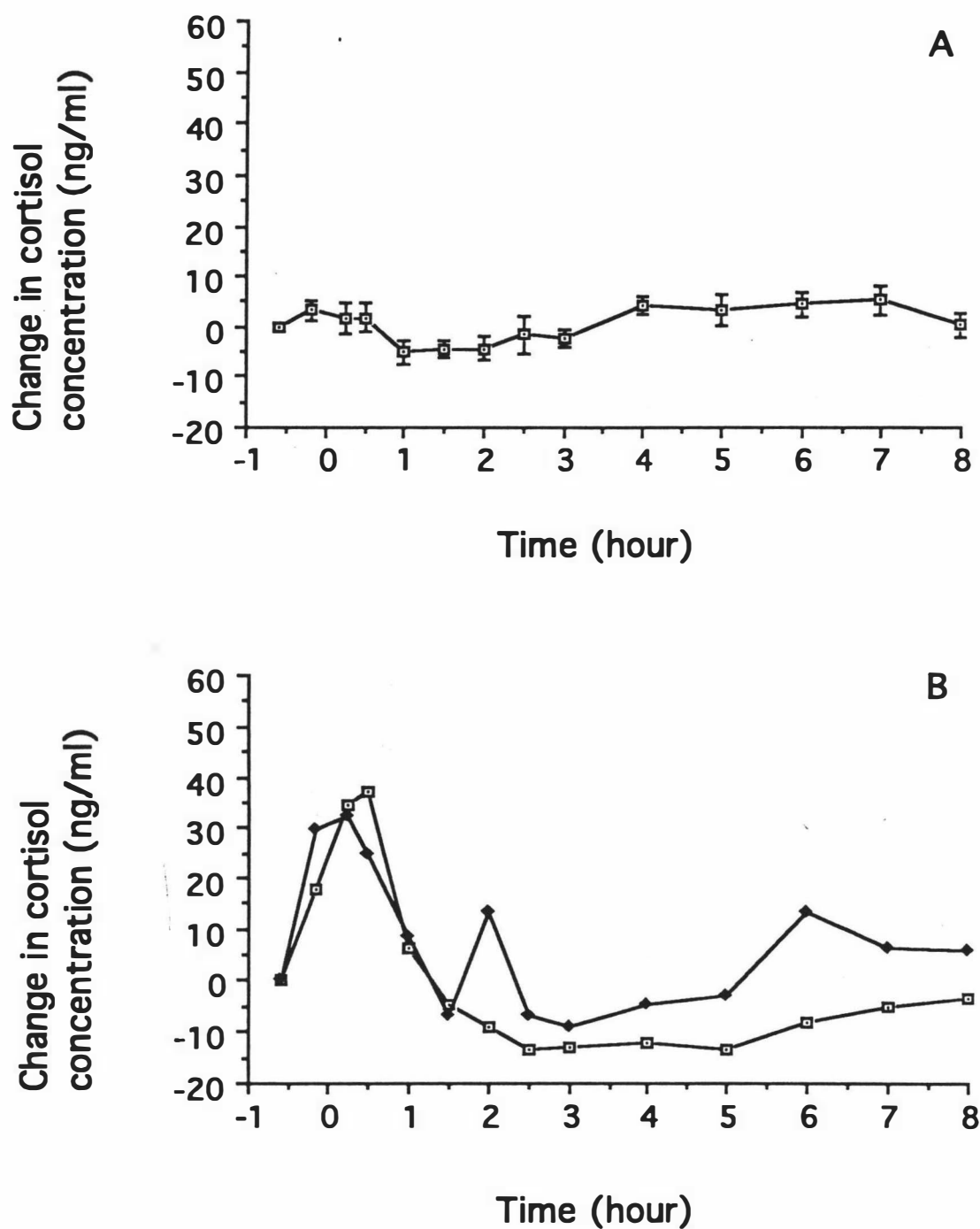


Fig 3.5: Change in plasma cortisol concentration of calves in response to local anaesthetic administration. A - Low responders (n=7) and B - Mild responders (n=2).

area distal to the docking site but it did return to the area proximal to the docking site within two to two and a half hours.

A comparison of the cortisol responses of all calves which did (n=27) and did not (n=36) receive epidural local anaesthetic 20 minutes before treatment is illustrated in Fig 3.6. The mean concentrations of cortisol in the two categories were similar at -45 minutes and -10 minutes, as were the mean increments in concentration between these times. Administration of an epidural local anaesthetic therefore did not apparently affect the cortisol responses of calves in addition to pretreatment handling.

### ***Rubber ring***

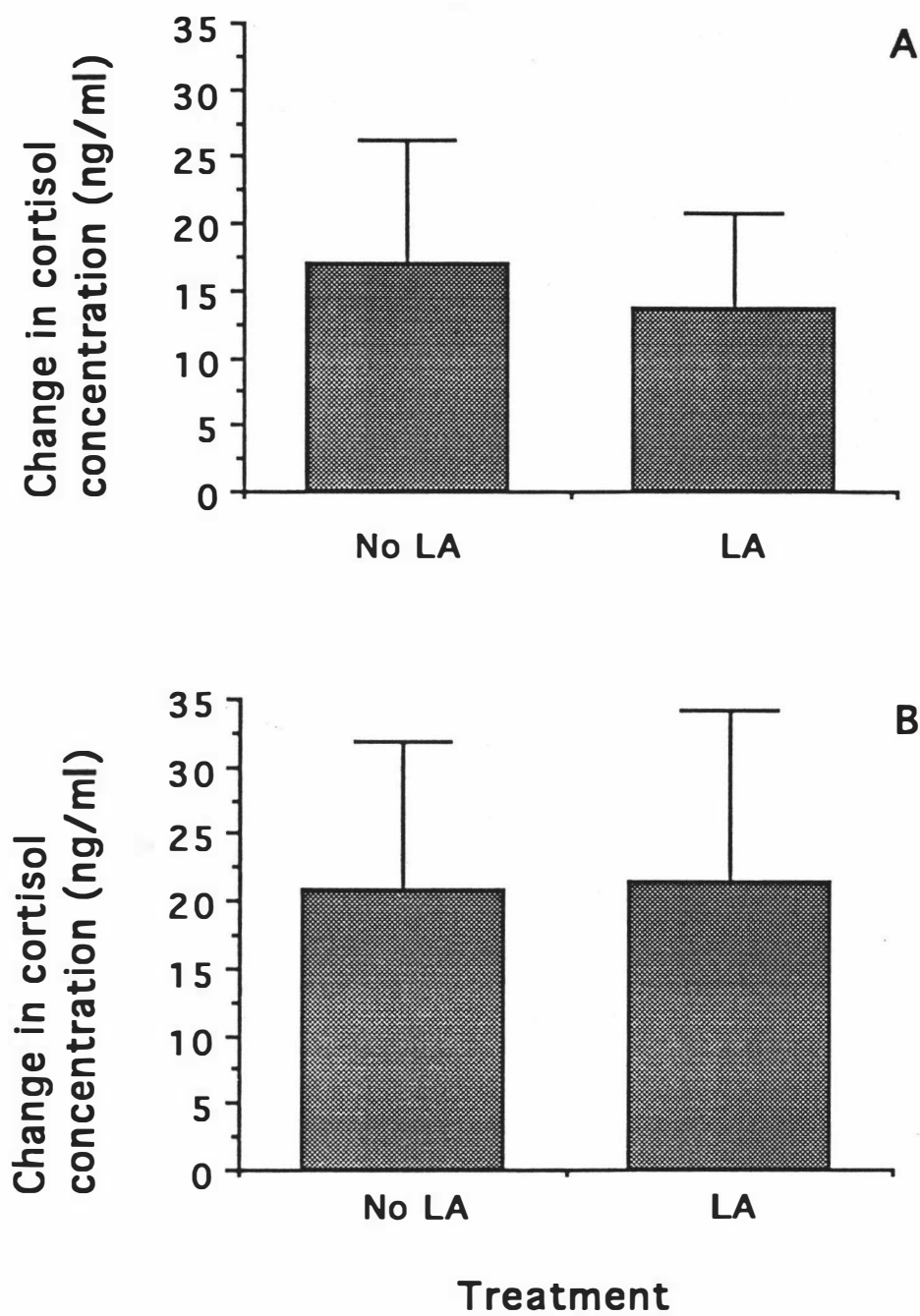
Tail docking with the rubber ring resulted in no significant change in plasma cortisol concentration (Fig 3.7A) throughout the entire sampling period. The individual results from eight calves indicated that use of a rubber ring was a relatively benign procedure, but one calf produced a larger rather variable response over the eight hour sampling period (Fig 3.8A and B).

### ***LA + rubber ring***

Administration of an epidural local anaesthetic followed by docking with the rubber ring caused a small drop in plasma cortisol concentration which returned to pretreatment levels within one hour (Fig 3.7B) after treatment. Thereafter the cortisol concentration remained at pretreatment levels for the entire sampling period. There were no mild responders in this group.

### ***Iron***

Tail docking with the iron resulted in a small transient rise in plasma cortisol concentrations that remained significant for 40 minutes before the concentration returned to pretreatment levels (Fig 3.9A). Two of the individuals were mild responders (Fig 3.10B). One exhibited a marked transient rise in concentration that returned to pretreatment levels by one hour after tail docking, the other showed a small elevation in concentration for the entire sampling period. The remaining seven calves were low responders



**Fig 3.6:** Change in cortisol concentration of calves with or without the administration of local anaesthetic. (A) 45 minutes before treatment (B) 10 minutes before treatment and in LA calves 10 minutes after local anaesthetic administration.

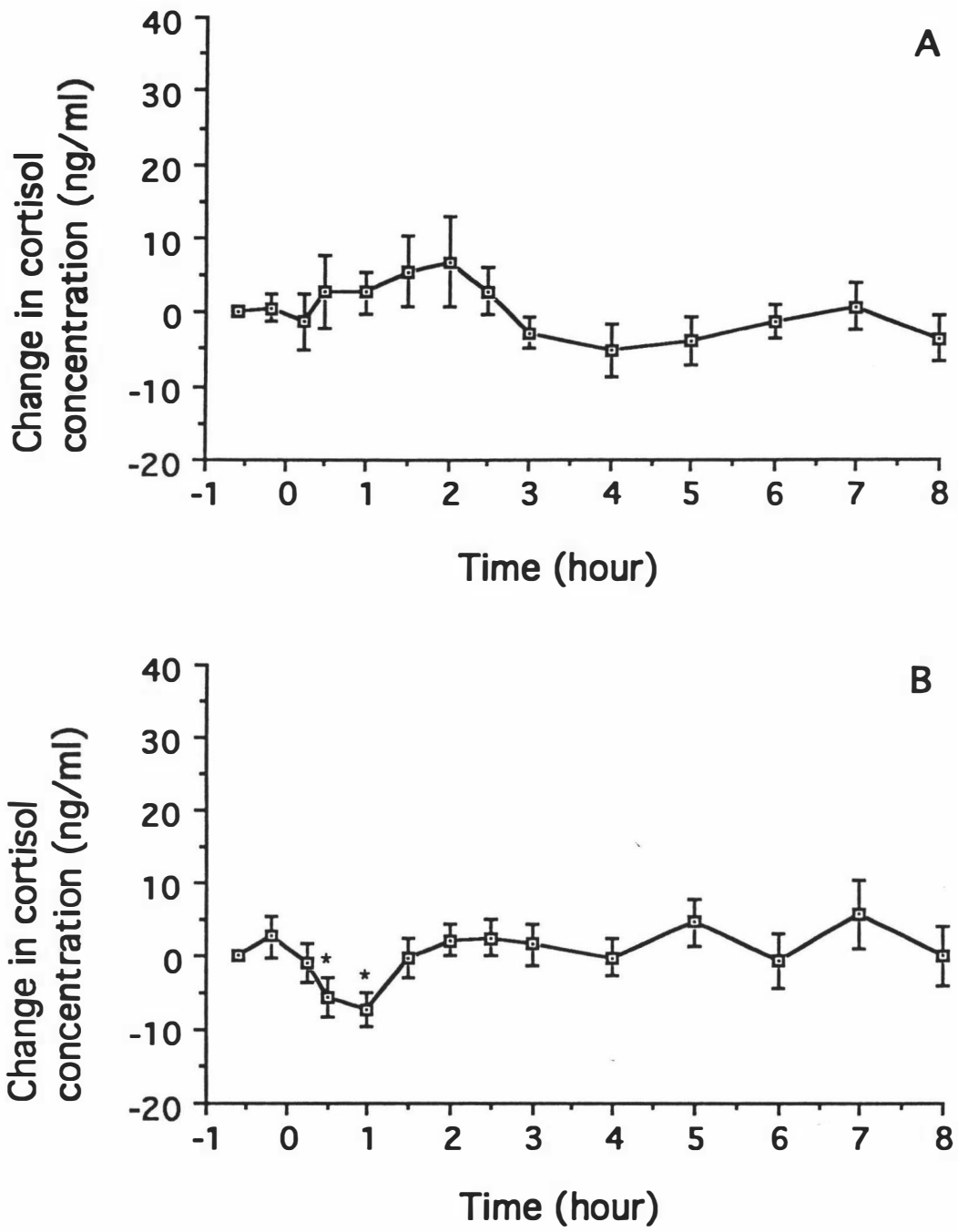
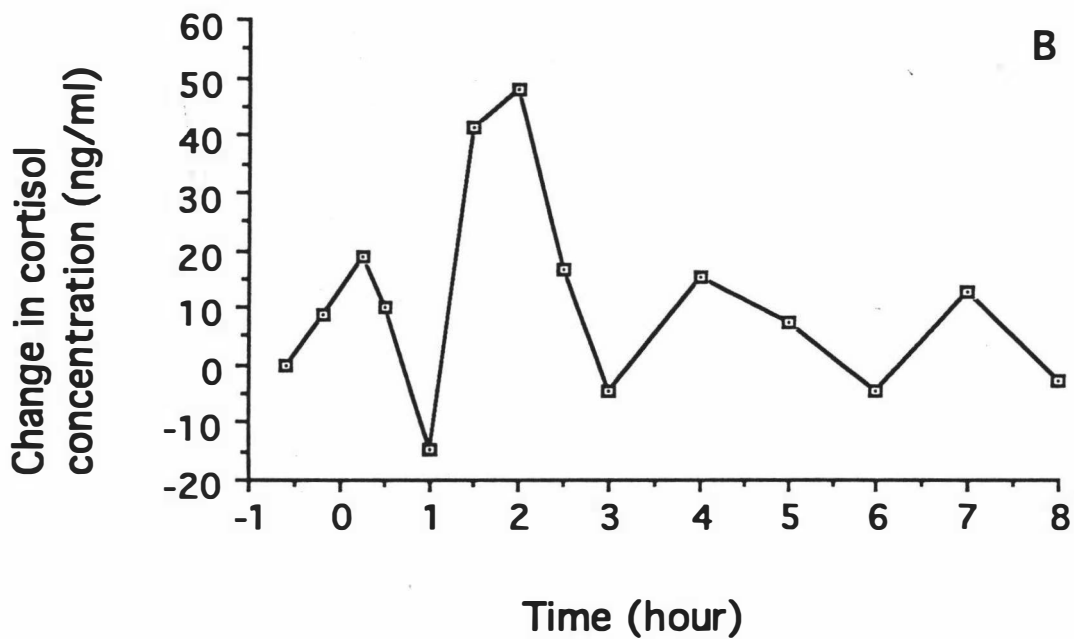
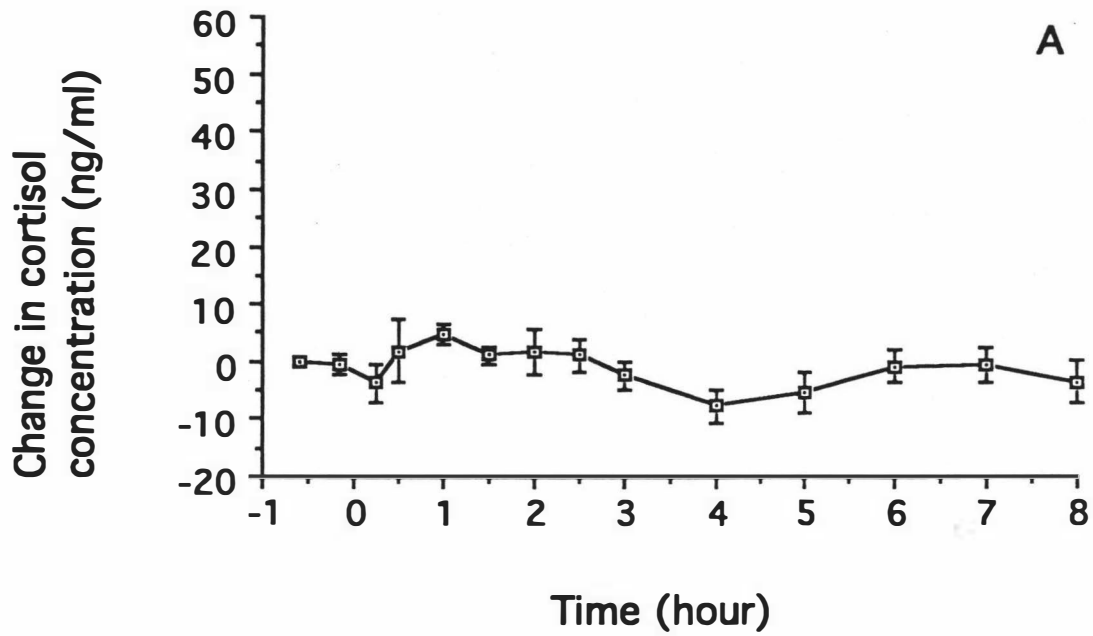
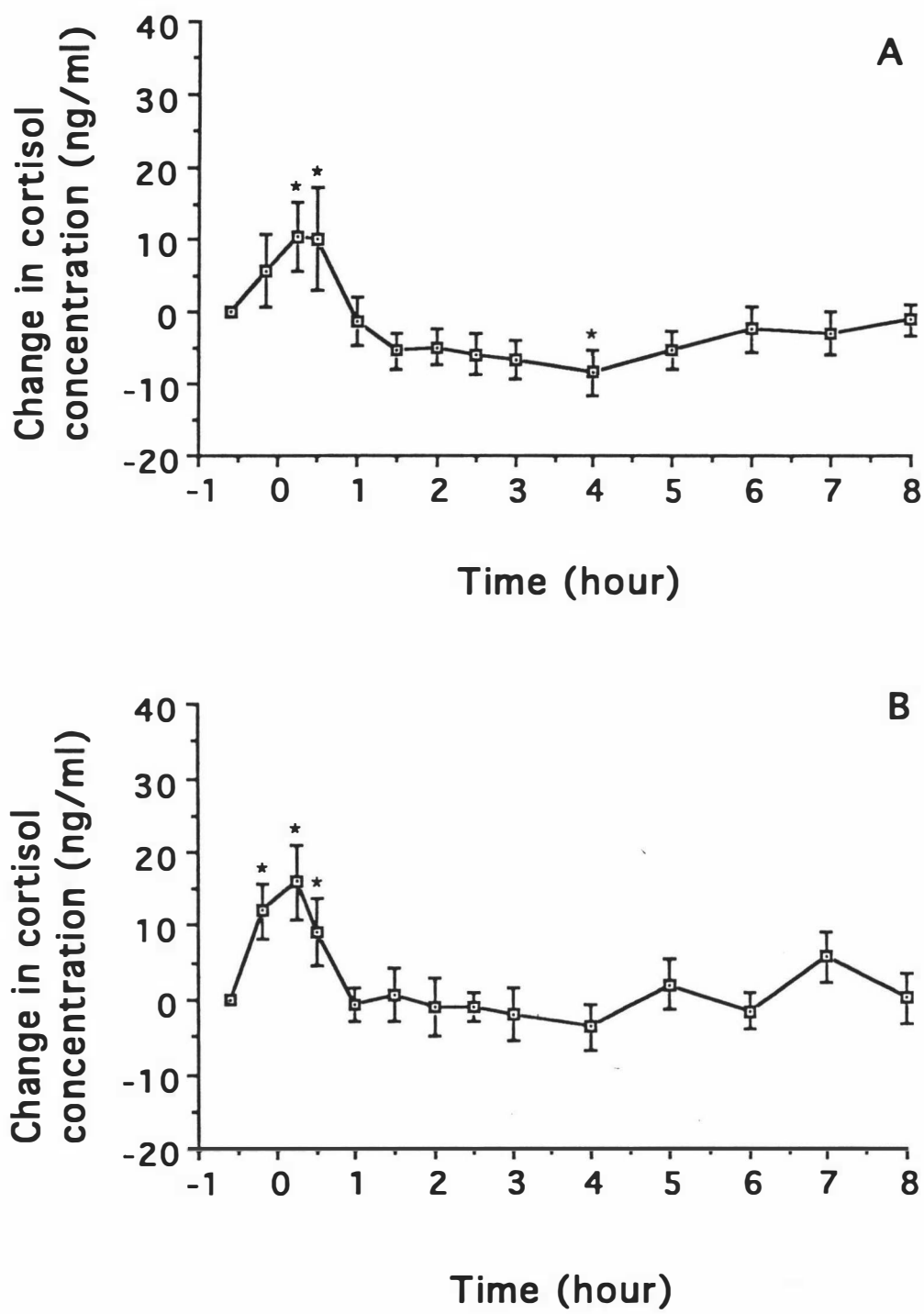


Fig 3.7: Change in plasma cortisol concentration of calves in response to tail docking with the rubber ring (A) without and (B) with local anaesthetic (mean  $\pm$  SEM). n=9. Time 0 represents time at tail docking.  
 \* significantly different from 0 ng/ml  $P(<0.05)$ .



**Fig 3.8:** Change in plasma cortisol concentration of calves in response to the rubber ring. A - Low responders (n=8) and B - Mild responder (n=1).





**Fig 3.9:** Change in plasma cortisol concentration of calves in response to tail docking with (B) and without (A) a local anaesthetic using the docking iron (mean $\pm$  SEM). n=9. Time 0 represents time at tail docking.  
\* significantly different from 0 ng/ml ( $P<0.05$ )

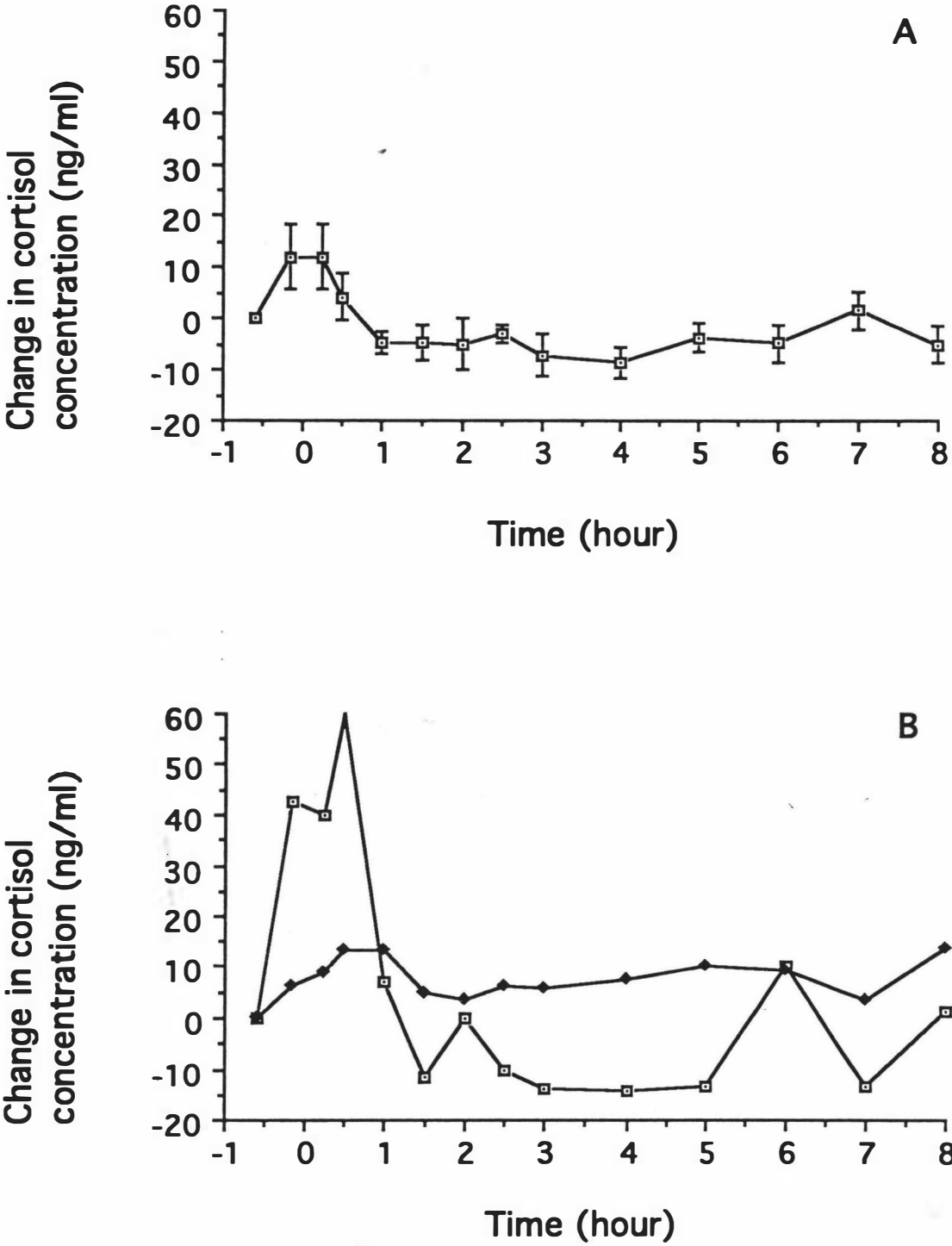


Fig 3.10: Change in plasma cortisol concentration of calves in response to tail docking using the iron. A - Low responders (n=7) and B - Mild responders (n=2)

(Fig 3.10A).

### ***LA + iron***

Administration of epidural local anaesthetic prior to tail docking and iron tail docking resulted in a significant increase in plasma cortisol concentration of 15.9ng/ml in the group as a whole (Fig 3.9B). The mean cortisol concentration returned to pretreatment levels by one hour after treatment and remained there for the remaining seven hours of the sampling period. The individual calves were divided into low responders (n=5) and mild responders (n=4) (Fig 3.11B). Of the four mild responders, two exhibited marked increases in plasma cortisol concentration (of about 30ng/ml) which returned to pretreatment values within one hour of tail docking, and the other two exhibited low protracted responses that remained elevated for the entire sampling period from one hour after tail docking. The responses of the remaining five calves (Fig 3.11A) did not show any significant changes with time over the entire sampling period.

### ***ACTH***

Administration of ACTH resulted in a marked rise in plasma cortisol concentration of about 28ng/ml; the concentrations remained significantly elevated for three hours (Fig 3.12). By five hours after treatment the plasma cortisol concentrations had decreased significantly below pretreatment values where they remained for two hours before rising again.

## **3.31 Comparison of treatments**

### ***Control, LA control and ACTH***

No significant differences were detected between the mean cortisol concentrations of *control* and *LA control* calves over the entire sampling period (Fig 3.13), but both *control* and *LA control* calves had significantly lower cortisol concentrations than *ACTH* calves until at least two and a half hours after treatment (Fig 3.13). By five hours after treatment the *control* and *LA control* calves had significantly higher concentrations than did the *ACTH* calves.

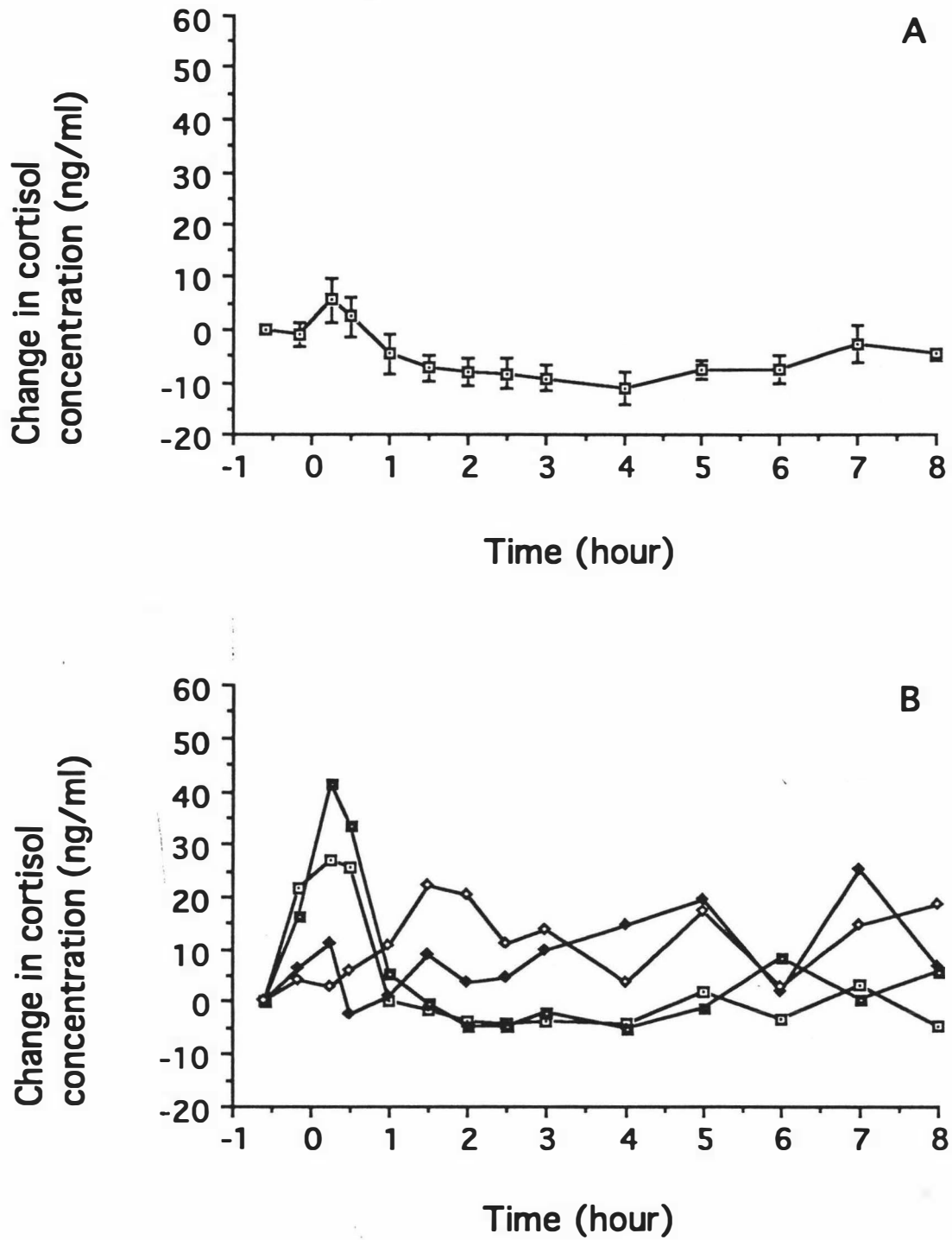


Fig 3.11: Change in plasma cortisol concentration of calves in responses a local anaesthetic and the docking iron.  
A - Low responders (n=5) and B - mild responders (n=4).

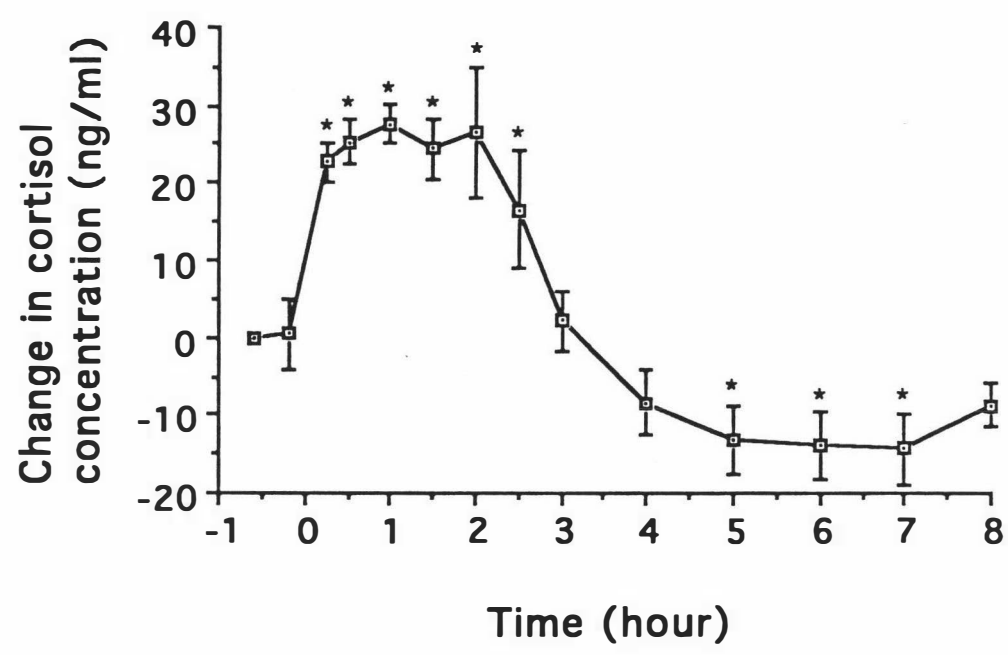
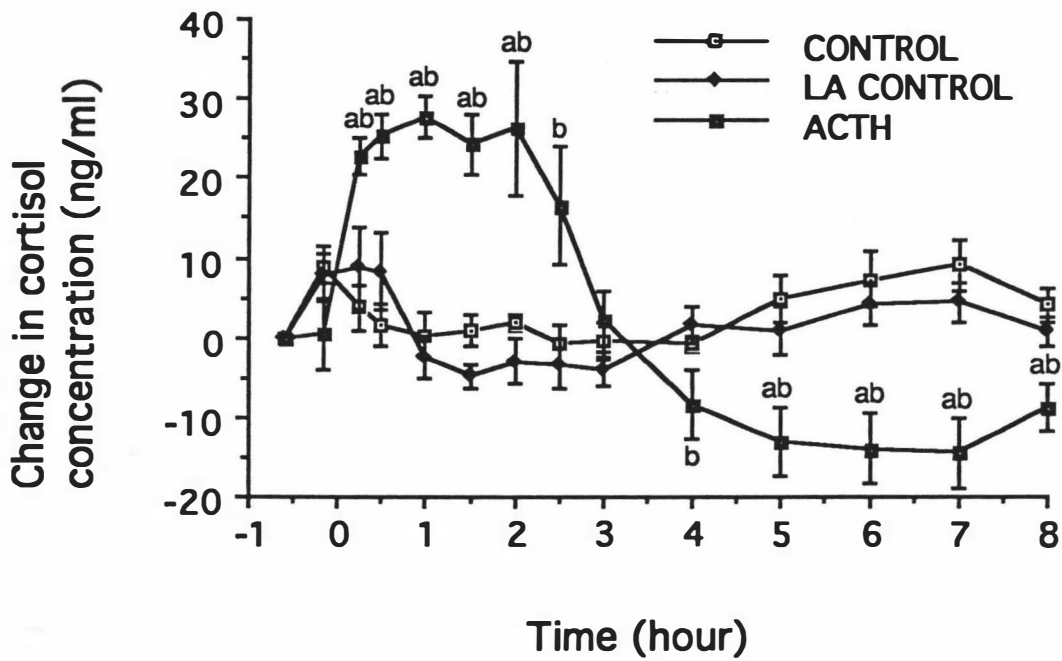


Fig 3.12: Change in plasma cortisol concentration of calves in response to an ACTH challenge (mean  $\pm$  SEM). n=9. Time 0 represent time at tail docking.  
\* significantly different from 0 ng/ml (P<0.05).



**Fig 3.13:** Change in plasma cortisol concentration in calves in response to control handling, local anaesthetic administration and ACTH challenge (Mean  $\pm$  SEM).  $n=9$ . Time 0 represents time of tail docking. Means with different superscripts differ significantly ( $P<0.05$ )

a - control  
b - LA control  
c - ACTH

### ***Control, LA control, ring and LA + ring***

No significant differences were detected ( $P < 0.05$ ) between mean cortisol concentrations in *control* and *ring* calves over the entire sampling period (Fig 3.14). *LA control* calves had significantly higher cortisol concentrations than did *LA + ring* calves at 30 minutes after treatment but the concentrations were similar at all other times during the eight hour study (Fig 3.15).

### ***Control, LA control, iron and LA + iron***

No significant difference were detected between the *control* and *iron* calves or between the *LA control* and *LA + iron* calves during the whole observation period except at seven hours when the cortisol concentrations in the *control* calves were greater than those in *iron* calves (Figs 3.16; 3.17).

### ***Ring and LA + ring***

The plasma cortisol concentrations in the *ring* calves were significantly greater than in the *LA + ring* calves at one hour after treatment. No significant differences were detected between the cortisol concentrations in these two groups at any other sampling times (Fig 3.18).

### ***Iron and LA + iron***

No significant differences in the plasma cortisol concentration were detected between the *iron* and *LA + iron* calves over the entire sampling period (Fig 3.19).

### ***Ring and Iron***

The plasma cortisol concentrations in the *iron* calves were significantly greater than in the *ring* calves at 15 minutes after treatment. At 1.5 hours after treatment the cortisol concentrations in the *ring* calves had become significantly higher than those in the *iron* calves (Fig 3.20). Otherwise, no significant differences were detected.

## **3.32 Chronic responses**

The blood samples which were taken from the calves at 24, 48, 72 and 96

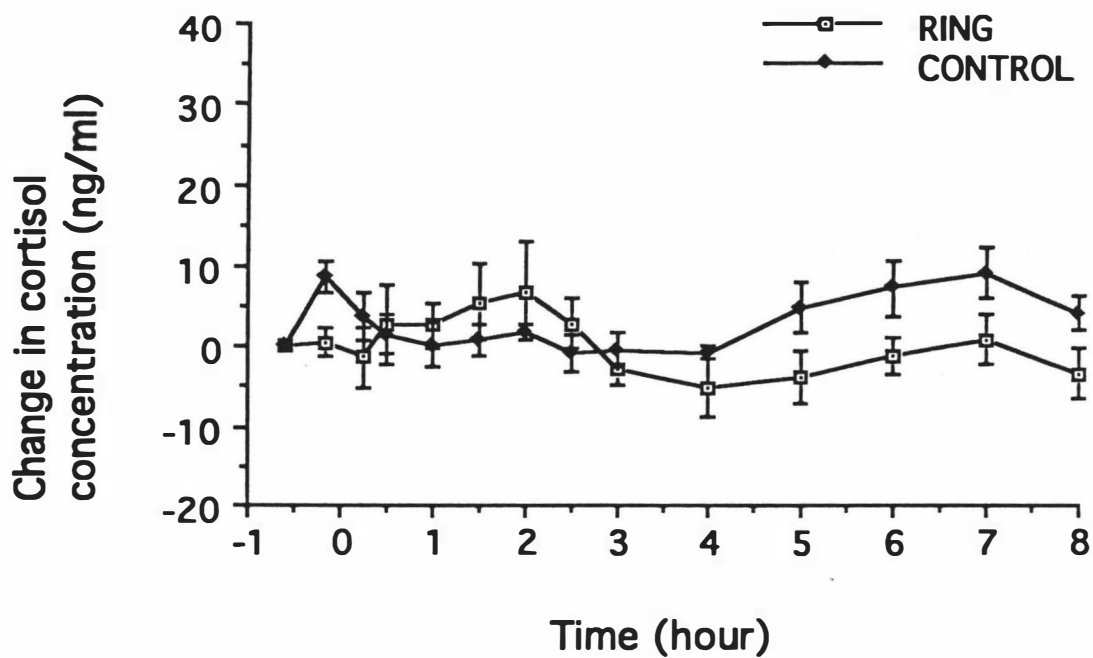


Fig 3.14: Change in plasma cortisol concentration in calves in response to control handling and application of the rubber ring (mean  $\pm$  SEM).  $n=9$ . Time 0 represents time of tail docking.

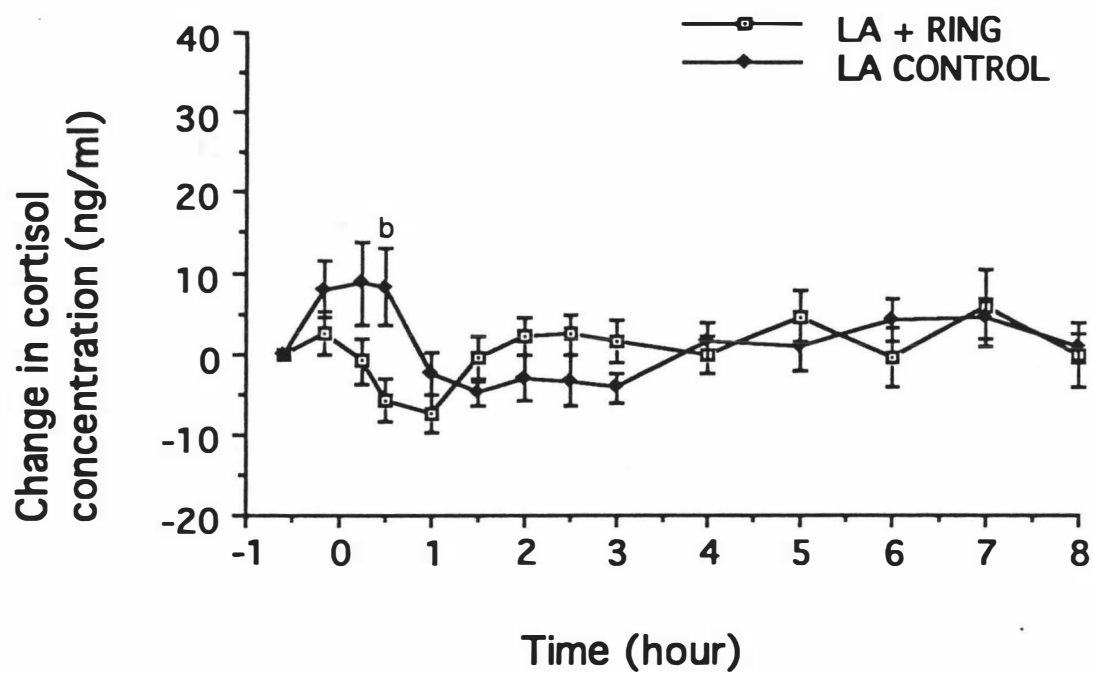


Fig 3.15: Change in plasma cortisol concentration in calves in response to local anaesthetic administration and LA + ring (mean  $\pm$  SEM).  $n=9$ . Time 0 represents time of tail docking. The mean with superscript differs significantly ( $P<0.05$ ).  $b=LA+ring$



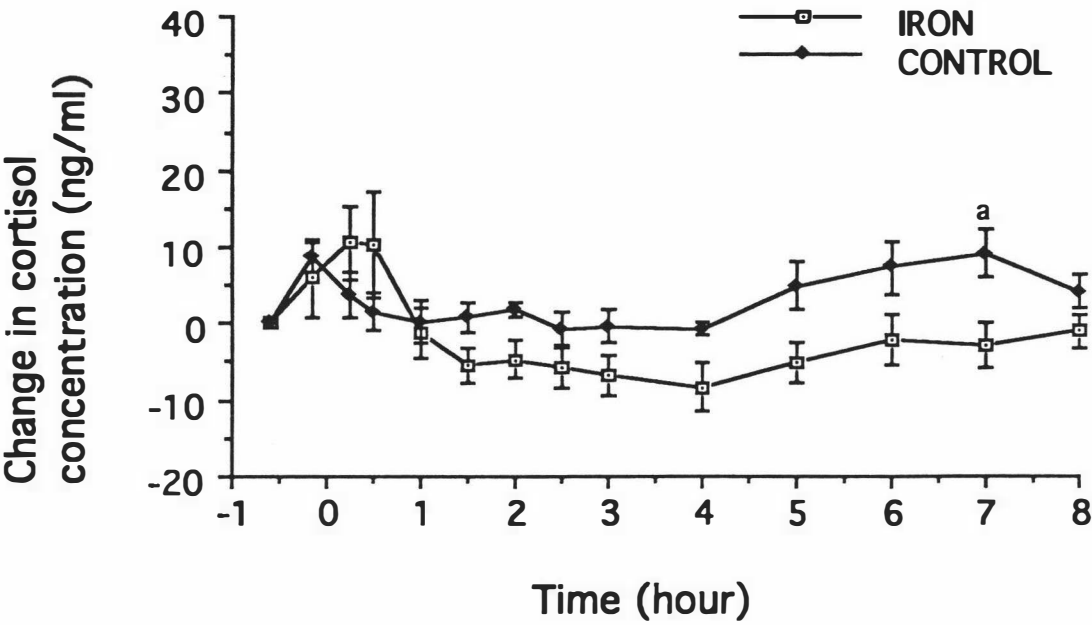


Fig 3.16: Change in plasma cortisol concentration in calves in response to control handling and the docking iron (mean  $\pm$  SEM). n=9. Time 0 represents time of tail docking. The mean with a superscript differs significantly ( $P < 0.05$ ). a - control

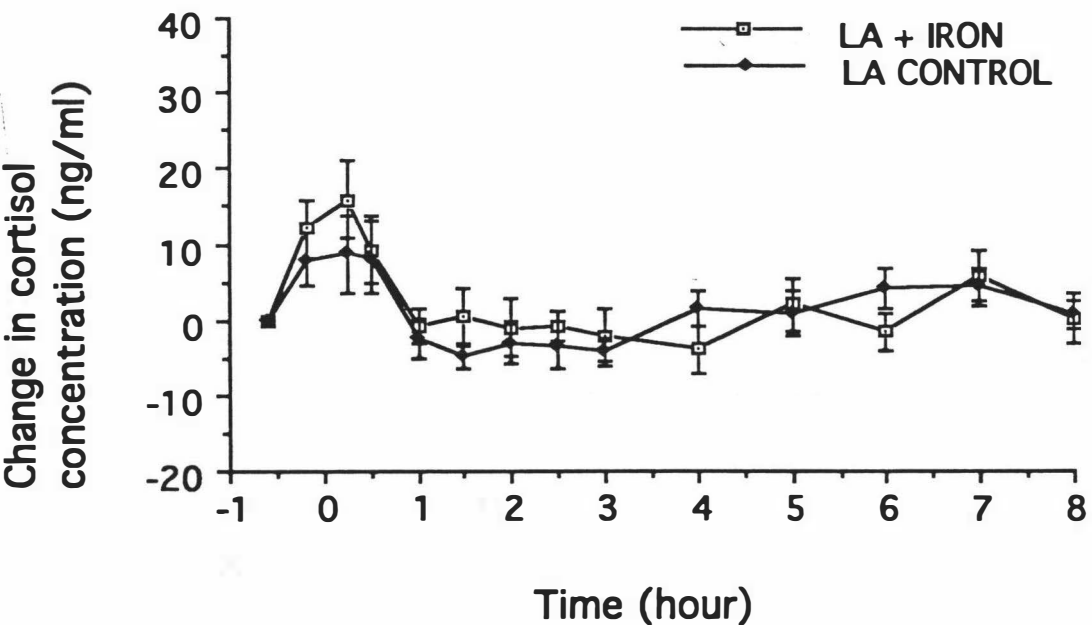


Fig 3.17: Change in plasma cortisol concentration in calves in response to local anaesthetic administration and LA + iron (mean  $\pm$  SEM). n=9. Time 0 represents time of tail docking.

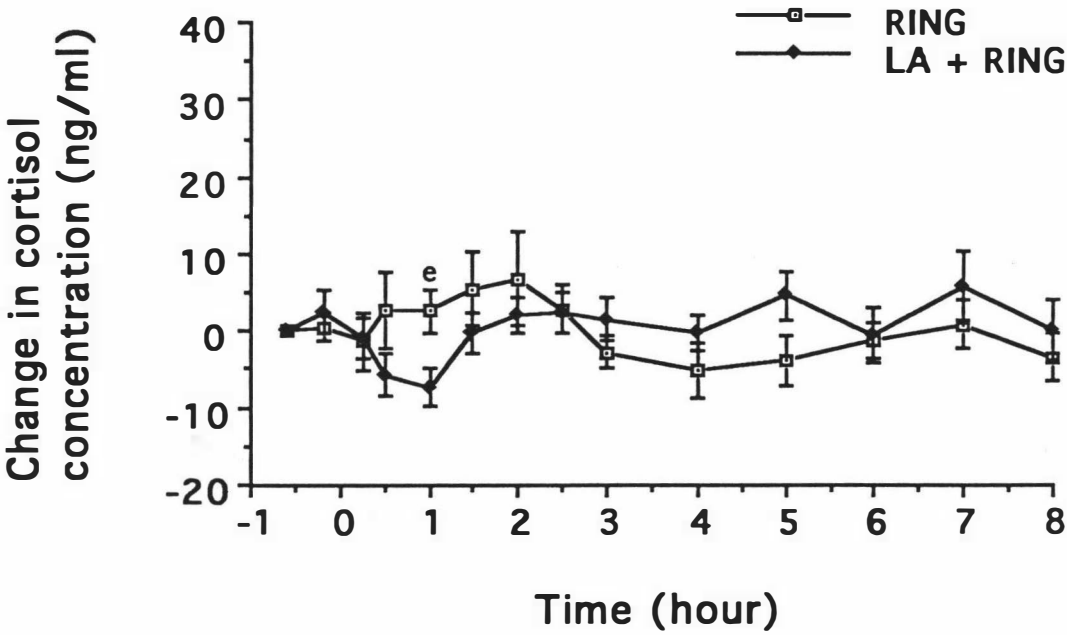


Fig 3.18: Change in plasam cortisol concentration of calves in response to the rubber ring and LA + ring (mean  $\pm$  SEM). n=9. Time 0 represent time of tail docking. Mean with different superscript differs significantly ( $P<0.05$ ). e - LA + ring

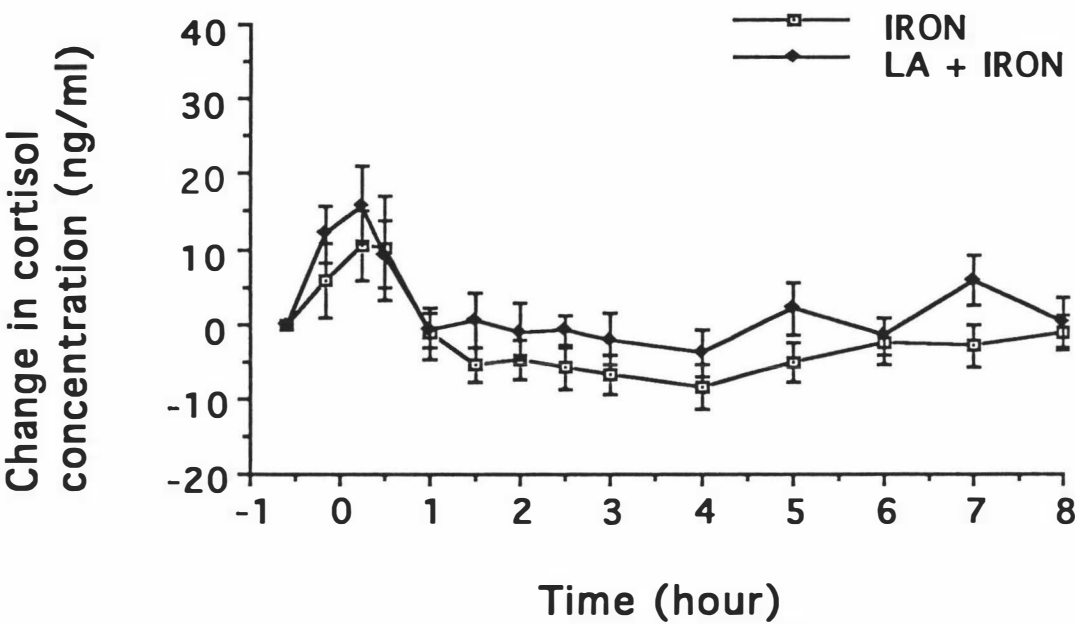


Fig 3.19: Change in plasma cortisol concentration of calves in response to the docking iron and LA + docking iron (mean  $\pm$  SEM). n=9. Time 0 represents time at tail docking.

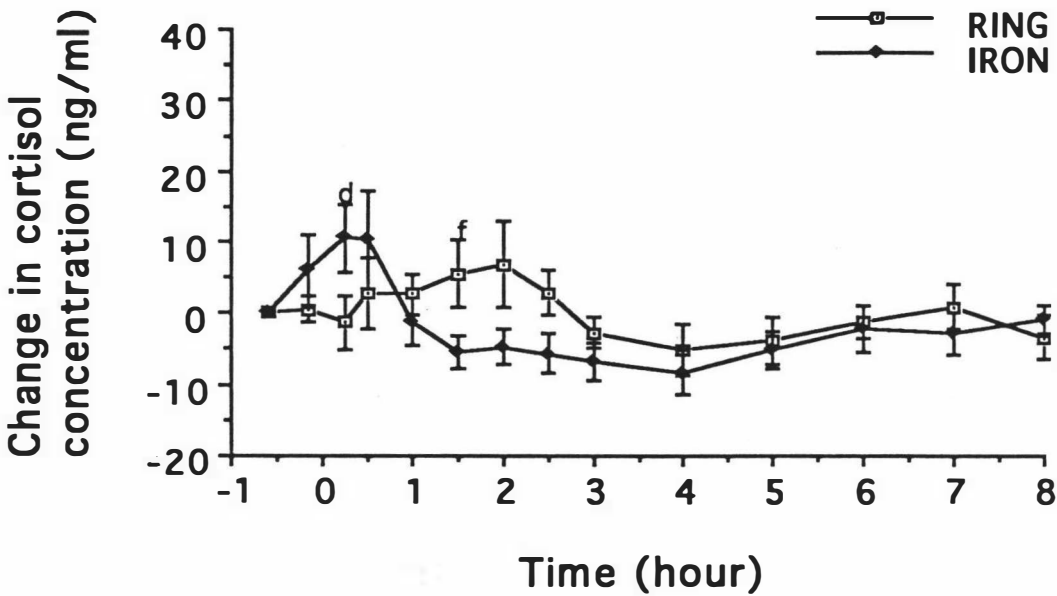


Fig 3.20: Change in plasma cortisol concentration of calves in response to the rubber ring and the docking iron (mean  $\pm$  SEM). n=9. Time 0 represents time at tail docking. Means with different superscripts differ significantly ( $P<0.05$ ) d=ring, f=iron

hours after treatment revealed no significant elevations in plasma cortisol concentrations that could be taken as evidence for chronic distress following tail docking. These results are summarised in Table 3.3.

### **3.33 Integrated cortisol responses**

The integrated responses to all treatments were not significantly different with the exception of the response in *ACTH* calves which was significantly higher than those for all other treatments (Fig 3.21). The integrated responses to the seven treatments are also provided in Table 3.4. As no further information could be obtained using the integrated cortisol responses the discussion will mainly involve the results from the incremental data (Fig 3.4-3.12).

## **3.4 DISCUSSION**

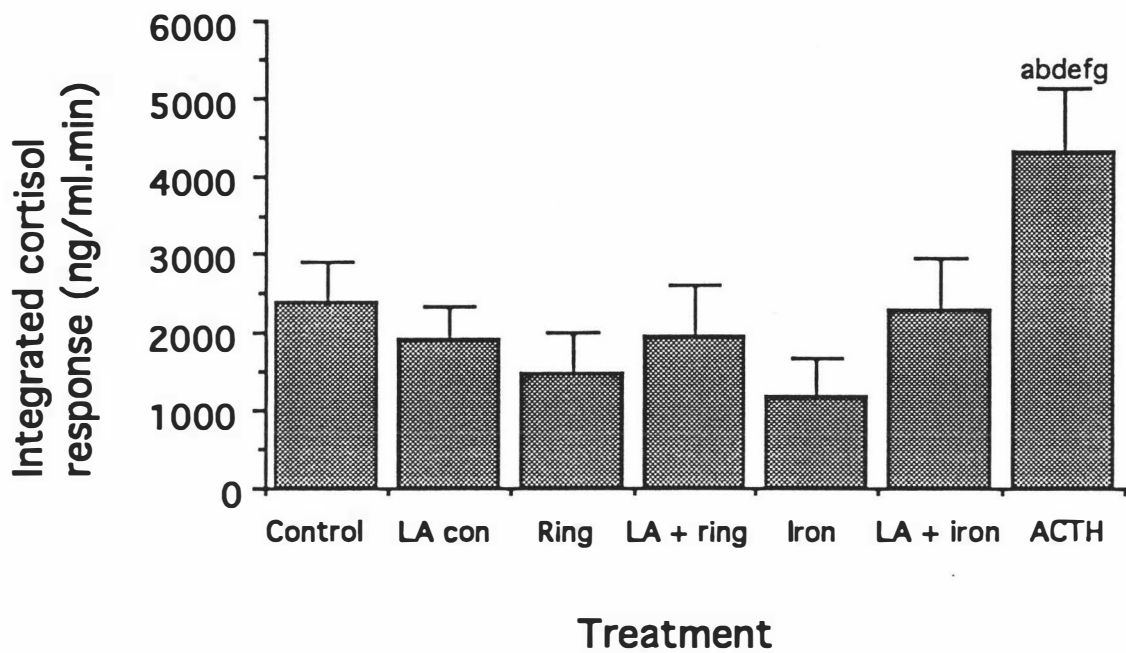
Using cortisol as an index of distress, there was little evidence in most calves to suggest that the acute response to tail docking using either a ring or the docking iron was any more distressing than the relatively benign procedures of restraint and blood sampling. Prior use of an epidural local anaesthetic to minimise the distress resulting from tail docking had few detectable benefits. A small proportion of calves showed unexplained larger cortisol responses than the majority in most treatments - these calves were referred to as mild responders.

### **Rubber ring and LA + ring**

#### ***Rubber ring***

Calves tail docked with a rubber ring produced a cortisol response not significantly different from that of the controls and these responses were low with the exception of one ring calf. It is not clear why one calf exhibited a larger cortisol response than the rest. On the basis of the other eight calves with low responses, tail docking using the rubber ring does not appear to be a particularly noxious procedure in most calves.

<b>TABLE 3.3:</b>						
Change in plasma cortisol concentrations for the subsequent four days after treatment. Mean +/- S.E.M.						
<b>TREATMENT</b>	<b>45 minutes</b>	<b>8 hours</b>	<b>24 hours</b>	<b>48 hours</b>	<b>72 hours</b>	<b>96 hours</b>
	pretreatment	post treatment	post treatment	post treatment	post treatment	post treatment
	(ng/ml)	(ng/ml)	(ng/ml)	(ng/ml)	(ng/ml)	(ng/ml)
<b>Control</b>	<b>10.41</b>	<b>14.82</b>	<b>8.64</b>	<b>8.85</b>	<b>6.44</b>	<b>7.67</b>
	2.19	0.80	1.91	1.70	1.31	2.00
<b>LA control</b>	<b>13.68</b>	<b>14.53</b>	<b>11.72</b>	<b>8.94</b>	<b>7.89</b>	<b>11.15</b>
	2.78	2.70	3.44	1.82	1.04	2.60
<b>Ring</b>	<b>18.27</b>	<b>16.84</b>	<b>15.30</b>	<b>9.17</b>	<b>9.62</b>	<b>6.54</b>
	2.39	2.61	1.85	1.28	1.64	1.21
<b>LA + ring</b>	<b>14.10</b>	<b>14.18</b>	<b>11.25</b>	<b>10.44</b>	<b>10.25</b>	<b>10.51</b>
	2.30	2.71	2.34	2.59	2.45	2.52
<b>Iron</b>	<b>17.01</b>	<b>17.40</b>	<b>9.01</b>	<b>10.86</b>	<b>7.92</b>	<b>10.57</b>
	2.44	2.18	1.79	2.31	1.80	2.99
<b>LA + iron</b>	<b>13.21</b>	<b>12.23</b>	<b>7.74</b>	<b>8.04</b>	<b>8.83</b>	<b>6.44</b>
	2.61	2.03	1.68	1.67	2.41	1.92
<b>ACTH</b>	<b>22.01</b>	<b>13.26</b>	<b>10.57</b>	<b>8.82</b>	<b>10.88</b>	<b>7.95</b>
	4.15	3.18	1.07	2.09	2.82	1.66



**Fig 3.21:** Integrated cortisol response of calves in response to different treatment (mean  $\pm$  SEM).  $n=9$ .

Means with different superscripts differ significantly ( $P < 0.05$ ).

- a - control
- b - LA control
- c - ACTH
- d - ring
- e - LA + ring
- f - iron
- g - LA + iron

<b>TABLE 3.4:</b>					
Integrated cortisol responses and duration of elevation above pretreatment plasma cortisol levels after the seven different treatments.					
				<b>a</b>	<b>b</b>
<b>Treatment</b>	<b>n</b>	<b>Mean</b>	<b>S.E.M.</b>	<b>Mean:ACTH</b>	<b>Duration</b>
		(ng/ml.min)		ratio	(hour)
Control	9	2370	544	55	0.25
LA control	9	1923	413	45	0.50
Ring	9	1466	551	34	0.00
LA + ring	9	1946	663	45	0.00
Iron	9	1183	482	28	0.50
LA + iron	9	2276	685	53	0.50
ACTH	9	4298	826	100	3.00
a - Thre proportions of each mean response as a percentage of the ACTH response					
b - The time after treatment when the cortisol concentration returned to pretreatmen values, -45 minutes.					



Ischaemic tail docking with rubber rings relies on occlusion of arterial supply to and venous drainage from the tail by applying pressure to the blood vessels which run mainly along the bone, ventral to the caudal vertebrae and dorso-lateral to the transverse processes of the caudal vertebrae (Brown and Carrow, 1963; Ghosal and Getty, 1967). After an initial nociceptor barrage produced by application of the rubber ring to the tail, a progression from hypoxia to anoxia in the tail would be expected to cause a gradual decrease in the nociceptor activity as Lester (1991) suggested occurs in lambs. This activity would gain access to the central nervous system via the intact nerves passing through the rubber ring. It has been shown that nociceptors can function for more than three hours after occlusion of the blood supply to the tissues in which they are situated (Grubb *et al.*, 1990). As no significant cortisol rise was seen in most calves, it could be that although tissue damage presumably occurred, any associated nociceptor activity was not intense enough in those cases to elicit a marked cortisol response.

### ***LA + ring***

Administration of an epidural local anaesthetic prior to the application of a rubber ring resulted in a mean cortisol response similar to those of *control*, *LA control* and *ring* calves. As application of a rubber ring alone appeared to be a benign procedure in most calves, the administration of an epidural anaesthetic could not therefore effect much reduction in any distress the ring application caused. Moreover, local epidural anaesthetic administration itself apparently caused significant distress in two of the nine *LA control* calves. As the cortisol responses in those two *LA control* calves and the one *ring* calf were classed as mild responders these three animals may have been reacting more to the handling and unfamiliar environment than to particular procedures applied to their tails. Alternatively, the one responding *ring* calf may have experienced discomfort associated with ischaemia in its tail greater than the other *ring* calves. The two responding *LA control* calves may have found the numbness distal to the injection site aversive or the process of administering the injection itself may have caused a degree of distress (Hall, 1971b).

## **Iron and LA + iron**

### **Iron**

No significant differences were detected between the mean response of calves docked with the *iron* alone and responses of *control* calves during the first six and a half hours after treatment. Tail docking of lambs with a docking iron was shown by Lester *et al* (1991a) to be no more distressing than tailing with a rubber ring but much less distressing than when a knife was used. This was the justification for using the docking iron method which had not been previously tried in calves in the present study. As with lambs, the present results also showed that tail docking with a docking iron causes no more distress than tail docking with a rubber ring in most calves, but effects of docking with a knife were not examined here.

It was argued for lambs that the reason the distress response was lower when tail docking was done with an iron than when it was done with a knife lay in the way the tissues were severed (Lester *et al.*, 1991a). The knife simply transects all tissues of the tail where it is applied whereas the docking iron involves amputation of the tail by the cauterising action of its heated, chiselled surface. It is widely accepted clinically that third degree burns do not cause as much pain as first and second degree burns (Johnston, 1985) because third degree burns destroy the nociceptors in the tissue with a consequent loss of sensation in the affected area. Lester *et al.*, (1991a) discussed the concept that the searing effect of the docking iron possibly destroys the nociceptors at the site of the burn and therefore reduces the ability to perceive noxious stimulation. A similar effect may explain the low cortisol responses to the iron in seven of the present calves.

### **LA + iron**

There appeared to be little advantage in giving an epidural local anaesthetic when the docking iron was used because the mean cortisol responses of *LA + iron* and *LA control* calves were not significantly different (Fig 3.17). Nor were there significant differences between the mean cortisol concentrations when comparing the responses of *LA + iron* and *iron* calves (Fig 3.19).

There was however greater variation in the individual cortisol responses of the *LA + iron* calves with four of nine showing larger responses (Fig 3.11). Two of these cortisol responses were similar to those of the mild responding *LA control* calves, so the response could be due to the administration of the local anaesthetic (Hall, 1971). An explanation as to why the other two mild responders had low but significantly protracted elevations in plasma cortisol concentration is unknown.

Although loss of sensation after local anaesthetic administration was tested by pricking the skin around the docking site to ensure effective desensitisation, this method could not detect sensitivity of the nerve supply from higher spinal nerves (Chapter Two). This could be one cause for the individual variation seen within the *LA control* and *LA + iron* calves. Another possible explanation is that an epidural local anaesthetic desensitises all nerves originating from the spine caudal to the portion of the spinal cord area affected by anaesthetic. Thus, some pelvic and hindlimb nerves could be affected in some calves, and the resulting induced ataxia and loss of proprioception could cause emotional distress. Some variability in such effects would be expected due to individual variation in epidural space size (Hall, 1971) and fat content within this space. However, this argument can be negated on the grounds that the two calves noted as having slight ataxia after local anaesthetic administration were classed as low responders on the basis of their cortisol responses.

### **Control and LA control**

Restraint and blood sampling apparently caused low levels of distress. The stimuli of handling and blood sampling and of local anaesthetic administration and even of tail removal failed to elicit mild cortisol responses in most calves. This contrasts with reports in the literature suggesting that mild to marked cortisol responses would be usual in lambs and calves in unfamiliar situations including handling and blood sampling (Mellor and Murray 1989a; Lester *et al.*, 1991a; Wood *et al.*, 1991, Kent *et al.*, 1993; Molony *et al.*, 1993; Robertson *et al.*, 1993). However, the calves in the

present study belonged to a Massey University farm where they were quite familiar with being handled on a weekly and sometimes on a daily basis with feeding and weight gain trials. This habituation to handling may have reduced the distress involved in our experiment.

### **ACTH**

The response seen in the *ACTH* calves was typical of those seen in previous studies when animals were given an exogenous dose of ACTH (Alam *et al.*, 1986; Verkerk, 1993). This response indicated that the adrenal glands of the calves in the present study were responsive to ACTH. However, it may not bear any relevance to the functional capacity of any other steps in the hypothalamic-pituitary-adrenal cascade because its action is to stimulate release of the last hormone, cortisol, in that cascade. The rise to high plasma cortisol levels to a plateau which was maintained for two hours indicates that a maximal adrenal response was achieved by the amount of ACTH administered here.

The plasma cortisol responses taken 24, 48, 72 and 96 hours after treatment indicate that there is no development of chronic distress after tail docking.

### **3.41 General Considerations**

The major conclusions of this investigation based on the integrated cortisol responses were:

1. Exposure of female Friesian dairy calves to the experimental environment, including handling, blood sampling, local anaesthetic administration and tail docking using either method apparently caused only mild distress in most calves.
2. There was apparently no advantage in administering an epidural local anaesthetic prior to tail docking using either method.
3. The cortisol responses of the three to four month old calves were not apparently limited by the secretory capacity of the adrenal cortex as shown by the marked responses to ACTH injection.
4. There was no recurrence of a chronic distress response during the four

days after treatment.

When comparing the effects of tailing with a rubber ring and the docking iron, both treatments resulted in similar proportions of low and mild cortisol responders. Accordingly, there is no apparent advantage in using the docking iron, and the standard practice of using the rubber ring could be recommended for continued use in calves of this age. In fact there were obvious disadvantages in using the docking iron as a small proportion of calves exhibited continued bleeding (which required bandaging) from the tail stumps for several hours after treatment. This could lead to secondary problems like sepsis and chronic inflammation. The accumulation of blood or other fluids at the docking site can provide a site for infection. However, although the rubber ring method does not normally permit access of pathogens at the time of application it is not entirely exempt from longer term problems. Normally, granulating tissue forms under the ring which acts to protect the tail stump from infection and aid in the healing process. However, it has been reported that tetanus can occur following tail docking in lambs, particularly after the use of the rubber ring (Bruere and West, 1993).

The purpose of giving the epidural local anaesthetic was to alleviate the distress response to tail docking but the present results indicated little or no advantage in giving an epidural local anaesthetic. In fact the risk of spinal abscesses and the additional time and handling involved with epidural injections negates any slight advantage of giving a local anaesthetic. It is noteworthy however, that injecting the local anaesthetic itself was not apparently distressing in most calves (Fig 3.4B), although two calves did exhibit a mild cortisol response (Fig 3.5). It is possible that these mild responses were due to novel sensations associated with the introduction of the epidural anaesthetic of a nature similar to anecdotal reports in human subjects of some pain associated with induction of epidural anaesthesia.

The acute cortisol responses provide no evidence of significant distress in most calves and there is no evidence of distress between 24 and 96 hours

(Table 3.2). Beyond 96 hours long term effects of nerve damage could lead to the development of neuropathic pain, similar for example to the phantom limb pain in human amputees, and experimental conditions have produced signs of neuropathic pain in almost 100% of animals treated (Bennett and Xie, 1988). Previous studies of the effects of peripheral nerve amputation in dogs (Gross and Carr, 1990), chickens (Gentle, 1986; Gentle and Hunter, 1988) and lambs (French and Morgan, 1992), have shown that neuroma formation is often associated with abnormal and higher electrical activity in affected nerves (Breward and Gentle, 1985). This excitability is an important feature of the neuromas and is implicated as the cause of chronic pain and self mutilation in dogs (Gross and Carr, 1990). Since several somatic nerves are damaged by tail docking in calves it will be worthwhile to determine if neuromas develop with subsequent associated neuropathic pain.

Of equal concern to any acute or chronic pain-induced distress, however, is the possible distress which may affect the animal throughout the rest of its life because of the lack of a tail. Cows without tails spend more time fruitlessly flicking their tail stumps and adopting other fly-avoidance behaviours than do undocked animals (Ladewig and Matthews, 1992). It is not clear, as yet, whether or not the higher numbers of flies seen on docked cows (Ladewig and Matthews, 1992, Phipps, 1993 personal communication) cause them unacceptable levels of distress. Dougherty *et al.* (1993) demonstrated that the rates of dry matter intake are not apparently affected by the presence of stable flies, but Phipps (personal communication) has demonstrated a reduction in liveweight gain in docked cows compared with their undocked twins.

Also, the concerns of Kilgour (1984) that because of our poor knowledge of bovine behaviour, we may have eliminated one of the modes cows use for social signalling or communication, may have important welfare implications.

### **3.5 CONCLUSIONS**

Tail docking 3-4 month old female Friesian dairy calves with either a rubber ring or a docking iron is apparently no more distressing than handling and blood sampling in most calves. Furthermore, the prior administration of an epidural local anaesthetic had no additional alleviating effects on the cortisol response to either of these methods.

## **CHAPTER FOUR: TAIL DOCKING IN CALVES; EFFECTS ON BEHAVIOURAL RESPONSES OF A RUBBER RING USED WITH OR WITHOUT LOCAL ANAESTHETIC.**

### **4.1 INTRODUCTION**

Many biological responses of animals have been used to assess the responses of farm animals to apparently stressful husbandry procedures. As there is apparently no single reliable index of distress, it is recommended that several types of responses (for example; behavioural, physiological or production parameters) be evaluated (Dawkins, 1980; Levine, 1985). Of these response types, it is often a change in behaviour that gives the first indication that an animal may be experiencing a form of distress (Dawkins, 1980). Surgical tissue removals such as castration and tail docking (Mellor and Murray, 1989a,b; Mellor *et al.*, 1991; Lester 1991, Molony *et al.*, 1993; Robertson *et al.*, 1993) have been associated with obvious behavioural signs of distress, behaviours which were probably induced by pain and could therefore assist in the identification of animals experiencing pain. The development of guidelines for the recognition of pain and the assessment of its intensity will help the observer to determine whether an animal is experiencing pain-induced distress and whether or not there is a need to apply measures which alleviate pain.

Behavioural responses are diverse and may be specific to the stimuli received. Chapman *et al.* (1985) stated that animals may either decrease or increase their activity in attempts to avoid or escape noxious stimuli. Both suppression of some activities (feeding or grooming) and increases of others (head shaking, tail shaking) may continue throughout a period of noxious stimulation. Alternatively all voluntary behaviours may cease.

Behavioural studies of lambs after they had been subjected to various procedures have demonstrated that changes in behaviour can be correlated to plasma cortisol concentration (Mellor and Murray, 1989a,b; Lester *et al.*,



1991a,b; Molony *et al.*, 1993). This enabled the identification of behaviours indicative of different levels of distress and demonstrated a good general agreement between the presumed intensity of the noxious stimulus and the intensity of the distress apparently experienced by the lambs.

As in lambs, procedures performed in calves have been identified as noxious by reference to cortisol responses, and behavioural responses which are specific to those noxious stimuli have been sought by exploring correlations between behaviour and the cortisol responses. Work by Mellor *et al.* (1991) after castrating calves less than one week old demonstrated little response in both behaviour and plasma cortisol concentrations. However, an earlier study by Fell *et al.* (1986) included observations of behaviour to help quantify pain and/or distress arising from surgical or rubber ring castration of 4-11 week old calves. Macauley and Friend (1987) included some observations of standing, kicking and cantering in response to castration that were correlated to plasma cortisol concentrations in older calves. More recently, Robertson *et al.* (1993) used restlessness, tail wagging, foot stamping and abnormal postures to indicate pain and distress in calves after three types of castration. A comparative study of freeze and hot-iron branding in dairy cattle using physiological and behavioural measurements (Lay *et al.*, 1991) showed an increase in plasma cortisol concentrations and greater "escape-avoidance" reaction in branded cows compared to controls. In addition, a study of effects of dehorning on behaviour and cortisol concentrations in 3-8 week old calves has revealed distinct "escape, pain and stress reactions" such as rearing, tripping with the foreleg, forcing ahead, falling down and tail wagging (Taschke and Folsch, 1993).

The behavioural responses to tail docking have been examined in one study by Wilson (1972) in which the "abnormal" behaviours of prepartum cows were assessed after tail docking. The cows were apparently unconcerned by the presence of rings on their tails and continued to graze normally. Six hours after treatment tail movements were greater in those cows with rings than in the controls and that was associated with significantly higher plasma cortisol

concentrations in the docked cows. Wilson (1972) observed no exaggerated signs of pain or discomfort in any cow after the application of a rubber ring but he did indicate that such responses have been observed on other occasions. However, the precise details of the behaviours which were considered to be "normal" or "abnormal" were not provided.

No specific details of the behaviour of calves after tail docking are apparently available in the literature. Accordingly, the aims of the present study were to determine if any behavioural changes could be observed after the application of a rubber ring in three to four month old calves and to determine if the administration of an epidural local anaesthetic, designed to eliminate pain, modified these behaviours.

## **4.2 MATERIALS AND METHODS**

Forty five female Friesian dairy calves, three to four months of age, were investigated for behavioural changes during routine tail docking on a Massey University farm. All calves in this study were scheduled for tail docking in accordance with the then usual farm practice.

All calves were randomly allocated into one of three treatments ( $n=15$  per treatment). The study was carried out over three days. During the first two days the weather was fine but after 10am on the third experimental day, it rained heavily during the observation period. On each experimental day the behaviours of 15 calves, five from each treatment were monitored from 8.30am until 5.30pm.

On the day of the study the calves were brought into a milking shed at 6.30am, allocated a treatment and sprayed with tail paint for individual identification. Those calves allocated to the local anaesthetic treatment were also clipped along the first three caudal vertebrae to enable hygienic epidural lignocaine administration (as described in Chapter Three). Immediately after treatment (8.15am) the calves were quietly walked as a group along a 50m

race to the observation paddock. The observation paddock (20m x 35m) allowed ad libitum access to grass and water.

Five hours after observations began the calves were walked 200m along the race to rejoin the rest of the herd.

#### 4.21 Treatments

Calves were randomly allocated to one of three treatments; control, docking with a rubber ring or epidural local anaesthetic plus rubber ring.

##### **Control (*control*)** n=15

Calves were handled as if for tail docking.

##### **Rubber ring (*ring*)** n=15

Calves were handled and a rubber ring was applied to each tail, at least 2.5cm below the vulva.

##### **Local anaesthetic plus ring (*LA + ring*)** n=15

An epidural local anaesthetic (3ml lignocaine) was administered between the first and second coccygeal vertebrae 10 minutes prior to the application of a rubber ring (Chapter Three).

#### 4.22 Behaviour Measurements

1. Instantaneous scan observations of each animal were carried out every 10 minutes and recorded on pre-prepared data sheets which specified the following behaviours.

**Standing:** Calves standing still or walking.

**Grazing:** Calves grazing while either standing still or walking.

**Ruminating:** Calves ruminating while either standing or lying.

**Tail shake:** Seen as calves intermittently and vigorously producing thrashing movements of their tails such that they appeared to be trying to dislodge something from their tails. The tail shakes were measured in bouts rather than counting the number of times the tail crossed a fixed point on the animal's body. These movement were quite distinct from tail flicks seen as part of fly removal behaviour.

**Vocalisation:** Any bawling made by the calves.

**Drinking:** Any consumption of water from the trough provided.

**Posture:** Standing and lying postures were noted. For example, whether or not the calves were lying in sternal or lateral recumbency.

**Restlessness:** The number of times a calf stood up and lay down; each unit scored included both standing up and lying down.

2. Continual observations of the 15 calves were carried out and their behaviour recorded on timed observation sheets. Behaviours not listed on the observation sheets were recorded as comments.

3. A video recording of the calves in the paddock was carried out over the five hour observation period.

## 4.23 Presentation of results

Behaviours of the calves receiving each treatment have been presented either as the mean percentage of animals displaying a particular behaviour within three 10 minute scan samples (for every 30 minutes) or as the number of animals displaying a particular behaviour during scan observations.

In addition to the scan sampling data other observations were extracted from the notes taken during the five hour observation period and the continuous video recording. This enabled the number of times tail shaking and

vocalisation occurred and the amount of restlessness during every 30 minutes to be quantified.

### 4.3 RESULTS

No between day differences were detected between calves observed on the two fine days compared to those calves observed on the wet day. Therefore results from the three experimental days were pooled.

Some behaviours that were on the checksheet were not used because they were absent in all groups. These behaviours included "abnormal" postures (Mellor *et al.*, 1989; Lester *et al.*, 1991; Molony *et al.*, 1993) and drinking.

#### ***Control***

Standing/walking (71% to 100%) and grazing (47% to 95.5%) were the predominant activities of the control calves during the first three hours of observation (Fig 4.1, 4.2). Thereafter, the amount of standing decreased (from 58% to 15.5%) as did the amount of grazing (from 55.5% to 7%). During the period of decreased standing/walking and grazing, calves tended to lie down and some calves were observed ruminating (4% to 11%, Fig 4.3). Individuals stood up or lay down for long periods and remained awake when lying.

No other behaviours were noted in the *control* calves, although one calf did tail shake 30 minutes after treatment, but this behaviour occurred while another calf was sniffing its perineal region.

#### ***Ring***

The standing, walking, grazing and ruminating behaviours of calves after the application of a rubber ring were similar to those of the *control* calves. Over the first three hours after treatment there was a high proportion of calves displaying standing/walking (53% to 98%) and grazing (44% to 91%) behaviours (Fig 4.1, 4.2). A few calves were seen ruminating one hour after

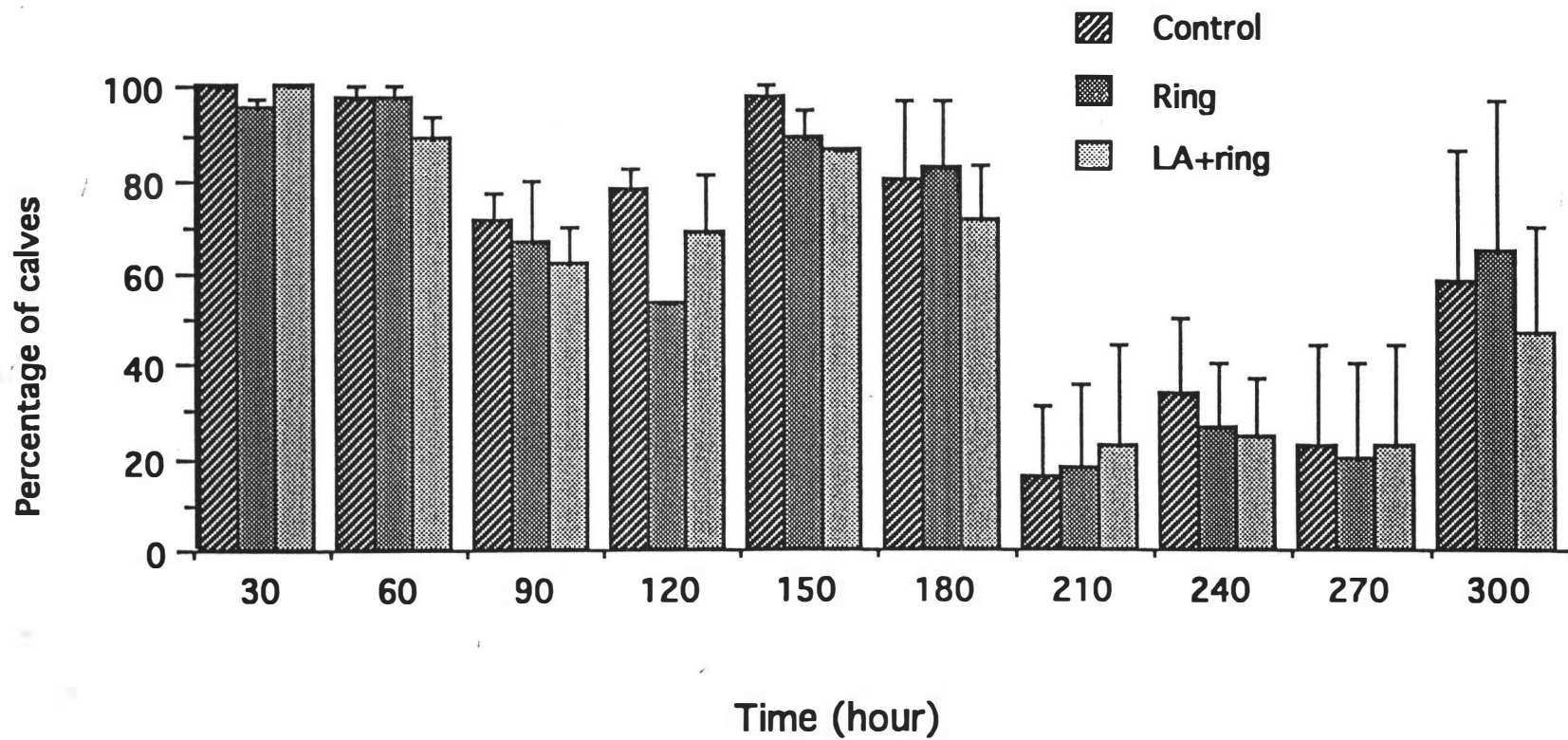


Fig 4.1: Percentage of calves (mean  $\pm$  SEM) standing after control handling, and rubber ring application with or without local anaesthetic. (n=15)

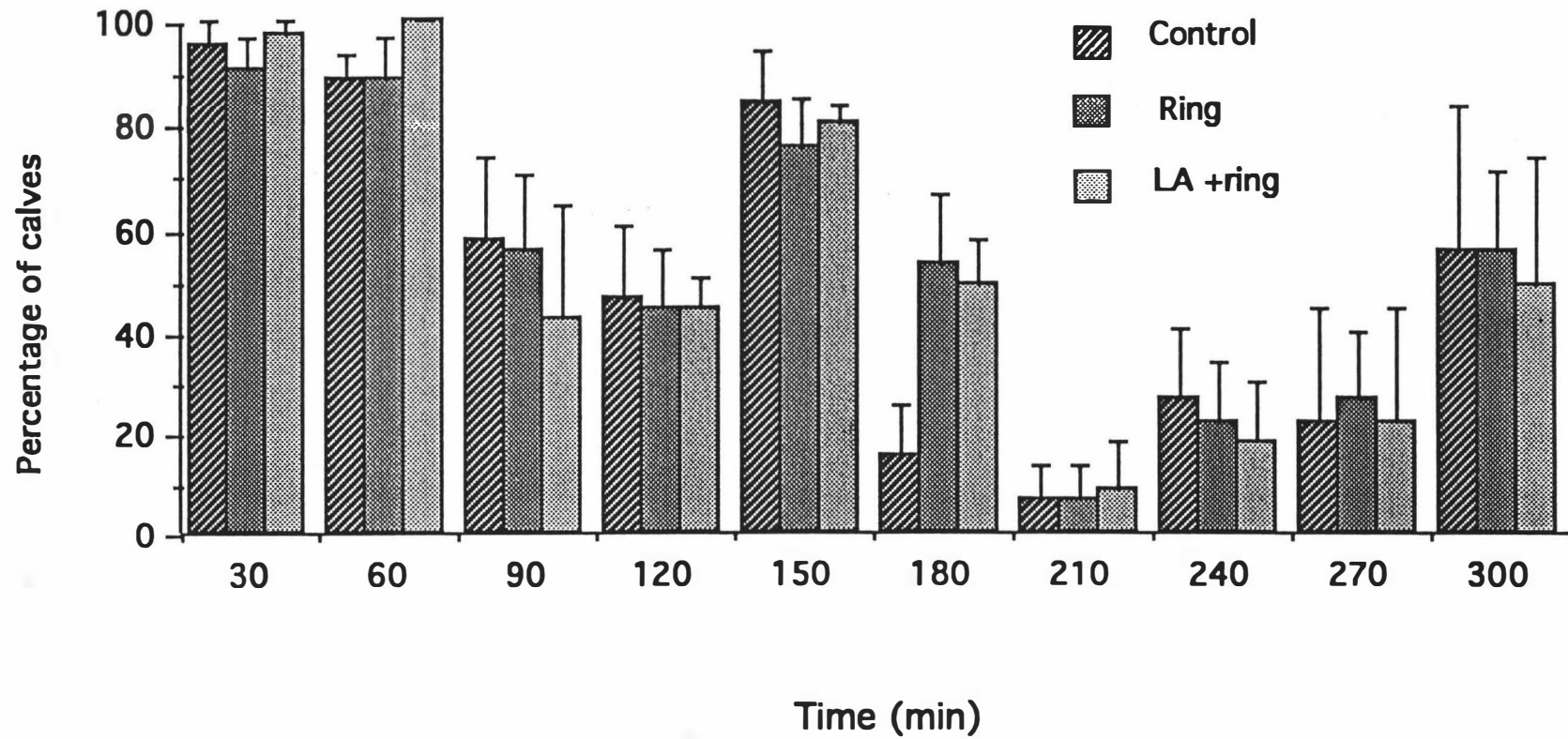


Fig 4.2: Percentage of calves (mean  $\pm$  SEM) grazing after control handling, and rubber ring application with or without local anaesthetic. (n=15)

treatment and this number increased (from 2% to 18%) as the percentage of calves grazing decreased (Fig 4.3). Calves were usually lying down when ruminating.

During scan sampling observations tail shaking was seen in 10 of the 15 *ring* calves (67%) during the 30 minute period after treatment (Fig 4.4). Thereafter only two calves of the 10 *ring* calves displayed this behaviour intermittently for a further one hour. The frequency of occurrence of tail shaking (Table 4.1) was high, especially during the first 30 minutes after the application of the rubber ring (45 tail shaking bouts per 10 calves). Five of the 10 calves which tail shook also vocalised during the first two hours after treatment (Fig 4.5).

Two of the five *ring* calves that vocalised and tail shook were also seen at various times over the first two hours displaying other behaviours not seen in the controls. These calves were observed kicking up their hind legs and turning their heads while attempting to bite at their tails. Twenty minutes after the application of the ring, one of the *ring* calves was observed kicking up its hind legs and running up and down the paddock intermittantly over a period of five minutes.

Restlessness was also evident in the *ring* calves compared to the *control* calves. The five *ring* calves that were observed tail shaking and vocalising were restless over the first hour after treatment, standing up and lying down repeatedly (Table 4.1) and were observed walking in a zig-zag fashion, while the majority of the other calves were grazing.

### ***LA + ring***

As with the *control* and *ring* calves, the majority of *LA + ring* calves stood/walked (62% to 100%) and grazed (42% to 100%) constantly over the first three hours after treatment (Fig 4.1, 4.2). Rumination occurred in a small proportion of the calves after one and a half hours (2%) and was observed more often (20%) after three hours when grazing behaviour had decreased (Fig 4.3).



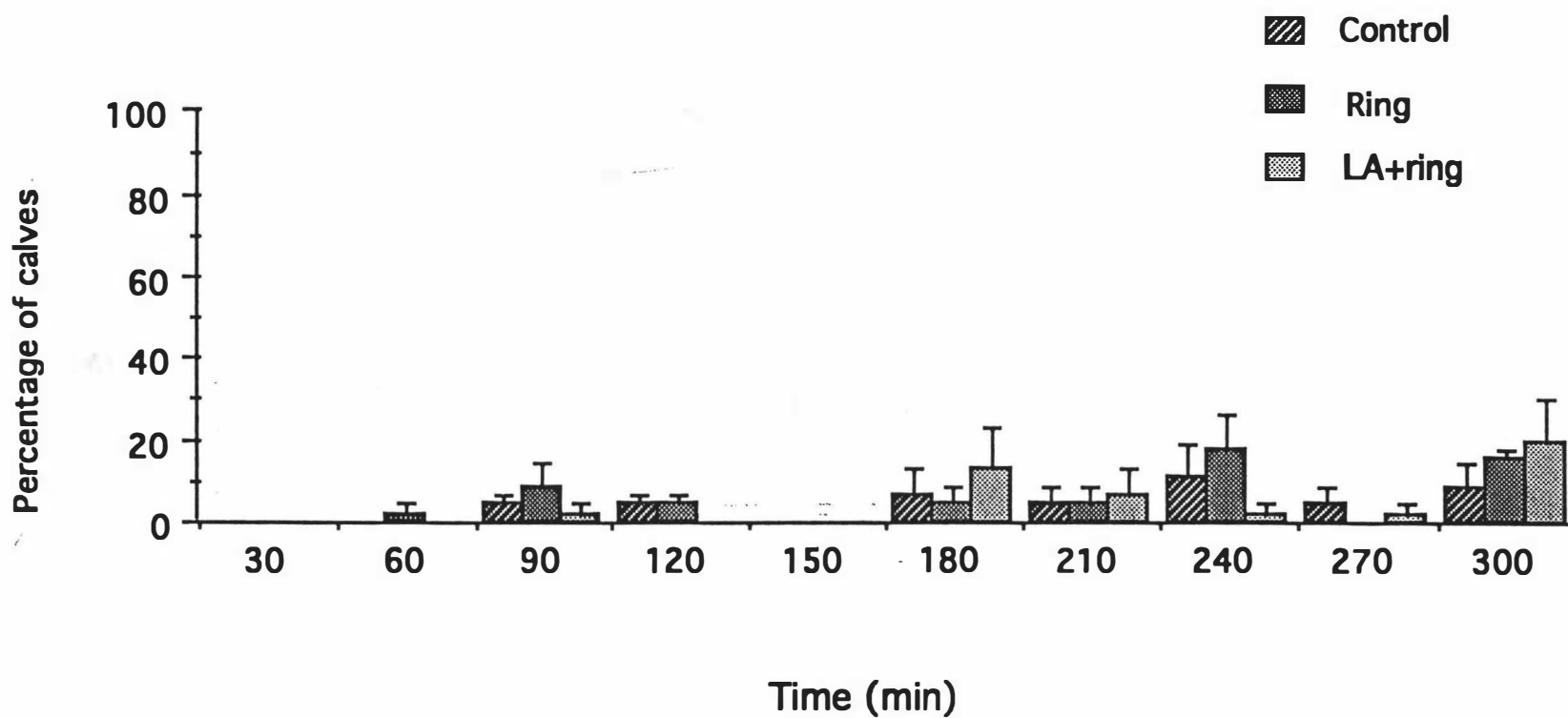


Fig 4.3: Percentage of calves (mean  $\pm$  SEM) ruminating after control handling, and rubber ring application with or without local anaesthetic. (n=15)

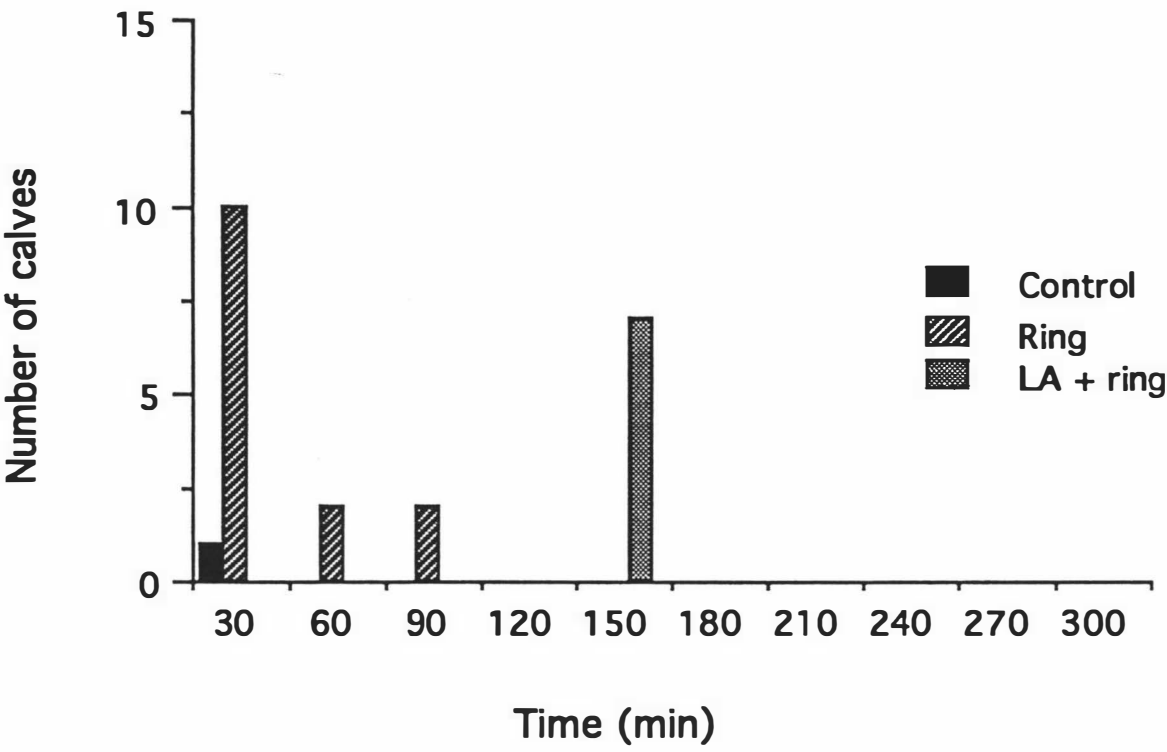


Fig 4.4: Number of calves observed per 30 minutes tail shaking after control handling and rubber ring application with or without a local anaesthetic. (n=15)

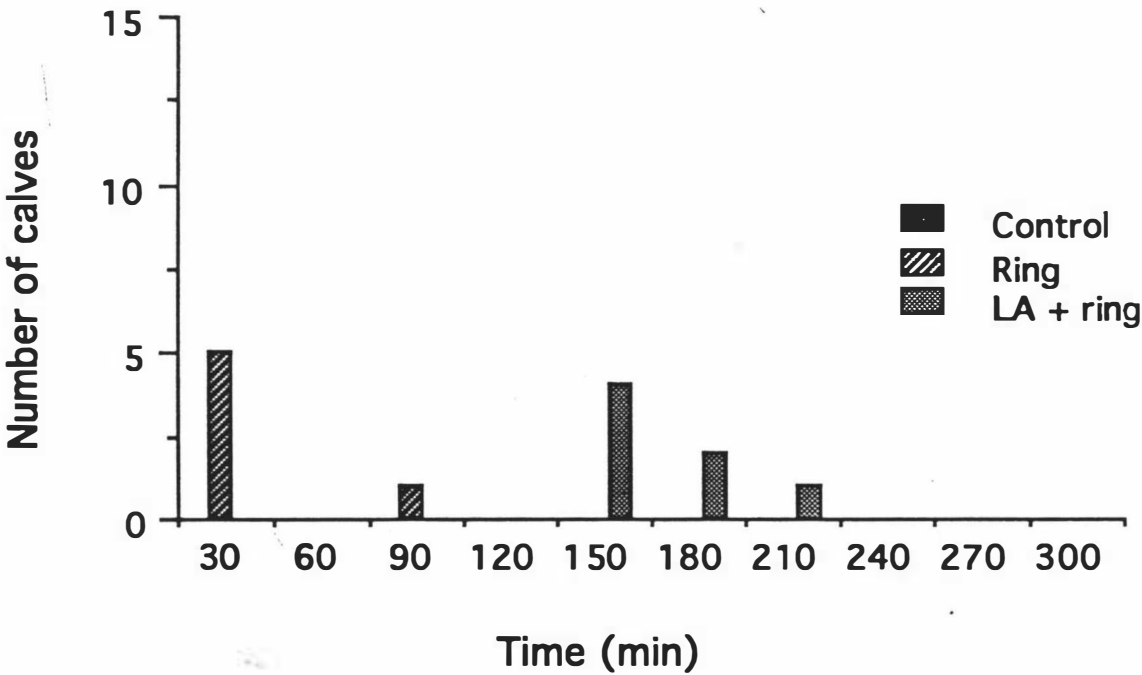


Fig 4.5: Number of calves observed per 30 minutes vocalising after control handling and rubber ring application with or without a local anaesthetic. (n=15)

<b>TABLE 4.1:</b>								
Frequency (NO. of bouts observed per 30 minutes per treatment) of behaviours in calves after control handling and rubber ring application with or without a local anaesthetic.								
<b>TIME (min)</b>	<b>CONTROL</b>		<b>RING</b>			<b>LA + RING</b>		
	TAIL SHAKE	VOCAL.	TAIL SHAKE	VOCAL.	RESTLESS	TAIL SHAKE	VOCAL.	RESTLESS
<b>30</b>	3		45	12	12			
<b>60</b>			15		7			
<b>90</b>			18	7				
<b>120</b>								
<b>150</b>						34	5	4
<b>180</b>							12	6
<b>210</b>							3	3
<b>240</b>								2
<b>270</b>								
<b>300</b>								

Some *LA + ring* calves, which had behaved similar to the *control* calves for the first one and a half to two hours, became restless thereafter with five of the fifteen calves (33%) pacing and repeatedly standing up and lying down (Table 4.1). Tail shaking and vocalisation were first observed after two and a half hours (Table 4.1, Fig 4.4, 4.5). Again, those calves that vocalised (five out of 15) also exhibited tail shaking (seven out of 15). One of the 15 *LA + ring* calves was observed attempting to bite at its tail one and a half hours after the application of a rubber ring.

#### 4.4 DISCUSSION

The major original findings of the present study were as follows. After tail docking with a rubber ring about 67% of the calves exhibited a behaviour which could be linked to the treatment. In the *ring* calves which did respond, the unique behaviours probably indicate a period of noxious input probably linked to pain due to the onset of ischaemic tissue damage. In the *LA + ring* calves the behavioural responses after two to two and a half hours were probably due to discomfort and/or novel sensations felt as the local anaesthetic wore off. The other behaviours recorded, standing, grazing and ruminating, were apparently unaffected by the treatment.

Of the 30 calves tail docked (*ring* and *LA + ring*) during this behavioural study, 17 exhibited behaviours not observed in the *control* calves. The specific unique behaviours, which included tail shaking, vocalisation and a high degree of restlessness, running, kicking with the hind legs and biting at the tails could therefore have been indicators of pain and/or discomfort. In other studies where noxious procedures were applied to calves the resulting behaviours were correlated with changes in cortisol concentration. For instance, after castration of calves Mellor *et al.* (1991) detected no behavioural or cortisol responses in hand-reared calves, whereas Robertson *et al.* (1993) reported significant behavioural and cortisol responses in slightly older calves left with their mothers.

In the present study behaviour and plasma cortisol concentrations could not be measured in the same calves due to the experimental set-up of the cortisol study preventing totally free movement in the penned calves. However, as reported in Chapter Three, tail docking with a ring resulted in about 10% of the calves exhibiting significant cortisol responses. On the other hand, about 57% of the calves tail docked in this study displayed unique behavioural responses. The large discrepancy between the proportion of calves displaying notable behavioural and cortisol responses could indicate that either or both indices of distress are not reliable. If the behavioural results are correct then we can assume that cortisol, in the case of tail docking, underestimates the distress involved. Alternatively, if the 90% of calves that apparently exhibit little or no distress, as indicated by plasma cortisol concentrations, is correct, then the particular behaviours observed in this study may be too sensitive as measures of tailing distress. In that case, most of the unique behaviours observed could be indicating only the novel or perhaps irritating experience of the ring application or of the local anaesthetic wearing off.

Two hours after treatment the unique behavioural responses seen in the *ring* calves were absent. Presumably by two hours blood flow to and from the tail would have ceased along with afferent nerve discharge rendering the tail insensitive (Anon, 1955; Paletta *et al.*, 1960). The same sequence of events would presumably have occurred in the *LA + ring* calves. This raises the question of why these calves exhibited similar behaviours to the *ring* calves after two hours when the local anaesthetic was expected to have worn off.

Epidural anaesthesia results in desensitisation of the following; the area of the tail and croup as far as the mid-sacral region; the anus, vulva and perineum; and the posterior aspect of the thigh (Hall, 1971) (Chapter Two, Fig 2.9). During the cortisol study the effectiveness and duration of the local anaesthetic was tested by pin-pricking the tail. It was found that the area distal to the rubber ring remained insensitive throughout in the docked calves, whereas the area proximal to the docking site, and the entire tail in the *LA*

*control* calves, regained sensation by about two hours after administration of the local anaesthetic (Chapter Three). The present behavioural observations were consistent with this because the *LA + ring* calves began to tail shake at two to two and a half hours after treatment, indicating a return of sensation. Although sensation returned to the tail about two to two and a half hours after treatment in the *LA + ring* calves, it is unlikely that the behaviours seen were indicative of pain in the distal tail because the tail would have been numb as indicated by the lack of response to the needle-prick observed at that time in the *ring* calves (Chapter Three). Therefore, it may be concluded that the novelty of the sensations experienced by the *LA + ring* calves as the local anaesthetic wore off was the likely cause of the unique behaviours rather than pain-induced distress.

Two of the 30 (6.7%) calves docked with a rubber ring in this study displayed very obvious unique behaviours like running and kicking up their hind legs. This number correlates more closely with the number of mild cortisol responders reported in Chapter Three (10%), raising the possibility that only these types of behaviour may indicate significant pain-induced distress with respect to tail docking. Therefore, restlessness, attempting to bite the tail, tail-shaking and vocalisation may not be good indicators of pain-induced distress with regard to tail docking in calves, particularly as the intensities of these behaviours were seen in *LA + ring* calves at a time when the tail would have been insensitive (Chapter Three) were similar to those seen in the *ring* calves.

About 67% of the *ring* calves in this study displayed unique behaviours. Even if all of them did experience mild tail docking distress, the duration of the unique behaviours which might indicate this should be considered. The unique behaviours were only present in the calves during the first one and a half hours after treatment.

Alternatively, if it is assumed that novelty and not noxiousness was the cause of the majority of unique behaviours seen in the docked calves, the question

of whether or not calves exhibit more than one type of response to perceived noxious stimulation of the tail remains to be addressed. Duncan (1979) has shown in chickens that "flighty" birds reacted to a noxious stimulus with a marked increase in heart rate which returned to pretreatment levels within a few minutes, whereas "docile" birds reacted to the same stimulus with lower more protracted heart rate elevations which were maintained for longer periods. Therefore, if this could be related to calf temperament, those calves that reacted to the ring by running and kicking may produce a marked increase in cortisol which lasts a short time as reported in Chapter Three, whereas calves that attempted to bite their tails, vocalised and tail shook may have produced low protracted elevations in cortisol responses (Chapter Three) or vice versa. Both these types of cortisol responses were seen after tail docking with the docking iron, and could not be adequately explained. The absence of both these responses, with respect to the cortisol concentrations, in calves docked with the rubber ring (Chapter Three) could have occurred by chance. Presumably the distinction observed in chickens may also occur in calves, although no such observations have been published. Simultaneous observations of plasma cortisol and behaviour in calves are required to elucidate the situation.

In the present study, the remaining five of the 15 *ring* calves that did not display any unique behaviours may not have responded behaviourally because they did not feel any pain, discomfort or novelty of the ring on their tails, or they did feel novel sensations but, for some unknown reason, did not respond to them behaviourally.

In the majority of calves some behaviours such as standing, lying, grazing and ruminating were apparently unaffected by treatment. It is well documented that cattle tend to exhibit allomimetic behaviour (Kilgour and Dalton, 1984; Hart, 1985). For instance, they will all graze and rest at the same time (Hancock, 1950; Fraser and Broom, 1990). This is consistent with the observations in this study where all calves followed a similar grazing and standing pattern.

Changes in feeding and ruminating behaviour in cattle are considered to provide good evidence to indicate periods of distress (Blood and Radostits, 1989a; Fraser and Broom, 1990). Ruminating behaviour was observed after all treatments although only a small proportion of calves actually displayed this behaviour. This was not unexpected in this case as the routine pattern of grazing and ruminating was disrupted when the calves were removed from the paddock for two and half hours in the morning, a time when they would normally have been grazing (Fraser and Broom, 1990). Hence once the calves were returned to the paddock they spent most of the time grazing, when normally they might have been ruminating.

It is noteworthy that ruminating behaviour was first observed in the *ring* calves (one out of 15) one hour after treatment. It is therefore unlikely that these particular calves were experiencing marked distress, as ruminating is thought to cease in times of pain or marked distress (Blood and Radostits, 1989b).

#### **4.41 Criticism of experimental design.**

Instantaneous scan sampling is not always suitable for recording behaviours of short duration, like tail shaking and vocalisation, because the behaviour may not be occurring at the instant of any one sample point and therefore could be missed. So all of the calves in this study could have displayed these behaviours, but may not have been noted as doing so. However, the calves displaying tail shaking and vocalisation during the scan samples were the same animals seen tail shaking and vocalising during continuous observation, including the video recording. Problems with instantaneous sampling, where the behaviour is recorded at a fixed time interval, occurred in a study on lambs (Mellor and Murray, 1989 personal communication) where individual lambs were apparently standing or lying continuously over an observation period when in fact it was known that all lambs stood up and lay down repeatedly during that period.

Continual recording of the behaviour of 15 animals may be difficult. However, only specific listed behaviours were being monitored and the results of the



continuous observations are similar to those from the video recording. If more subtle behaviours were to be recorded, visual observation would have been difficult with a group of this size.

Recording the behaviours of many animals in a reasonably large paddock with a video camera had its problems. The calves often moved out of the range of the video so some behaviours can still be missed.

Another problem that arises with this type of observational study is the way in which the data are recorded as being present or absent. In present/absent data collection, each behaviour is either there or not, so it is difficult to determine the intensity of a behaviour and to establish whether the behaviour goes outside the "normal" range as may be established for example with heart rate and plasma cortisol concentrations. Thus, more information might have been gained if the intensity of grazing behaviour (the amount of grass consumed per unit time) could have been recorded rather than sampling whether the calf was seen grazing or not. This would have enabled grazing or "sham-grazing" (animals that appear to be grazing but are not actually consuming much) to be distinguished.

The major limitation was that the cortisol and behaviour studies were not carried out at the same time. Therefore many of the discussion points are only speculative as more information is required before adequate answers are known with respect to the behavioural indicators of distress.

## **4.5 CONCLUSIONS**

The unique behaviours observed following the application of a rubber ring and when the local anaesthetic wore off were likely to be caused by the novelty of the stimulus experienced by these calves. These behaviours included calves tail shaking, vocalisation, restlessness and attempting to bite their tails, . However, some very obvious unique behaviours such as kicking with the hind legs and running may have been indicative of pain-induced

distress. The unique behaviours were not seen one and a half hours after docking , in the *ring* calves, so that any distress which might be caused by tail docking with the rubber ring is likely to be short-lived. The general conclusion is therefore that tail docking caused little distress in most three to four month old female Friesian dairy calves, and that any mild distress caused in a minority of calves is of short duration.

## **SECTION TWO**

### **CHAPTER FIVE:**

### **DISBUDDING IN CALVES; EFFECTS ON THE CORTISOL RESPONSES OF TWO METHODS USED WITH OR WITHOUT LOCAL ANAESTHETIC .**

#### **5.1 INTRODUCTION**

Dehorning of cattle is regularly carried out on New Zealand farms. Dehorning of dairy calves is carried out within a few weeks of birth until 18 months of age usually without the use of local anaesthetic. Dehorning in young calves with minimal horn development is known as disbudding. It is an offence under the Animals Protection Act 1960 to dehorn cattle over 20 months of age unless during the whole course of the operation general or a local anaesthetic is used. The purpose of dehorning is to minimise carcass and hide damage and injury to stock and stockhandlers (Fox, 1984; Armstrong, 1985). However, the welfare of the cattle being dehorned needs to be taken into consideration.

The methods of dehorning/disbudding include either amputation, using a variety of implements, for example, scoop, saw, shears or embryotomy wire, or alternatively the germinal tissue of the horn bud is destroyed by cautery (hot iron) or corrosive chemicals (caustic paste or caustic pencil; Bruce *et al.*, 1992). All methods involve tissue damage and presumably afferent nerve discharge from nociceptors. The noxious stimulation created by the different dehorning methods is assumed to cause distress.

A range of variables has been used to evaluate the distress caused by noxious procedures. As noted in Chapters 1 and 3, the most commonly used variables are those which indicate changes in the activity of the hypothalamic-pituitary-adrenal axis and include cortisol. Activity of this axis has been shown to increase in animals in response to physically and emotionally noxious experiences such as transport (Crookshank *et al.*, 1979; Kent and

Ewbank, 1983, 1986a,b), handling and restraint (Herd, 1989; Zavy *et al.*, 1992), castration or dehorning of calves (Carter *et al.*, 1983; Cohen *et al.*, 1990; Mellor *et al.*, 1991; Robertson *et al.*, 1993), and castration and/or tailing of lambs (Mellor and Murray, 1989a,b; Lester *et al.*, 1991a,b; Wood *et al.*, 1991; Molony *et al.*, 1993) and kids (Mellor *et al.*, 1991)

Transient increases in plasma cortisol concentrations occur for several hours after surgical tissue removals such as castration and/or tail docking in sheep (Shutt *et al.*, 1988; Mellor and Murray, 1989a,b) and goats (Greenwood and Shutt, 1990, 1992; Mellor *et al.*, 1991), and after dehorning and tail docking in cattle (Wilson, 1972; Carter *et al.*, 1983; Laden *et al.*, 1985; Boandl *et al.*, 1989; Goonewardene and Hand, 1991). These help define the magnitude and duration of the acute distress response to such procedures (Stafford and Mellor, 1993)

In other studies variables such as liveweight gain have been measured for periods of several months to assess possible chronic effects of husbandry tissue removals. Winks *et al.* (1977) concluded that mature Brahman crossbred steers should not be dehorned due to subsequent reductions in live weight gain. In a follow up study, Loxton *et al.* (1982) concluded that there was no reduction in live weight gain after dehorning Brahman crossbred steers at ages ranging from four months to two and a half years. The latter study indicated that the age at dehorning is not critical because an initial reduction in weight in the dehorned cattle was short lived and no persistent effects were evident at maturity. The fact that there was an initial reduction in weight suggested, however, that short term disturbances to the animals' physiological state due to dehorning should be investigated.

Johnston and Buckland (1976) examined dehorning and castration as stressors in a study of the "baseline" and cortisol responses to these common farming procedures applied to male holstein calves. The results of this work showed no marked increase in cortisol levels 15 minutes after the treatment. However no further blood samples were taken until 24 and 48 hours after

treatment, so that responses occurring between those sampling times would not have been detected. A study of the effects of electro-immobilisation on the stress of dehorning and subsequent haemorrhage showed significantly higher cortisol levels in the plasma of all animals dehorned than in controls (Carter *et al.*, 1983). In this study, as before (Johnston and Buckland, 1976), the total cortisol response (i.e. both the magnitude and duration) to dehorning was not adequately defined due to infrequent sampling. In more recent work the cortisol responses to dehorning using cautery, with or without the use of a local anaesthetic, at 7-16 weeks of age were better defined and apparently lasted for about two to three hours (Laden *et al.*, 1985; Boandl *et al.*, 1989). Nevertheless several questions remain to be answered.

First, are the durations of the cortisol responses (as an index of distress) to dehorning by cautery similar in the Holstein calves studied previously (Laden *et al.*, 1985; Boandl *et al.*, 1989) and in Friesian calves which are common in New Zealand? Secondly, does dehorning using a scoop, a common method in older calves (over 6 months of age), elicit a similar or a different (larger or smaller) cortisol response to that which follows the use of cautery? Thirdly, how effective is the use of local anaesthesia in reducing the cortisol responses to dehorning using a scoop or cautery? The present study was designed to address these questions.

## 5.2 MATERIALS AND METHODS

Fifty-five male Friesian calves six to eight weeks old weighing between 35kg and 67.5kg (mean 52.5kg) were investigated during disbudding using standard methods on a Massey University farm. All calves in this study had been scheduled for disbudding according to usual farm practice.

The calves were penned in groups in a open-sided shed with a sawdust floor at 5pm on the day before the study, with 32 and 23 calves respectively being studied on successive days. Groups of approximately a quarter of this size were separated into four 5m x 6m pens for the night. All the calves in this

study were randomly allocated to a treatment. Numbers were sprayed onto the back of every individual for identification purposes, and an additional two to three calves from each group had their torso's clipped and a girth bandage applied to enable the application of heart rate monitors on the study day. Heart rates for 15 calves were evaluated in this way, however these results form part of another research project and are not part of this thesis.

The calves were fed whole milk from a calfeteria (plastic drum with teats) early on the morning of the study but the milk was removed after the first pretreatment blood sample was taken.

On the morning of the study the calves were reassembled into two groups of equal size and were quietly moved into two holding pens (7.5m<sup>2</sup> area each) where blood sampling and disbudding were conducted. Prior to any manipulations blood samples were obtained by venipuncture from all the calves.

### **5.21 Blood sampling**

Blood samples (5ml sample) were taken by venipuncture from either jugular vein. A blood sample was taken 70 minutes before treatment (-70 minutes) from all the calves and a second blood sample (-10 minutes) was taken before the calves were placed in the restraining crush. Further blood samples were taken at 15, 30, 60, 90, 120, 150, 180, 210, 240, 300, 360, 420 and 480 minutes after treatment. On each occasion the calf was restrained firmly, but gently against the wall of the pen by two people, while a third took the sample. The whole procedure from restraint to completion of sampling usually took less than 30 seconds.

Twelve to sixteen calves receiving all of the different treatments were kept together in each of the two holding pens. The blood sampling time for each calf was related to the time of treatment as indicated above. However, individual calves for bleeding had to be identified, restrained and bled within each holding pen. The order of bleeding the calves in each pen was the

same on each occasion.

## 5.22 Treatments

There were seven treatment groups (Table 5.1). All treatments were conducted while each calf was restrained in a standard commercial crush (incorporating head and nose restraint and a rear chain; Te Pari Products) for two minutes, even when the precise procedure took less time. Blood samples were taken according to the above schedule in each case.

### **Control (*control*) n=8**

Calves were handled to simulate disbudding without any tissue removal occurring. Four control calves were studied on the first and another four on the second experimental day.

### **Local anaesthetic control (*LA control*) n=8**

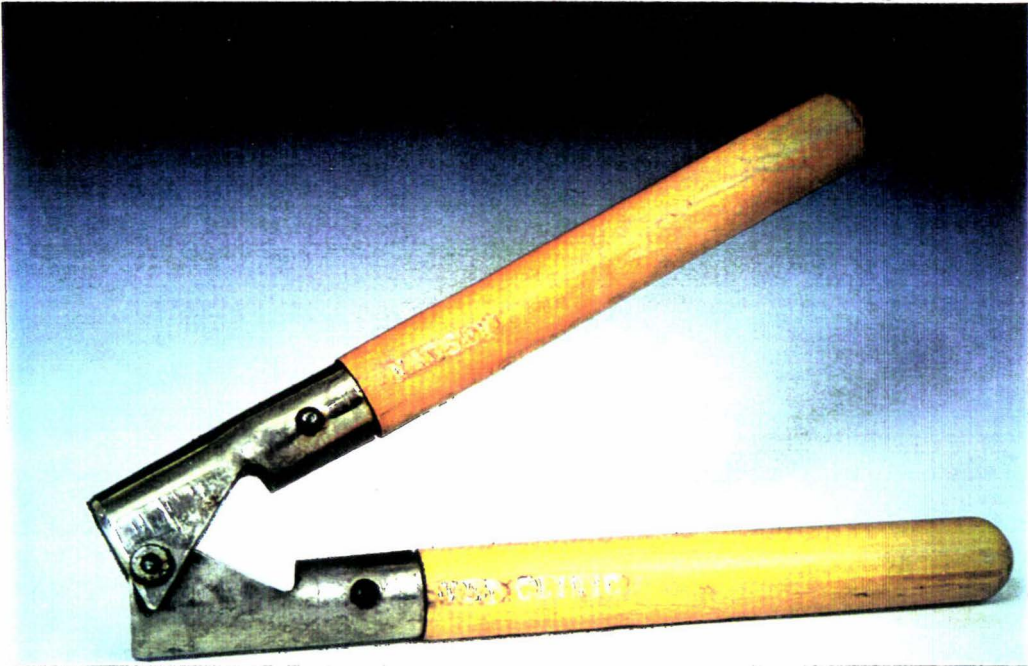
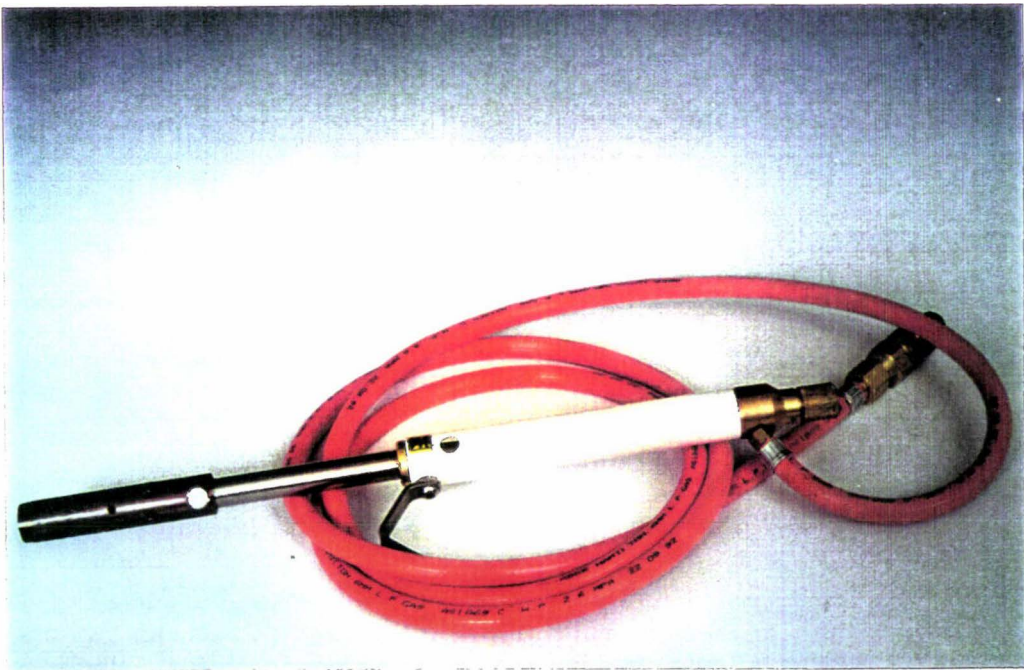
Calves were administered with a local anaesthetic (2% lignocaine hydrochloride 3ml per horn; Ethical Agents Ltd, South Auckland) around each cornual nerve 20 minutes prior to being restrained in the crush where disbudding was simulated but not carried out. The cornual nerve was sought where it crosses the prominent ridge of the temporal line, approximately midway between the postorbital bar and the horn (Dyce *et al.*, 1987). Loss of sensation occurs after 10-15 minutes (Hall, 1971a). Effectiveness of the local anaesthetic was tested by pricking the skin around the horn bud and watching the animal's response. In this way it was possible to estimate the duration of action of the local anaesthetic on the cutaneous area adjacent to each horn bud.

### **Scoop (*scoop*) n=8**

The calves were placed in the restraining crush and their horn buds removed with a standard dehorning scoop (Barnes Dehorner, Stones, U.S.A.). The scoop (Fig 5.1A) consisted of two interlocking semi-circular blades (radius 20mm) which when engaged removed the germinal tissue of the horn and some of the adjacent skin. The amount of removed skin depended on the bite

TABLE 5.1:			
Mean +/- SEM of the plasma cortisol concentrations, 70 minutes before treatment			
Treatment	n	Mean	S.E.M.
		(ng/ml)	
Control	8	5.45	1.06
LA control	8	5.20	1.41
Scoop	8	4.38	0.18
LA + scoop	8	5.93	2.36
Cautery *	7	1.77	0.31
LA + cautery	8	3.84	0.63
ACTH *	8	1.80	0.39
* Significantly different from control calves			



**A****B**

**Fig 5.1:** Equipment used in this study to disbud the horns of the calves  
(A) Scoop (Barnes dehorners, U.S.A.)  
(B) Gas heated cautery iron (Te Pari Products, Palmerston North)

of the scoop which was itself variable because of head movement and different sizes of the horn bud.

#### **Local anaesthetic and scoop (*LA + scoop*) n=8**

Local anaesthetic was administered 20 minutes before the horn buds were removed with the scoop as described above.

#### **Cautery (*cautery*) n=7**

Calves were moved into the restraining crush and the germinal tissue of the horn buds was cauterised using a purpose built, gas-heated disbudding iron (Te Pari Products, Palmerston North). The copper head had a diameter of 1.8cm and had cone shaped indentation 2cm deep (Fig 5.1). The iron was held firmly over the horn bud for about 10 seconds to cauterise the germinal tissue, after which the horn bud was left to drop off of its own accord.

#### **Local anaesthetic and cautery (*LA + cautery*) n=8**

Local anaesthetic was administered 20 minutes before the horn buds were cauterised as described above.

#### **Adrenocorticotrophic hormone injection (*ACTH*) n=8**

The calves were placed in the restraining crush for two minutes, during which time they were injected with 0.31mg of synthetic ACTH (Synacthen; Ciba Pharmaceutical, Auckland) into a jugular vein to elicit a high cortisol response.

### **5.23 Plasma cortisol assay**

Blood samples were collected in lithium heparinised vacutainers, chilled immediately, centrifuged and the plasma stored at -20°C until required. Plasma cortisol concentrations were determined by radio-immunoassay (Chapter Three); the lowest detectable concentration was 0.3ng/ml and the intra-assay and inter-assay coefficients of variation were 9.5% and 16.3%, respectively.

### 5.24 Integrated cortisol response

In order to give a single measure of both the magnitude and the duration of any increases in plasma cortisol concentrations after a treatment, the integrated cortisol responses were calculated. The integrated cortisol response is defined as the area between a horizontal line drawn through the pretreatment concentration (at -70 minutes) and the cortisol response curve during defined periods after treatment when the concentrations were greater than the pretreatment value (Mellor and Murray, 1989b).

### 5.25 Statistical analyses

Where applicable the cortisol results have been expressed as the mean  $\pm$  standard error of the mean (SEM). Significant differences between means were determined by two-way analysis of variance with the Fischer probability of least significant difference (PLSD) coefficient to compare treatment values at each time point (StatView SE+Graphics, version 1.03, 1988 Abacus Concepts Inc.). A probability of  $P < 0.05$  or less was considered to be a significant difference. To correct for individual variation of the pretreatment cortisol concentration, the pretreatment concentration was subtracted from the entire cortisol response curve. Two-way analysis of variance with the Fischer PLSD coefficient was also used to determine whether there were significant changes with time after each treatment and to detect significant differences between the integrated cortisol responses.

## 5.3 RESULTS

Except where otherwise stated, all results in this section refer to plasma cortisol concentrations adjusted by subtracting the pretreatment value.

The cortisol responses of the control calves studied on each of the two experimental days were compared to check for differences between the two days. No differences were found so the results from all control calves were pooled.

The order in which the calves were bled had no significant effect on plasma cortisol concentration at each sampling time. Figure 5.2 illustrates the relationship of bleeding order and cortisol concentration for the -70 minute sample. Similar analyses of the effects of bleeding order on the cortisol concentration in later blood samples also resulted in nonsignificant outcomes.

The mean  $\pm$  SEM plasma cortisol concentrations at -70 minutes for calves receiving each treatment are shown in Table 5.1 and Fig 5.3. There were significant between group differences in the mean concentrations. The *control* calves had a significantly greater ( $P<0.001$ ) cortisol concentration than *cautery* and *ACTH* calves. In addition, *LA control* calves had significantly greater cortisol concentrations ( $P<0.05$ ) than both *cautery* and *ACTH* calves.

The majority of calves receiving each treatment showed transient rises in plasma cortisol concentrations, the magnitudes and durations of which varied with the treatment.

### **Control**

Restraint and simulated disbudding in the crush were followed by a small but significant transient rise in the mean plasma cortisol concentration. The mean concentration increased by about 5 ng/ml before returning to pretreatment values 30 minutes after treatment (Fig 5.5). Thereafter all mean concentrations were similar to pretreatment values except at 8.5 hours.

The individual calves exhibited a similar pattern of change in cortisol concentration to that of the mean *control* values, except for three calves in which the plasma cortisol concentration remained close to pretreatment levels throughout the 11 hour sampling period.

### **LA Control**

The mean pattern of change in plasma cortisol concentration in the *LA control* calves (Fig 5.6) was similar to the pattern exhibited by the *control* calves (Fig

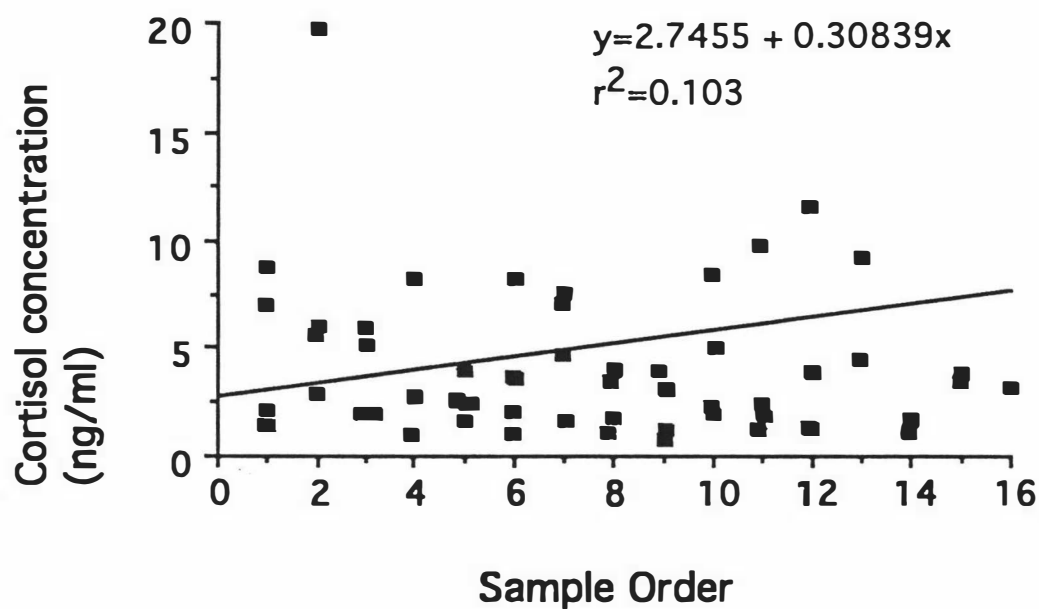


Fig 5.2: Relationship between plasma cortisol concentration and the sample order for the pretreatment blood sample.

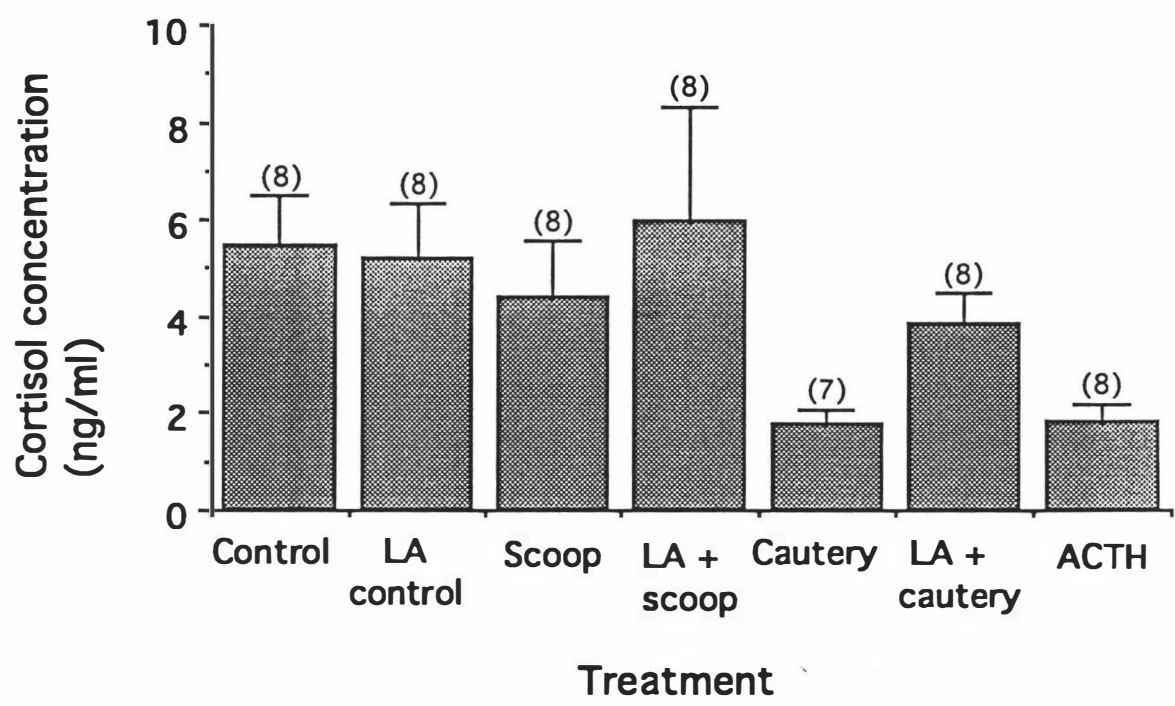


Fig 5.3: Pretreatment plasma cortisol concentration in calves of the seven treatment groups (mean + SEM). Sample sizes are in brackets above columns.

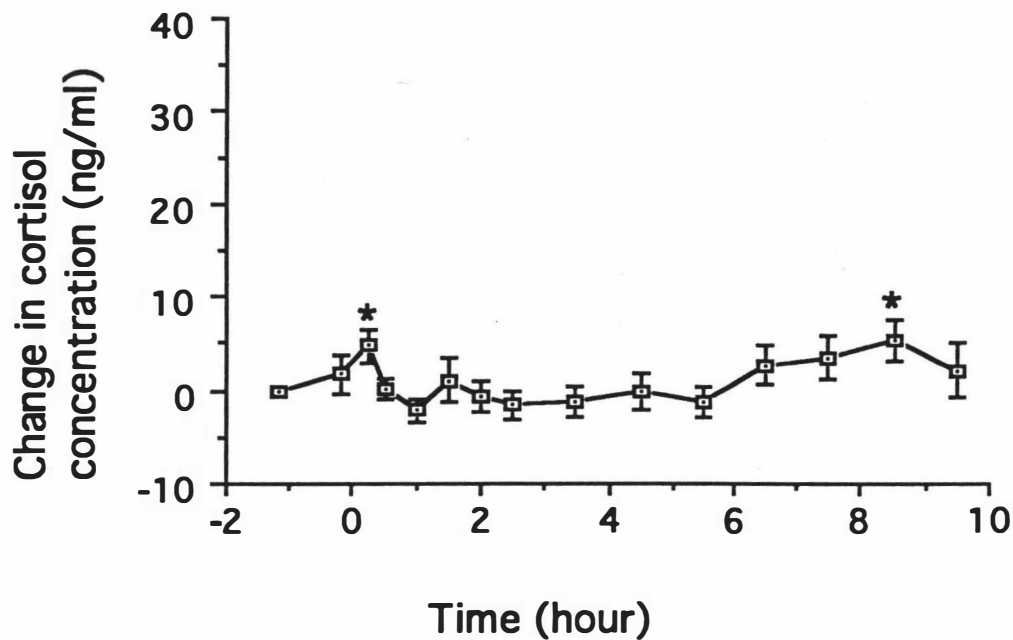


Fig 5.5: Changes in plasma cortisol concentration in response to control handling (mean  $\pm$  SEM).  $n=8$ . Time 0 represents time of dehorning. \* significantly different from 0 ng/ml ( $P<0.05$ ).

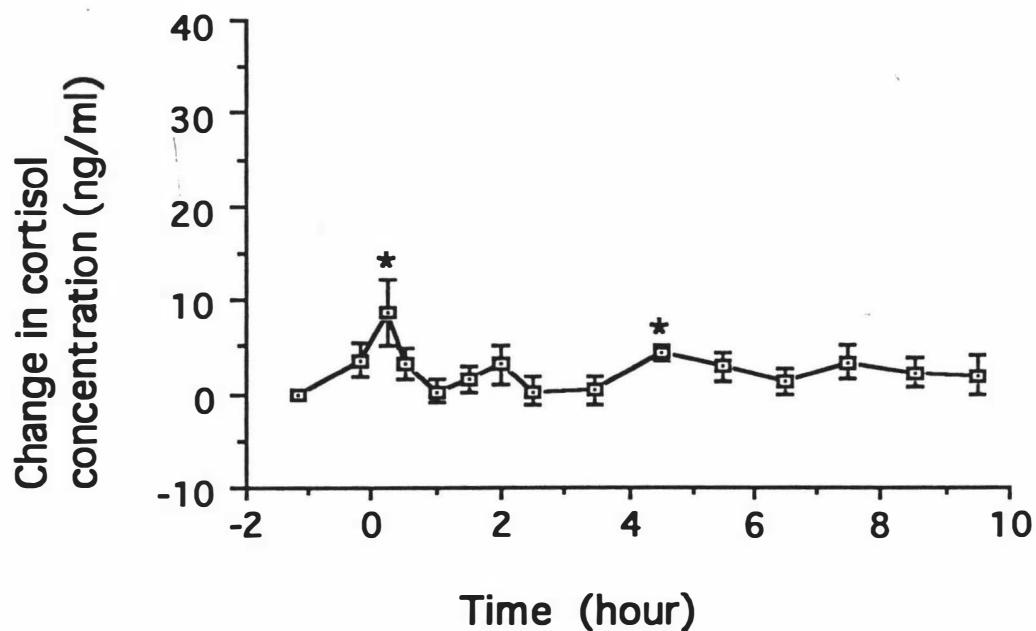


Fig 5.6: Change in plasma cortisol concentration in calves in response to LA administration (mean  $\pm$  SEM).  $n=8$ . Time 0 represents time of dehorning. \* significantly different from 0 ng/ml ( $P<0.05$ ).

5.5). A mean increase in plasma cortisol of about 9ng/ml occurred 15 minutes after treatment but as with the *control* calves, cortisol concentrations returned to pretreatment levels by about 30 minutes. Three of the eight *LA control* calves did not show a transient rise in cortisol concentration after restraint, local anaesthetic administration and simulated disbudding in the crush.

It is of interest to compare the cortisol responses of all calves which did (n=24) and did not (n=31) receive local anaesthetic 20 minutes before treatment (Fig 5.4). The mean concentrations of cortisol in the two categories were similar in local anaesthetic and non-local anaesthetic calves at -70 minutes and at -10 minutes. Administration of local anaesthetic therefore did not apparently affect the cortisol levels of calves prior to treatment.

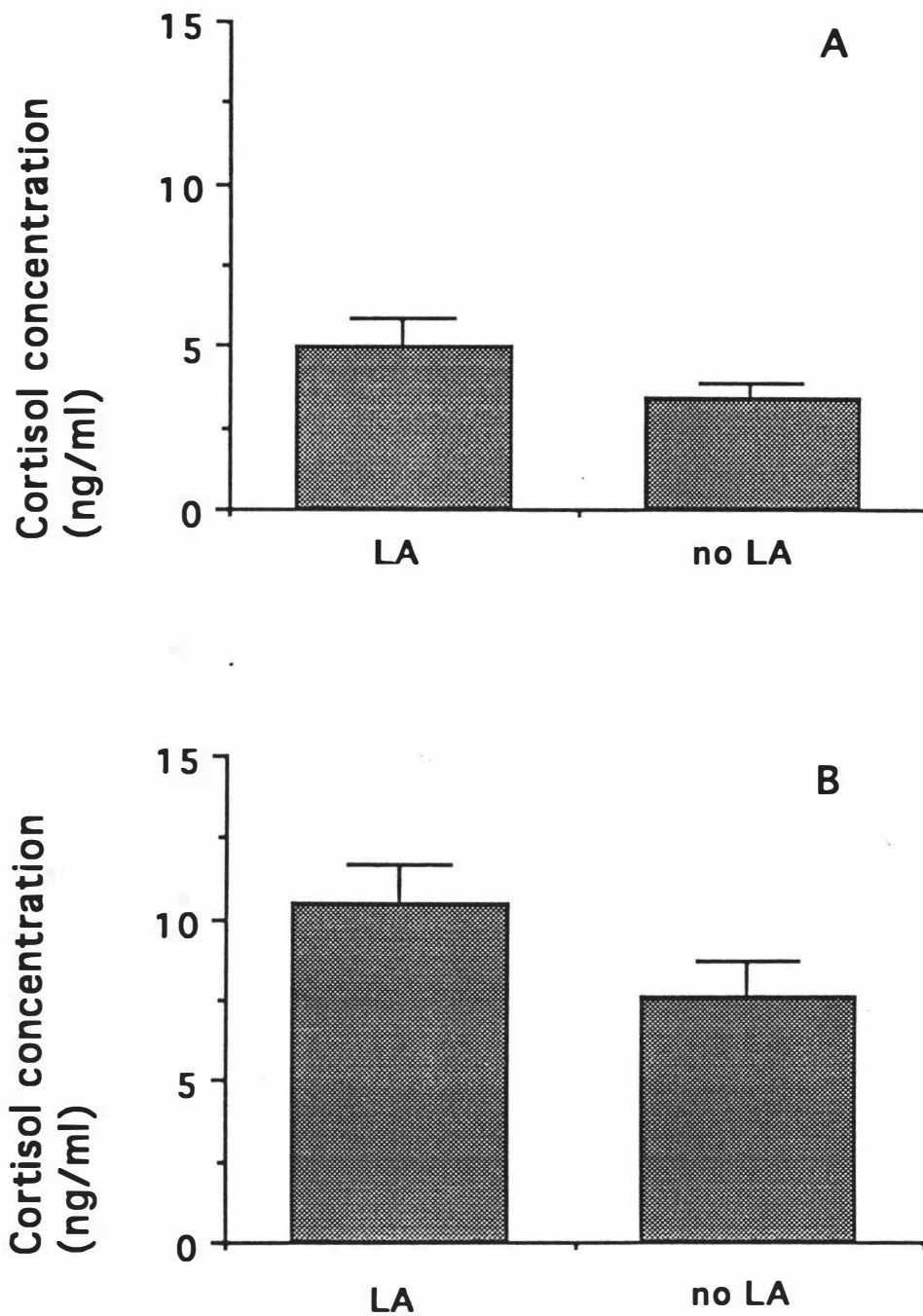
### **Scoop**

Disbudding with the *scoop* caused a marked transient rise in mean cortisol concentration followed by a fall to plateau values which were sustained until at least five hours after treatment (Fig 5.7). The mean concentration returned to control values by 6.5 hours (Fig 5.13). One of the *scoop* calves showed an initial rise of only 10 ng/ml compared to the mean rise for the group of 28ng/ml.

### **LA + Scoop**

In the *LA + scoop* calves there was a small but significant transient rise in plasma cortisol concentrations which returned to control levels 30 minutes after treatment (Fig 5.8). This was followed by a more significant and protracted rise in plasma cortisol concentration which then returned to *LA control* levels by 7.5 hours after disbudding (Fig 5.14). During the first two hours after treatment the mean cortisol concentrations in *LA + scoop* calves were not significantly different from those in either the *control* or the *LA control* calves (Fig 5.14). Two of the individuals in the *LA + scoop* group had different patterns of cortisol responses from that indicated by the mean. One of these calves exhibited little or no change in plasma cortisol concentration





**Fig 5.4:** Plasma cortisol levels in calves with or without the administration of LA.  
(A) 70 minutes before treatment  
(B) 10 minutes before treatment and in LA calves 10 minutes after local anaesthetic administration.

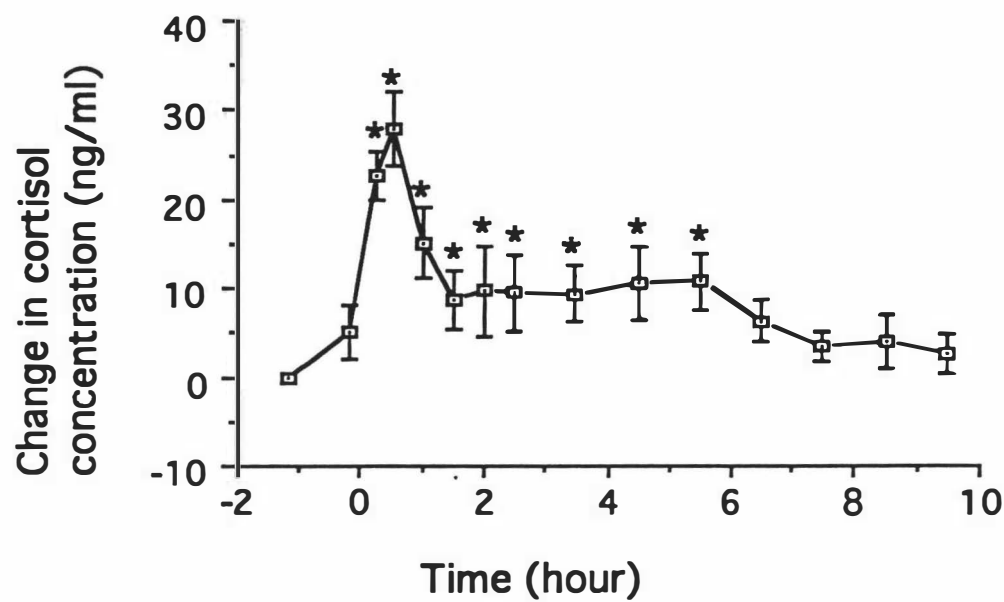


Fig 5.7: Change in plasma cortisol concentration in calves in response to the scoop ( mean  $\pm$  SEM). n=8. Time 0 represents time of dehorning. \* significantly different from 0 ng/ml ( $P<0.05$ ).

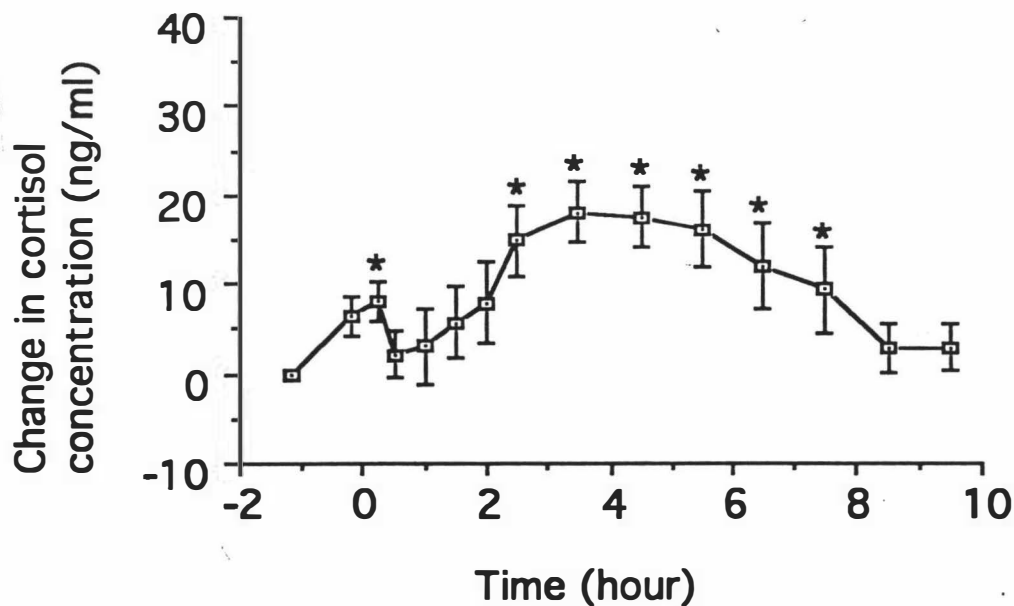


Fig 5.8: Change in plasma cortisol concentration in calves in response to LA + scoop ( mean  $\pm$  SEM). n=8. Time 0 represents time of dehorning. \* significantly different from 0 ng/ml ( $P<0.05$ ).

over the entire sampling period. The other calf responded with a more marked initial transient rise of 25ng/ml compared to the mean for all calves of about 8ng/ml.

### **Cautery**

The calves disbudded by cautery had an initial transient rise in mean plasma cortisol concentration of about 18ng/ml at 15 to 30 minutes after treatment (Fig 5.9). This rise in concentration was significantly greater than that of the *control* calves until one hour after treatment (Fig 5.15). Thereafter cortisol concentrations in *cautery* calves did not differ significantly from *control* values. No marked individual variation occurred within this group.

### **LA + Cautery**

*LA + cautery* resulted in a small transient rise of about 12ng/ml in the mean plasma cortisol concentration which returned to pretreatment levels 60 minutes after disbudding (Fig 5.10). Over the entire sampling period the mean concentration in *LA + cautery* calves were not significantly different from either those in the *control* or the *LA control* calves (Fig 5.16). One individual in the *LA + cautery* group showed a marked and transient initial rise in cortisol concentration.

### **ACTH**

A marked transient rise in plasma cortisol concentration was detected 15 minutes after the ACTH injection (Fig 5.11). The mean concentration reached a peak within 30 minutes and these high levels were maintained until two hours after treatment after which time they began to decrease. From four and a half hours post treatment the mean concentration was not significantly different from the *control* values (Fig 5.12).

## **5.31 Comparison of groups**

### **Scoop and LA + scoop**

The initial marked transient rise in the plasma cortisol concentration of the *scoop* calves was virtually absent in the *LA + scoop* calves, as reflected by

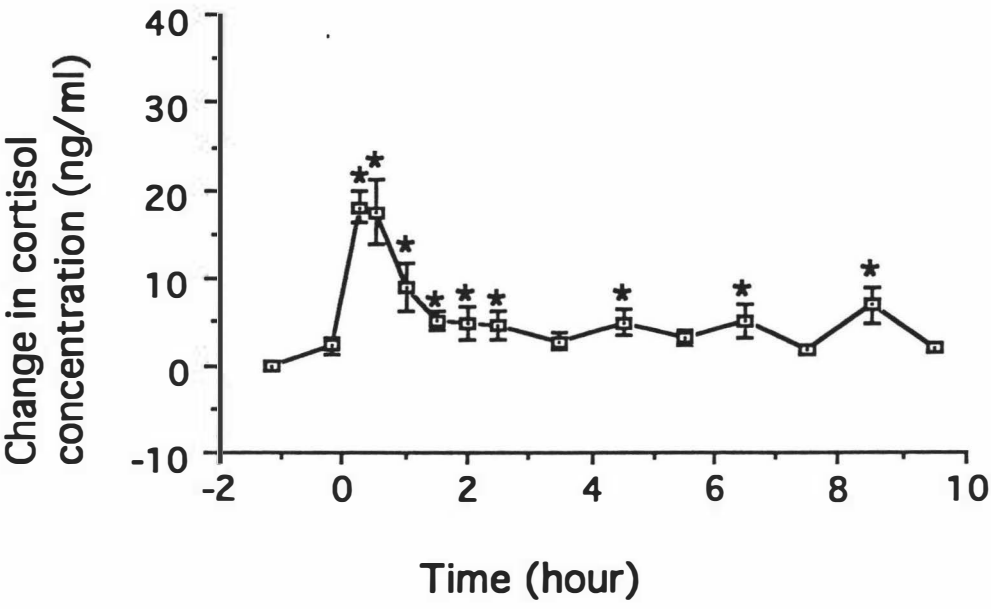


Fig 5.9: Change in plasma cortisol concentration in calves in response to cautery (mean  $\pm$  SEM).  $n=7$ . Time 0 represents time of dehoming. \* significantly different from 0 ng/ml ( $P<0.05$ ).

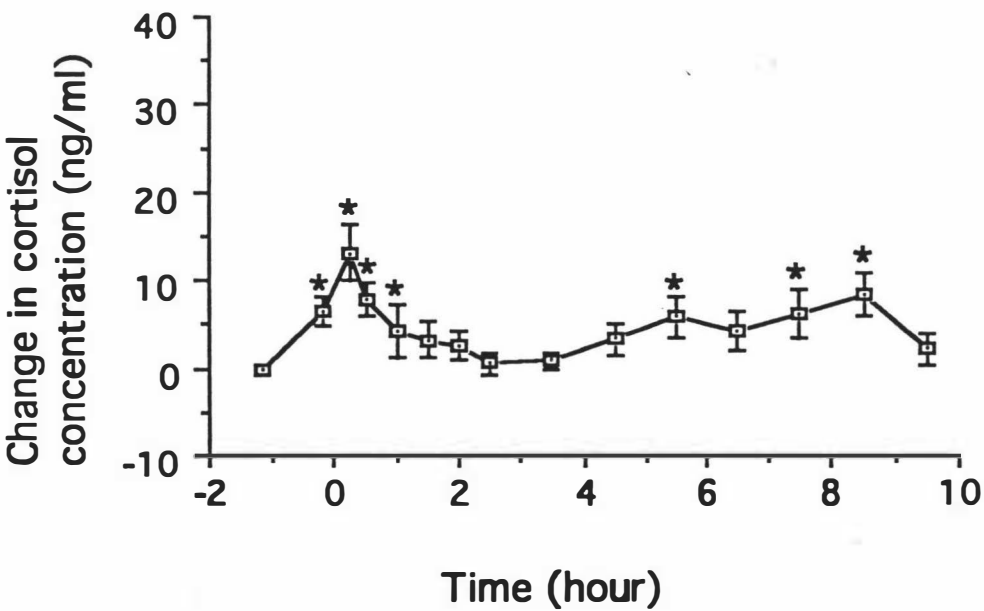


Fig 5.10: Change in plasma cortisol concentration in calves in response to LA + cautery (mean  $\pm$  SEM).  $n=8$ . Time 0 represents time of dehoming. \* significantly different from 0 ng/ml ( $P<0.05$ ).

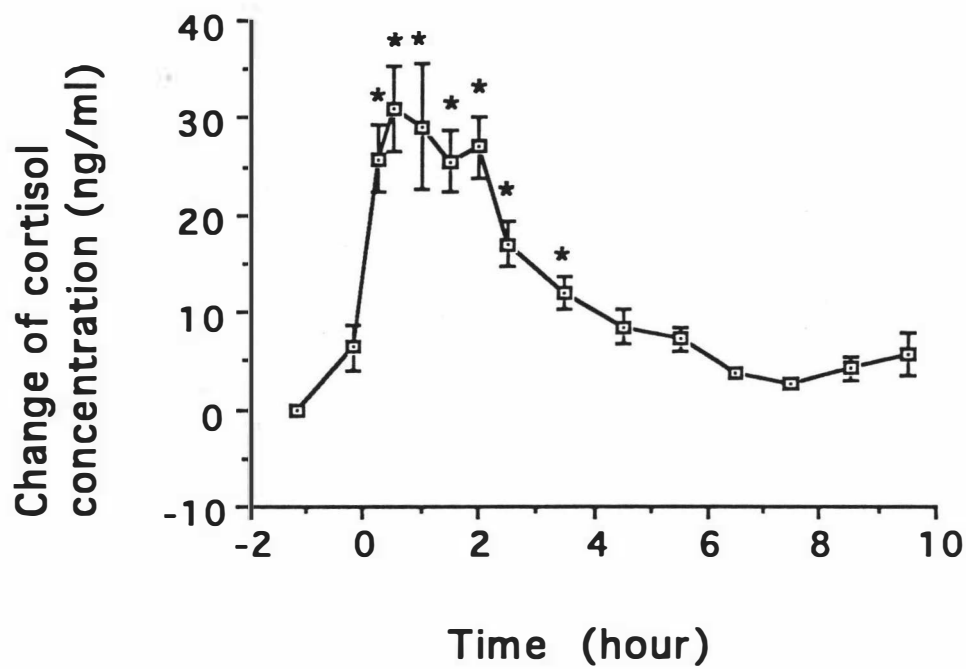


Fig 5.11: Change in plasma cortisol concentration in calves in response to ACTH. (mean  $\pm$  SEM). n=8. Time 0 represents time of dehorning. \* significantly different from 0 ng/ml ( $P<0.05$ ).

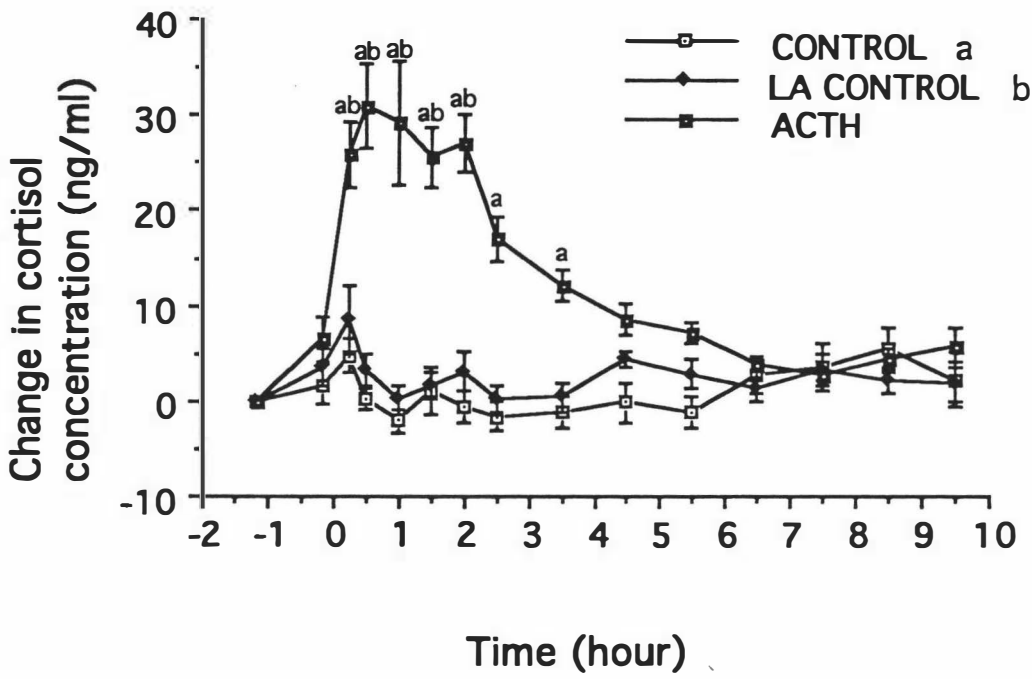


Fig 5.12: Change in plasma cortisol concentration in calves in response to control handling, LA administration and ACTH challenge (mean  $\pm$  SEM).  $n=8$ . Time 0 represents time of dehorning. Means with different superscripts differ significantly ( $P<0.05$ ). a=control, b=LA control

the significantly greater concentrations in the former group between 15 minutes and 60 minutes after treatment (Fig 5.17). In contrast, between two and a half and eight and a half hours after treatment the mean concentrations were generally higher in the *LA + scoop* calves, but only significantly so at three and a half hours (Fig 5.17).

### **Cautery and LA + cautery**

The mean plasma concentrations of cortisol in the *cautery* and *LA + cautery* calves were not significantly different during the entire sampling period (Fig 5.18).

### **Scoop and Cautery**

The mean plasma concentrations of cortisol in the *scoop* and *cautery* calves were not significantly different during the entire sampling period (Fig 5.19).

## **5.32 Integrated cortisol responses**

The integrated cortisol responses (areas under the cortisol concentration curves) were calculated for three periods:

- 1) from 70 minutes before to 9.5 hours after treatment (Fig 5.21);
- 2) from 70 minutes before to two hours after treatment (Fig 5.20A), and
- 3) from two hours until nine and a half hours after treatment (Fig 2.20B).

The results are summarised in Tables 5.2, 5.3 and 5.4.

### **Control and LA control**

The integrated cortisol responses over the whole nine and a half hours of observation for the *control* ( $1590 \pm 517$ ) and *LA control* ( $1821 \pm 470$ ) calves were not significantly different (Fig 5.21). Similarly, no significant between-group differences in the responses were found for the first two hours or the subsequent seven and a half hours after treatment (Fig 5.21A and B).

### **Scoop and LA + scoop**

The integrated cortisol responses for the *scoop* ( $5513 \pm 1206$ ) and *LA + scoop* ( $6115 \pm 1441$ ) calves were not significantly different over the entire

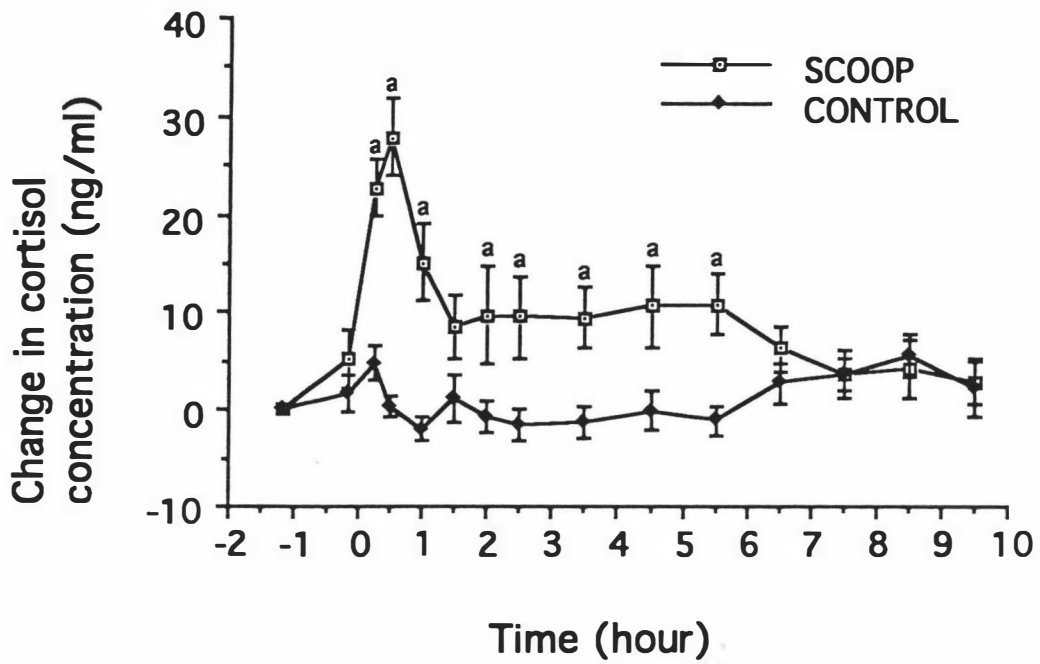


Fig 5.13 : Change in plasma cortisol concentration in calves in response control handling and scoop (mean  $\pm$  SEM).  $n=8$ . Time 0 represents time of dehorning. Means with different superscripts differ significantly ( $P<0.05$ ). a=control, c=scoop

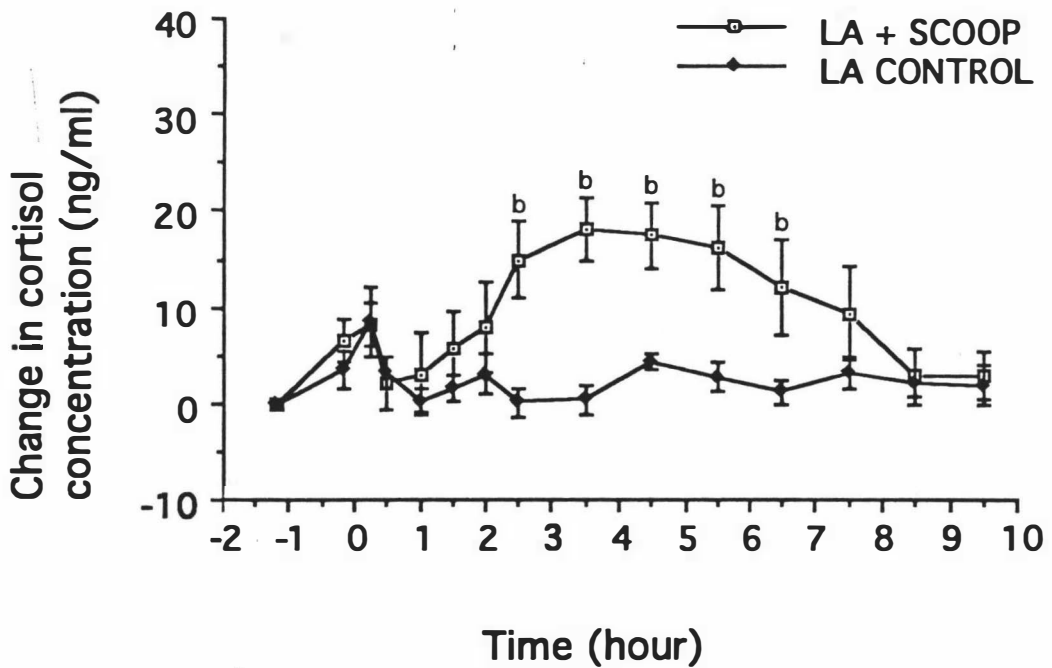


Fig 5.14: Change in plasma cortisol concentration in calves in response to LA administration and LA + scoop (mean  $\pm$  SEM).  $n=8$ . Time 0 represents time of dehorning. Means with different superscripts differ significantly ( $P<0.05$ ). b=LA control, d=LA + scoop



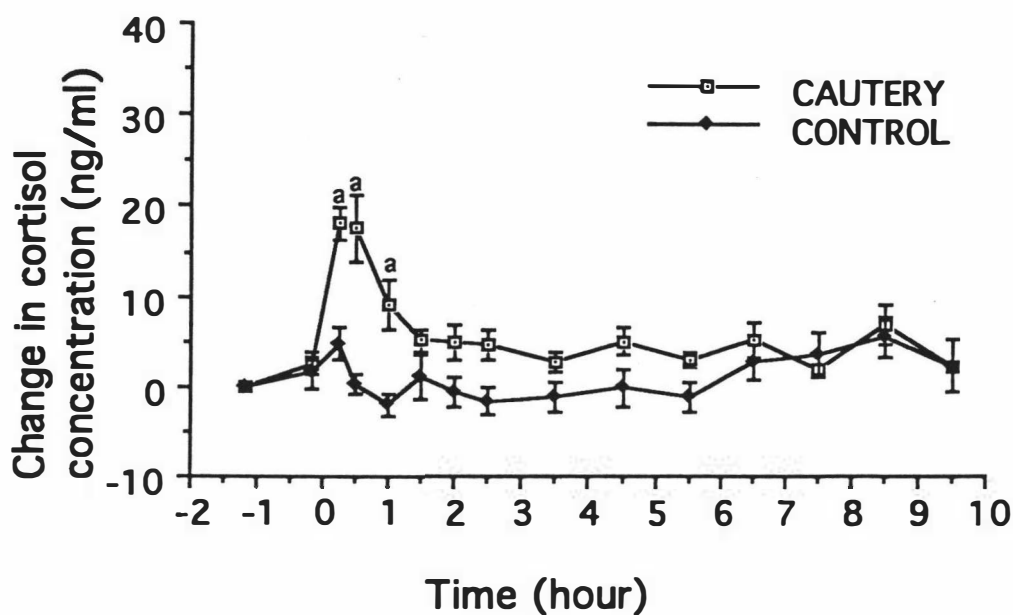


Fig 5.15: Change in plasma cortisol concentration in calves in response to control handling and cautery (mean  $\pm$  SEM).  $n=8$  (control) and 7 (cautery). Time 0 represents time of dehorning. Means with different superscripts differ significantly ( $P<0.05$ ). a=control

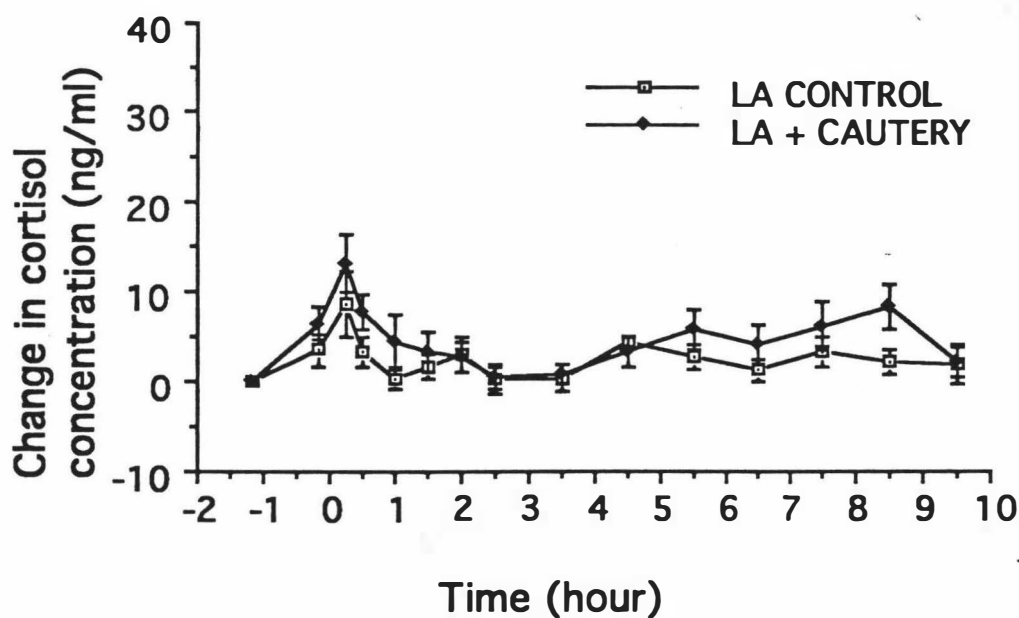


Fig 5.16: Change in plasma cortisol concentration in calves in response to LA administration and LA + cautery (mean  $\pm$  SEM).  $n=8$ . Time 0 represents time of dehorning.

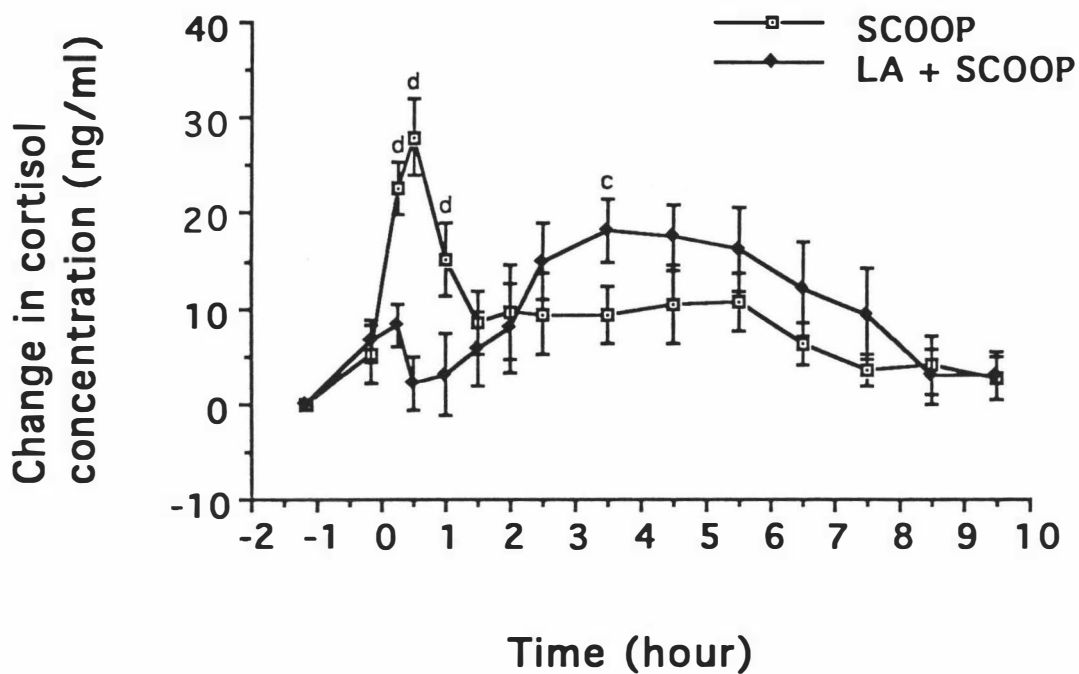


Fig 5.17: Change in plasma cortisol concentration in calves in response to scoop and LA + scoop (mean  $\pm$  SEM).  $n=8$ . Time 0 represents time of dehorning. Means with different superscripts differ significantly ( $P<0.05$ ). c=scoop, d=LA + scoop

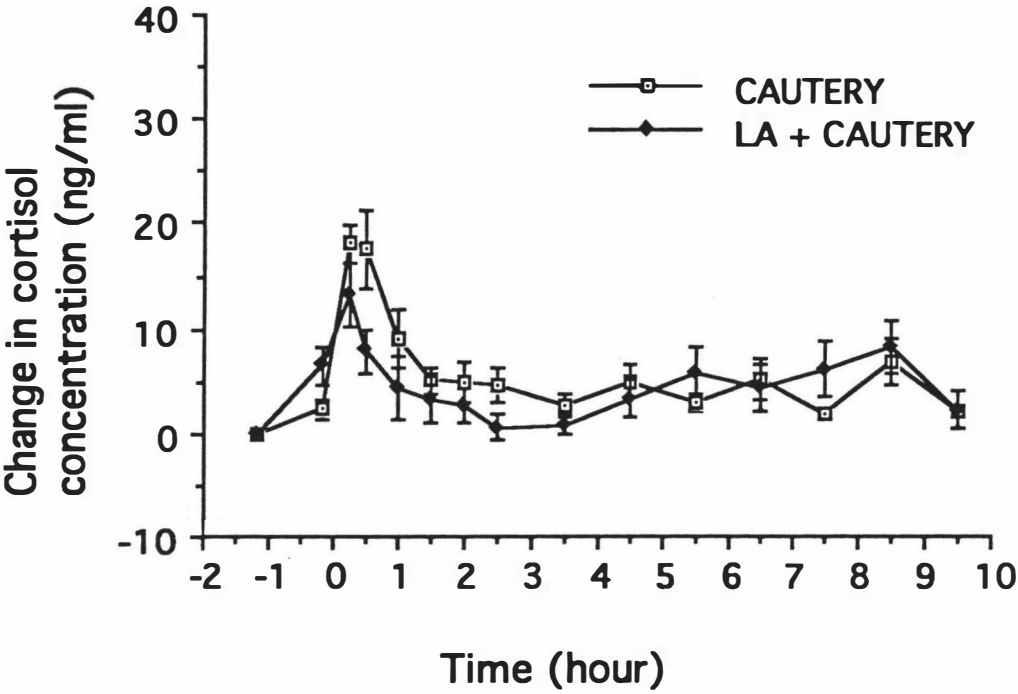


Fig 5.18: Change in plasma cortisol concentration in calves in response to cautery and LA + cautery (mean  $\pm$  SEM) n=8. Time 0 represents time of dehorning.

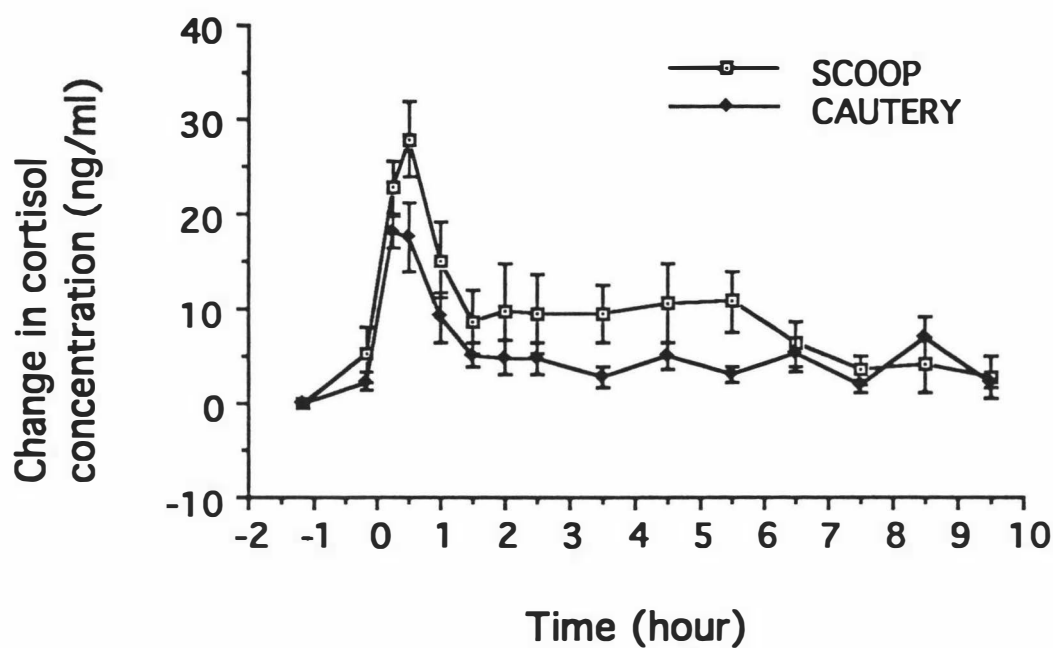


Fig 5.19: Change in plasma cortisol concentration on calves in response to scoop and cautery (mean  $\pm$  SEM).  $n=8$  (scoop) and  $n=7$  (cautery). Time 0 represents time of dehorning.

sampling period (Fig 5.21). During the first two hours the response in the *LA + scoop* calves was not significantly different from those of either *control* or *LA control* calves (Fig 5.21A). However the response of the *scoop* calves was significantly greater than that of *LA + scoop* calves over the first two hours of the study (Fig 5.21A), but not during the subsequent seven and a half hours (Fig 5.21B). After two hours, the greatest response was seen in the *LA + scoop* calves, which was significantly greater ( $P < 0.05$ ) than *control*, *LA control*, *cautery* and *LA + cautery* calves.

### **Cautery and LA + cautery**

The integrated cortisol responses over the whole nine and a half hours of observation for *cautery* ( $3069 \pm 577$ ) and *LA + cautery* ( $3139 \pm 740$ ) calves were not significantly different (Fig 5.20). However the response to *cautery* alone was significantly greater than the responses of both the *control* and the *LA control* groups during the first two hours after treatment (Fig 5.21A), but was not different over the subsequent seven and a half hours (Fig 5.21B). The response to *LA + cautery* was only significantly greater than that of the *control* calves during the first two hours after treatment (Fig 5.21A).

### **5.33 Comparison of all treatments**

No significant differences in integrated cortisol responses were demonstrated between calves disbudded with the scoop compared with the cauterising iron over the entire nine and a half hours of observation (Fig 5.21). However, the *scoop* calves had significantly greater responses than *control*, *LA control*, *LA + scoop*, *cautery* and *LA + cautery* calves during the first two hours after disbudding (Fig 5.20A). Thereafter (between two and nine and a half hours) the response of *LA + scoop* calves was significantly greater than those of both the *cautery* and *LA + cautery* calves, but not significantly different from *scoop* calves.

## **5.4 DISCUSSION**

Using changes in plasma cortisol concentrations as an index of distress, the

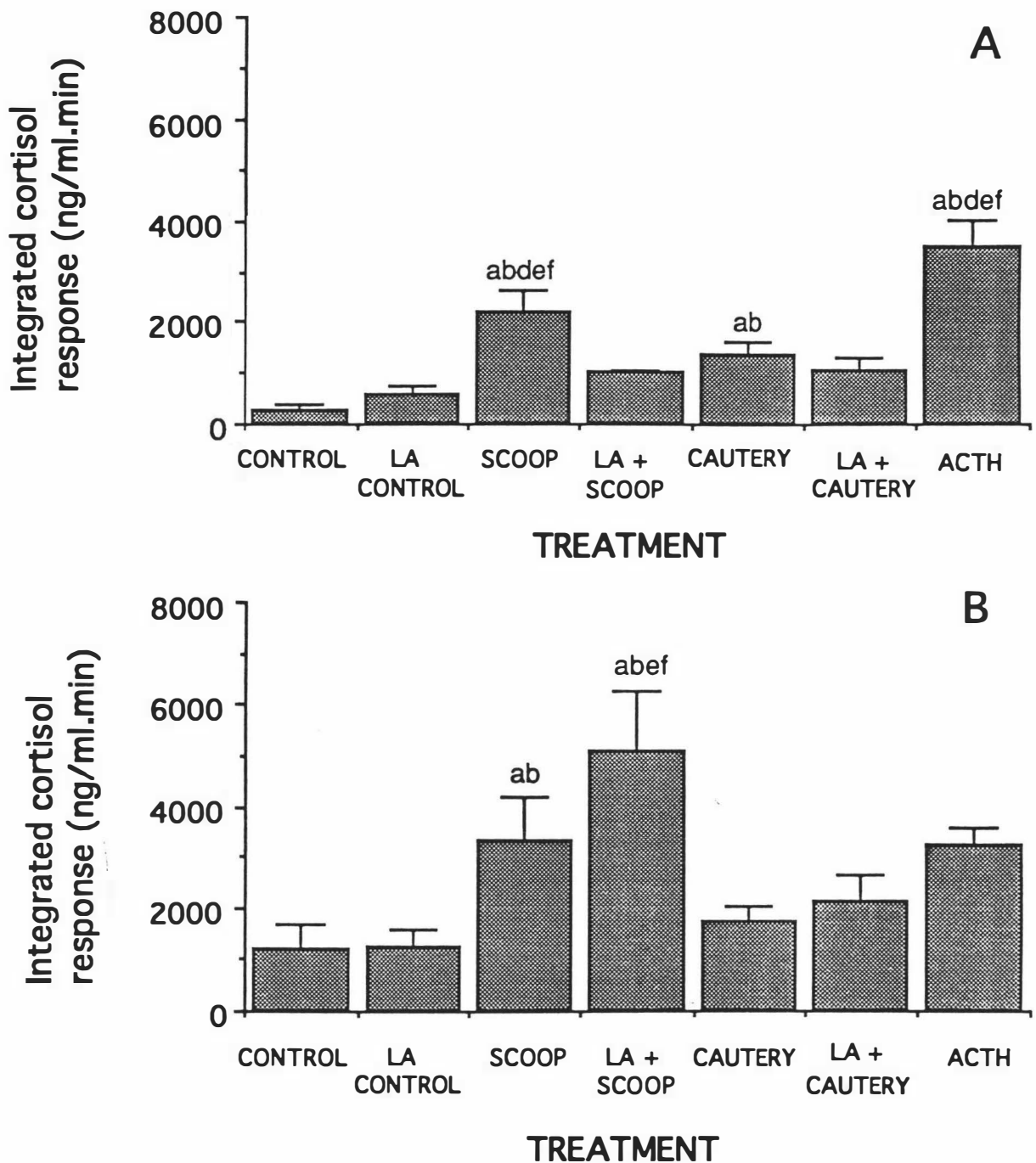


Fig 5.20: Integrated cortisol responses in calves to different treatments (mean  $\pm$  SEM) for the first 2 hours (A) and the final 7.5 hours (B). Means with different superscripts differ significantly ( $P < 0.05$ ).

- a - control
- b - LA control
- c - scoop
- d - LA + scoop
- e - cautery
- f - LA + cautery
- g - ACTH

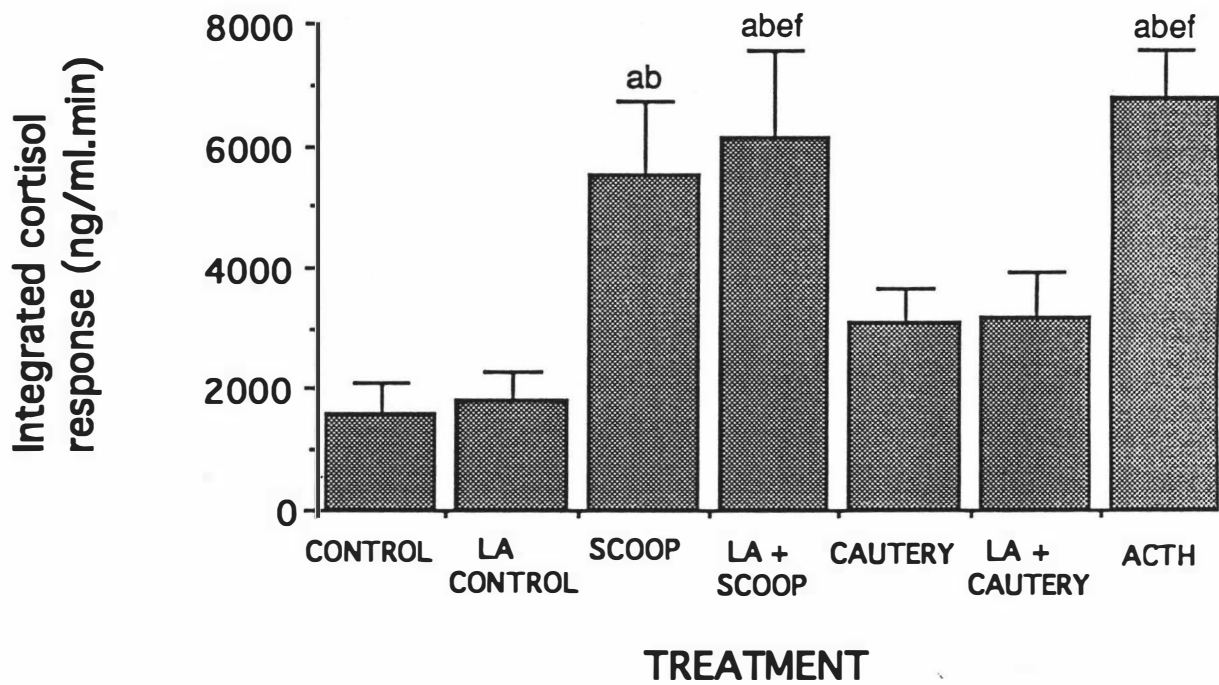


Fig 5.21: Integrated cortisol response in calves in response to different treatments for the total observation period - 9.5 hours (mean  $\pm$  SEM).

Means with different superscripts differ significantly ( $P < 0.05$ ).

- a - control
- b - LA control
- c - scoop
- d - LA + scoop
- e - cautery
- f - LA + cautery
- g - ACTH

TABLE 5.2:					
Integrated cortisol responses and durations of the different treatments.					
				a	b
Treatment	n	Mean	SEM	Mean:ACTH	Duration
		ng/ml.min)		ratio	(hour)
Control	8	1590	517	23	0.50
LA control	8	1821	470	26	0.50
Scoop	8	5513	1206	81	5.50
LA + scoop	8	6115	1441	90	5.00
Cautery	7	3069	577	45	2.50
LA + cautery	8	3139	740	46	1.00
ACTH	8	6756	825	100	3.50
a - The proportions of each mean response as a percentage of the ACTH response.					
b - The time after treatment when the cortisol concentration returned to pretreatment values.					



TABLE 5.3:				
Integrated cortisol response over the first two hours after treatment.				
Treatment	n	Mean	S.E.M.	Mean:ACTH
		(ng/ml.min)		ratio
Control	8	285	102	8
LA control	8	586	155	17
Scoop	8	2211	421	63
LA + scoop	8	1025	37	29
Cautery	7	1352	279	38
LA + cautery	8	1036	286	29
ACTH	8	3527	511	100

TABLE 5.4:				
Integrated cortisol response over the final 7.5 hours after treatment.				
Treatment	n	Mean	S.E.M.	Mean:ACTH
		(ng/ml.min)		ratio
Control	8	1208	453	37
LA control	8	1234	339	38
Scoop	8	3302	894	102
LA + scoop	8	5083	1206	157
Cautery	7	1712	339	53
LA + cautery	8	2102	554	65
ACTH	8	3229	337	100

present study led to several original findings.

(1) The *scoop* and *LA + scoop* procedures caused the greatest amount of distress but the pattern and possibly the nature of that distress differed between the two groups. (2) Disbudding by *cautery* caused less distress than disbudding with the *scoop*. (3) Prior use of a local anaesthetic reduced the distress resulting from disbudding when using *cautery* and the immediate cortisol response when using the *scoop*. (4) The *control* and *LA control* procedures were relatively benign and there was little evidence to suggest that experimental design affected the cortisol responses.

## **SCOOP AND LA + SCOOP**

### **Scoop**

Calves disbudded with a *scoop* produced greater cortisol responses than any other treatment with the exception of *LA + scoop* and *ACTH*. The high initial cortisol rise would indicate that these animals experienced a very distressful treatment that presumably would have involved a large pain component due to the extent of the tissue damage. Comparison of the cortisol responses to the *ACTH* injection and disbudding with the *scoop* suggested that the response to the *scoop* was maximal until 30 minutes after treatment because;

- 1) the dose of *ACTH* given (0.31mg) is known to result in a large cortisol response (Alam *et al.*, 1986; Verkerk *et al.* 1993),
- 2) changes in cortisol concentrations were similar in the *ACTH* and *scoop* treatments during the first 30 minutes after treatment and,
- 3) the *ACTH* calves maintained high plateau cortisol concentrations until 2 hours after treatment (Fig 5.11), suggesting that a maximal response was sustained during that period.

Tissue damage is followed by a sequence of events that includes direct nerve stimulation (fast and slow pain) and a pattern of chemical release which provokes and is part of an inflammatory response (Gebhart and Ness, 1991; Handwerker and Reeh, 1991). The combined effects of nociceptor input from the physical stimulation of a cut and the subsequent chemical release would presumably be a severe noxious experience which would be expected to

persist for some time. It is of interest, therefore, to consider why after 30 minutes in the *scoop* calves there was a decline in the plasma cortisol concentration. A number of possible explanations are provided below.

1. The nociceptor input from the initial noxious stimulus (tissue damage) could be sufficiently severe to subsequently elicit stress-induced analgesia through the release of endogenous endorphins (Hughes *et al.*, 1975; Carmody 1992). To test this hypothesis, intravenous pretreatment with naloxone (an opioid antagonist) using a single dose which blocks the effects of endogenous opioids (Wood *et al.*, 1991) or using a repeated dose regime, which maintains naloxone action for at least five hours could be employed. If stress-induced analgesia has been elicited after treatment, naloxone administration would result in a cortisol response which maintained higher plasma levels of cortisol than were observed after the 30 minute peak in the present study.

2. Alternatively, the cortisol pattern could be a genuine reflection of the disappearance of pain-induced distress which, independently of any stress induced analgesia decreases by two-thirds from the initial peak experienced at 30 minutes. If so, an initial period of intense pain presumably resolves into a subsequent period of pain at a lower level.

In both cases (1 and 2) it is not clear whether the continued elevation of cortisol concentrations above control levels until seven and a half hours after treatment reflected the actual response to disbudding or confounding affects of repeated handling. The handling and blood sampling may often have led to the head being held or knocked in such a way that the wounds caused by disbudding were aggravated. Also, as the calves were confined to an area where they were in close contact with each other, occasional calf to calf contact could not be avoided. Whether or not the repeated handling after disbudding caused plasma cortisol concentrations to remain elevated for longer than would have occurred otherwise, the present results would probably reflect a more distressing experience than is likely to occur in usual

farming practice. It is noteworthy that repeated handling and blood sampling did not apparently affect the magnitude and duration of the cortisol responses of lambs to surgical castration and tailing (Lester *et al.*, 1991b)

3. Another possible explanation is that only during the first one and a half hours after treatment does the cortisol pattern reflect changing levels of pain-induced distress, and that subsequent elevations above pretreatment values reflect some stimulatory effect on CRF, ACTH or cortisol release by the chemicals released from the damaged tissue. This idea could be investigated by giving a long-acting local anaesthetic or second and third administrations of lignocaine at one or two hours after treatment to abolish any nociceptor input. That would allow the direct or indirect effects of chemical release during the inflammatory response to be assessed for their influence on cortisol secretion. If there were no change in the response to scoop disbudding under such circumstances this would indicate an effect of endogenous chemicals on cortisol release. On the other hand abolition of the response with long-acting or repeated doses of short-acting local anaesthetic as occurred in the *LA + scoop* calves during the first two hours, would suggest that continued nociceptor input was largely responsible for maintaining the higher cortisol concentrations between two and seven and a half hours after treatment.

4. Finally, the response could reflect a combination of these effects.

### **LA + scoop**

It is noteworthy that the durations of the cortisol responses to treatment in the *scoop* and *LA + scoop* calves were both about five and a half hours, but that the onset of the cortisol response in the *LA + scoop* calves was delayed by about two hours (Fig 5.17). This delay presumably reflected the duration of action of the local anaesthetic in the *LA + scoop* calves. It also indicated that the local anaesthetic largely abolished the initial pain of disbudding, especially as there were similar cortisol responses during the first one and a half to two hours after treatment in the *LA control* and *LA + scoop* calves (Fig

5.14) and the skin in the region of the horn buds remained insensitive to needle-prick stimulation during the same period. However, as the responsiveness of deeper tissues was not tested, it is possible that nociceptor input from bone persisted despite skin insensitivity. This is unlikely in view of the virtual abolition by local anaesthetic of the initial marked cortisol response to the scoop and because of the similar initial responses of *LA control* and *LA + scoop* calves (Fig 5.14).

The different patterns of cortisol response from two hours after treatment in the *scoop* and *LA + scoop* calves merits comment. Compared to the maintenance of high plateau cortisol concentrations in *scoop* calves between two and six hours after treatment, the cortisol concentrations in the *LA + scoop* calves rose from low values to levels which were significantly greater at three and a half hours before decreasing to *control* values again (Fig 5.17). This difference between *scoop* and *LA + scoop* responses can be explained in terms either of effects of stress-induced analgesia or its absence, acting against a background sequence of chemical release from damaged tissue during the initiation of inflammatory and repair responses, sequences which presumably were temporally similar in the two groups. In the *LA + scoop* calves there was no initial period of marked pain-induced distress as indicated by the cortisol response not being significantly different from that in the *LA control* calves, so that compared to *scoop* calves there may have been less or no stress-induced analgesia beyond two hours in *LA + scoop* calves. The higher cortisol concentrations of the *LA + scoop* calves at three and a half hours are consistent with this view. On the other hand, if there was no stress-induced analgesia in either group, the rise in cortisol concentrations after about two hours in the *LA + scoop* calves would presumably have reflected the onset of nociceptor input and other novel sensations as the local anaesthetic effects wore off.

Of the sixteen calves that were disbudded by the scoop, the cortisol responses of three showed little or no difference from those of the controls. An explanation for this could be related to the technique of horn removal by

the scoop as the size of the bite taken by the scoop is dependent upon head movement and the horn bud size - the bigger the horn bud the more likely it is that the scoop bite will need to be greater to effectively remove the germinal tissue. Presumably the larger the bite the greater will be the tissue damage and hence the associated distress. This could be a factor involved in the three calves with low cortisol responses to scoop disbudding. These calves had lighter liveweights than the remainder of the *scoop* calves, so it is likely that their horn buds were smaller and consequently the bite and hence the wound generated by the scoop would have been smaller. If so, performing disbudding as early as possible when the horn buds are small might reduce the distress involved. However, since the bite of the scoop and horn bud size were not noted for the individual animals in the present study, this idea requires validation. Alternatively, the variability in the cortisol responses may reflect individual differences in the dynamics of CRF, ACTH and/or cortisol release and clearance which could affect the cortisol responses of individuals independently of wound size at the site of disbudding (Hennessy, 1986; Zhang *et al.*, 1990a,b).

### **CAUTERY AND LA + CAUTERY**

*Cautery* and *LA + cautery* apparently caused less distress as judged by plasma cortisol concentration than did the *scoop* or *LA + scoop* procedures. Evidence for this is as follows: (1) the duration of elevation of cortisol concentrations above control values in the *cautery* and *LA + cautery* calves was three hours compared to seven and a half hours in *scoop* and five and a half hours in *LA + scoop* calves; (2) the integrated responses until two hours after treatment for *cautery* and *LA + cautery* calves were significantly less than the *scoop* calves responses; and (3) the integrated responses between two and nine and a half hours for *cautery* and *LA + cautery* calves were not significantly different from *control* and *LA + control* calves.

### **Cautery**

Cauterising the horn buds produced a cortisol response that was significantly greater than in *control* calves one hour after the treatment but was not

significantly different at any time thereafter (Fig 5.15). The noxious stimuli of disbudding with a cauterising iron could presumably be intense enough to result in stress-induced analgesia which could be the cause of the rapid return to pretreatment values after one hour. On the other hand, the cauterising iron is designed to cauterise the skin and germinal tissue around the horn bud compared with the scoop which involves amputation of the horn bud itself and some of the surrounding tissues. An explanation for the difference in cortisol responses may therefore involve consideration of the different types of injury. Cautery will result in first, second or third degree burns in various combinations. Third degree burns involve the epidermal, dermal and subcutaneous tissues, and since sensory nerve receptors, including nociceptors, are in the dermis they are destroyed by a burn of this type (Groer and Shekleton, 1983). There is a consequent loss of sensation to the affected area which is why third degree burns do not cause as much pain as first and second degree burns (Johnston, 1985). Burning of the horn bud using a cauterising iron did result in third degree burns and hence would have destroyed the nociceptors at the site resulting in reduced perception of pain where the third degree burns occurred. This could be another explanation for the rapid restoration of pretreatment values after the initial transient rise in cortisol concentrations. However, the initial nociceptor input would have included a barrage of neural activity associated with the onset of tissue destruction caused by cautery. In addition, around the periphery of the wound the burns would more likely be classified as first or second degree burns which do result in pain. Nociceptor input from these lower degree burns would probably have contributed over a longer period to the cortisol response following cautery. A similar phenomenon was discussed by Lester *et al.* (1991), who compared cortisol responses of lambs to tailing with a knife or a heated docking iron. The cortisol responses to the two procedures were not similar as had been expected, as both procedures involve amputation of the tail; instead the cortisol response using the docking iron was lower than that caused by the knife. It was thought that this was probably due to the destruction of nerves with the third degree burns caused by the docking iron as argued here for dehorning by cautery.

### **LA + cautery**

The initial transient rise seen in cortisol concentration in *LA + cautery* calves was complete within one and a half hours after treatment and was not significantly different from that observed in the *control* calves. *LA + cautery* calves did not exhibit a rebound effect (delayed rise in cortisol concentration) when the local anaesthetic wore off after about two hours unlike the response of the *LA + scoop* calves; rather, the plasma cortisol concentrations were not significantly different from those of *control* or *LA control* calves throughout the entire nine and a half hour observation period (Fig 5.16). Thus the noxious input caused by cautery presumably had a shorter duration than that caused by the scoop as it had apparently resolved within one and a half hours.

### **CONTROL AND LA CONTROL**

The majority of *control* and *LA control* calves exhibited a transient rise in plasma cortisol concentration. The initial small transient rises seen in the *controls* and *LA control* calves were probably due to the onset of blood sampling and handling experienced by these calves. Contributory factors presumably were any minor physical pain of repeated venipuncture, emotional responses associated with that physical pain and the unfamiliar procedures of blood sampling, local anaesthetic administration and/or handling. Plasma cortisol concentrations soon returned to pretreatment values in these groups, presumably as the animals adjusted to the fairly benign situation. Such responses are apparently typical of those seen in repeatedly sampled control lambs (Mellor and Murray, 1989a; Lester *et al.*, 1991a; Mellor *et al.*, 1991; Wood *et al.*, 1991; Murray *et al.*, 1993), kids (Mellor *et al.*, 1991) and calves (Robertson *et al.*, 1993).

A non-significant deviation in the plasma cortisol concentrations of the *LA controls* from values in the *controls* occurred two hours after treatment (Fig 5.12) which might have been linked to novel sensations at the time the local anaesthetic was wearing off. As noted above this was the time when the *LA control* calves again responded with aversive behaviour to needle prick stimulation around the periphery of the horn bud. Wood *et al.* (1991) have



also shown a biphasic cortisol response to local anaesthetic administration with a second peak in the cortisol concentration occurring two and a half hours after treatment. It is probable that the return of sensation at the horn bud as the local anaesthetic wore off may itself be mildly noxious or unfamiliar enough to cause an increase in plasma cortisol concentration at this time.

A variation in individual responses was quite obvious when the individual plasma cortisol concentration versus time graphs were examined. For instance, in both the *control* and the *LA control* calves there were three calves that showed little or no change in plasma cortisol concentration. It could be that these six animals were low responders and that their physiological and psychological temperaments would have prevented them from producing a significant distress response unless the stressor was less benign (Manteca and Deag, 1993).

## **ACTH**

Administration of ACTH in the present study resulted in a typical adrenal response (Alam *et al.*, 1986 and Verkerk, 1993), which had a duration of at least four hours. This indicates that the adrenal glands in the present calves were responsive to ACTH. However, it may not bear any relevance to the functional capacity of any other steps in the hypothalamic-pituitary adrenal cascade because it involved only the final step in that cascade.

### **5.41 General considerations**

The practical advice which can be communicated from this work is firstly on the method of disbudding. The *scoop* causes a marked cortisol response, indicative of pain/distress, and on those grounds would not be the preferred method. However, the use of local anaesthetic abolishes the initial response, and further studies may reveal that a longer acting local anaesthetic could reduce the acute cortisol response substantially. It is known in lambs that where the duration of action of local anaesthetic exceeds the duration of distress caused by castration and tailing the behavioural and cortisol

responses are abolished (Wood *et al.*, 1991). Further development of scoop design may also reduce distress by reducing the size and depth of the wound.

*Cautery* using a local anaesthetic appeared to be the least distressing treatment. However, taking the integrated areas for the entire 9.5 hour sampling period into consideration, no significant differences occurred in the magnitude and duration between *cautery* and *LA + cautery*. This implies that no additional benefit can be gained by using a local anaesthetic when cauterising horn buds. In addition there was no significant difference between *cautery* and *scoop* calves over the entire sampling period with respect to integrated areas. However, there is a significantly greater response in *scoop* calves compared to those in the cautery treatments during the first two hours.

Bruce (personal communication) has noticed the regular occurrence of secondary infections with cautery if the iron is held too firmly and for extended period of time on the horn bud, but this can be avoided by improving the cauterising technique.

Of the two methods studied, cautery would be the better choice for minimising the distress of disbudding in calves of this age. In addition, the use of local anaesthetic prior to cautery would be recommended as it reduced the cortisol response to cautery.

It could be argued that the continued handling of all the present calves for blood sampling may itself have been a stressor and hence might have prolonged the elevation of cortisol levels. This is infact unlikely as the pretreatment cortisol values were within the normal range (Herd, 1989) and the cortisol concentration of the *control* calves had returned to these pretreatment values within 15 minutes (Fig 5.14). Furthermore, Lester *et al.* (1991b), demonstrated in lambs that additional lifting and handling after castration and tailing with the knife did not significantly affect the cortisol

responses exhibited by those lambs.

It is important to realise that this study only dealt with the acute effects of disbudding and there may be chronic complications that have not be considered. Disbudding should be followed up to show the effectiveness of the scoop or the cauterising iron. As the scoop literally removes the horn bud its effectiveness would presumably be close to 100%, however with cautery, the horn bud is cauterised and may not always be effectively destroyed. If the effectiveness with cautery were lower than with the scoop and the acute distress of the scoop could be abolished or substantially reduced practicably by using a longer acting local anaesthetic the use of the scoop could then be given stronger support.

## 5.5 CONCLUSION

The present cortisol results suggest that the use of the scoop for disbudding six to eight week old calves was significantly more distressing than cautery. Due to the high level of distress involved when using the scoop with or without a local anaesthetic this method of disbudding would not be recommended unless further work could achieve a decrease in distress by improving the technique.

Cauterising the horn buds caused less distress than use of the scoop and hence of the two, this would be the method of choice. The use of the local anaesthetic prior to cauterising the horn buds would be recommended as it does reduced the cortisol response to cautery during the first one hour after treatment. As the local anaesthetic only had a marginal benefit it could be argued that its use is not therefore justified in this situation. In the interests of the animals a local anaesthetic would be beneficial, however the cost, time and extra handling of animals this procedure will involve may negate any slight advantage administration of local anaesthetic may have.

## **SECTION THREE**

### **CHAPTER SIX:**

### **GENERAL DISCUSSION**

#### **6.1 CONCLUSIONS**

The major original findings obtained from this study on the distress involved in tail docking and dehorning dairy calves are as follows.

1. When using plasma cortisol concentration as an index of distress, tail docking with either a rubber ring or the docking iron caused no more distress in most calves than control handling and blood sampling.
2. Using the plasma cortisol concentrations obtained 24, 48, 72 and 96 hours after treatment there was no evidence to support the development of chronic distress after tail docking.
3. When using changes in behaviour as an index of distress, it was concluded on balance that tail docking with a rubber ring either with or without a local anaesthetic caused little or no distress in most calves.
4. A degree of between-animal variation in response was noted when using either cortisol or behavioural indices of distress, after tail docking, as a small proportion of calves which received some treatments that were not expected to cause distress showed signs of mild distress. The reasons for this were unknown.
5. Disbudding six to eight week old calves with a scoop caused a marked distress response which lasted for about five and a half hours, whereas an alternative method, the cauterising iron, was only slightly more distressing than control handling and blood sampling during the first one hour after disbudding.
6. Administration of a local anaesthetic before scoop disbudding produced little or no reduction in overall distress, as judged by cortisol responses,

despite a marked reduction in distress during the first two hours after treatment, because of a marked distress response which lasted from two to nine hours after disbudding.

7. Prior administration of local anaesthetic to calves disbudded by cautery effected a slight reduction in the distress response to cautery alone, decreasing that response to control levels.

8. In both the tail docking and disbudding experiments, control handling and blood sampling caused little or no distress as indicated by uniformly low cortisol responses. Blood sampling calves in a group also had no apparent effects on the cortisol responses.

With both tail docking and disbudding, cautery either caused no more distress (tail docking) or less distress (disbudding) than the alternative methods. Furthermore, with both procedures, cautery caused no or only a little more distress in most calves than was experienced by the control animals. Nevertheless, the docking iron can not be recommended in preference to a ring for tail docking because after its use bleeding continued for several hours from the tail stumps of some calves. The markedly lower disbudding distress caused by the cautery compared to the scoop was presumably due to the damaged tissue, including nociceptor destruction (Johnston, 1985), being confined to superficial tissues (mainly skin) with cautery, whereas the scoop usually removed both skin and bone adjacent to the horn buds, thereby causing deeper wounds. Therefore, cautery would be recommended over the scoop as a method of disbudding. Some precautions must be taken by the operator when using cautery for both of these procedures because of the hazard of exposure to the searing irons.

It was assumed at the beginning of these experiments that the prior administration of the local anaesthetic would be beneficial in reducing any distress caused by tail docking or disbudding. With tail docking, however little benefit was detected, presumably because the distress caused by tail

docking in most calves was no greater than the slight responses to unfamiliar handling and blood sampling. On the other hand, the use of a local anaesthetic prior to disbudding did markedly reduce the first two hours of the distress caused by scoop disbudding while the local anaesthetic was effective. Use of repeated local anaesthetic (not practical) or of long-acting local anaesthetic (more practical) would presumably extend the period of distress reduction and may prevent the 'over-shoot' response observed here when the single dose of short-acting local anaesthetic wore off. It is of interest that the cortisol concentrations of the cautery calves had already returned to pretreatment values by the time the local anaesthetic effects had worn off, which may explain the absence of an 'over-shoot' response with this method. Although it is clear that cautery should be recommended in preference to the scoop for disbudding six to eight week old calves, it is not clear whether or not the marginal distress reduction effected by local anaesthetic use prior to cautery would justify recommending such local anaesthetic use on farms.

A comparison of the relative distressfulness of tail docking and dehorning would be difficult using the results presented in this thesis because the ages of the calves in these two studies were different and because it is not known if the dynamics of the hypothalamic-pituitary-adrenal system alters with age, as it apparently does in lambs (Mellor and Murrar, 1989b). To directly compare these procedures calves of the same age would have to be used. Caution should be exercised when comparing the magnitudes of cortisol concentrations from different experiments because cortisol assays and laboratory techniques differ and may affect the results. The magnitude and duration of the plasma cortisol concentrations of calves used in the tail docking study were no different from those caused by restraint and blood sampling in previous studies (Stephens and Toner, 1975; Robertson *et al.*, 1993). Also, Slyvester *et al.* (1993) have shown that scoop dehorning in six-month old cattle caused a deviation in plasma cortisol concentrations from control levels until seven hours after treatment, which is similar to the duration of cortisol elevation in the scoop six to eight week old calves from the present study.

## 6.2 EXPERIMENTAL DESIGN AND LIMITATIONS

One possible criticism of the experimental design in the two present studies of cortisol responses was the grouping of several animals in one pen. The grouping of calves in this way prevented simultaneous cortisol and behavioural observations because it prevented the calves from freely expressing some behaviours. That was partly overcome in the tail docking study by observing behavioural responses separately (Chapter Four). However, doing so precluded access to their cortisol responses.

Another possible limitation of grouping several animals was the possible effects it might have had on the cortisol concentrations as it was necessary to identify, restrain and bleed one calf at a time, but to do that one had to move through the group of calves to reach the required animal. However, as a regression analysis of the sample order and the cortisol concentration at each sample time revealed no significant effect on plasma cortisol concentrations, handling and holding the calves as a group did not apparently affect their cortisol responses.

A further limitation to the present experimental design was the possible effects of repeated blood sampling and handling on calves which may have been distressed. This repeated sampling and handling could cause additional distress and thereby overestimate the response. Lester (1991) showed that repeated blood sampling and handling caused no additional distress over and above that already produced by castration and tailing in lambs. It is not known whether that was also true of the present tail docking and disbudding studies, but the return of plasma cortisol concentrations to pretreatment values within the observation period in all groups suggests that any effects did not persist beyond nine hours after treatment. Although there may have been some exaggeration of the distress responses by repeated handling within the period of observation, the responses here will at least represent the worst likely outcomes on the farm.

It is noteworthy that an increase in plasma cortisol concentrations at the onset

of blood sampling and handling is a typical response seen in cattle, sheep and goats (Kent *et al.*, 1993; Lester *et al.*, 1991a,b; Mellor *et al.*, 1991; Molony *et al.*, 1993; Robertson *et al.*, 1993). It could be that this initial rise occurs at the onset of noxious stimulation then a subsequent decline indicates that the animals have habituated to the novel experience. Although this may be the case, it is difficult to state with confidence that the low values observed in the control calves do represent a distress-free state. The development of remote sampling techniques may be able to identify the "normal" cortisol levels of distress-free ruminants, taking into account fluctuations caused by diurnal rhythms.

### 6.3 FUTURE ISSUES

#### Tail docking

The only reason for the continued practice of tail docking in New Zealand appears to be convenience for the farmer, as leptospirosis is no longer a major problem (Fraser, 1991) and milk hygiene may not be an issue as the dairy companies accept milk from both entire and docked cows. Although tailing is not apparently distressing in most calves, as shown here (Chapters Three and Four), removal of the tail may cause long term welfare problems due to the absence of a natural fly swat and signalling device. Insecticides could be used to effectively control the fly problem in cattle (Alexander, 1991) thereby minimising the disadvantage of the loss of a fly swat. However, the use of insecticides involves another contentious issue - that of chemical residues. There is the possibility that chemical residue could build up in the meat or milk of the treated animals and could remain in the soil thereby creating possible environmental contaminations. Furthermore, tail docking may cause the later development of neuromas with associated neuropathic pain, as seen in docked lambs (French and Morgan, 1992).

#### Dehorning

Dehorning cattle has been carried out over the years in the best interest of the stock handler and the animal. Dehorned cattle are safer to work with. The



animals themselves are also less likely to be injured during agonistic interactions. Yarding and transport brings cattle into close proximity with each other and often leads to injury through fighting. The presence of horns is thought to cause a large proportion of the wounds and bruises of carcasses at freezing works. The stage in the process when the injuries occur varies, but the type and position of the wounds and bruises indicate that they are probably caused by horns. This is of practical significance, because not only do some freezing works refuse to accept horned cattle, but the carcass damage that occurs due to the presence of horns, will reduce the financial returns the producers receive for their product.

## 6.4 COMMENTS

The work in this thesis illustrates three general principles that need to be applied when investigating common husbandry practices.

Firstly, it is important to determine the reasons why a particular husbandry procedure is carried out and whether or not there are any practical alternatives. Using tail docking as an example, there appears to be no real need for this procedure except for convenience, so that alternatives could include clipping the brush of the tail or hooking the tail to one side during milking in order to reduce the likelihood of being slapped in the face with a faeces covered tail.

Secondly, it is necessary to determine whether or not the procedure itself cause distress to the animal. If so, alternatives can be explored. Alternative mustering procedures, using more effective yards or restraint during the procedures and regular experience with yarding may reduce the distress cause by novelty. Different methods for achieving the same husbandry objective may cause different amounts of distress, as might the age when the procedure is done. Alleviating the distress by using a local anaesthetic may also help to reduce the distress involved, and should be evaluated.

Thirdly, possible long-term welfare problems associated with the procedure need to be considered. If there are long-term welfare problems then using alternative methods or avoiding use of the procedure should definitely be investigated for the animals' sake.



Appendix A: X-rays taken from calves in the present study (Chapter Three) showing the position of the rubber ring (A) and the site of tail removal when using the docking iron (B).

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