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Accelerating healing of calf frontal sinuses exposed by dehorning

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Abstract

Gauze swabs (7.5 cm square patches) were placed on the dehorning wounds in 24 of 50 tropically-adapted heifers weighing 180-200 kg. Frontal sinus exposure averaged 3.5 cm in diameter. Application of swabs reduced haemorrhage ($P<0.01$). Half the patches were dislodged within a day of surgery, and 80% of these within an hour. The remainder sloughed 10-44 days after surgery. Patches sealed exposed frontal sinuses from the time of application if they were not dislodged. Sealing took up to 4 weeks in 96% of un-patched wounds. Patches reduced purulent exudation from 11% to 1% of wounds ($P<0.01$), ie, it substantially reduced secondary bacterial infection. No fly strike occurred in patched wounds. There was a non-significant trend for patched wounds to reach the post-scab healing phase (6-13 weeks after surgery) earlier than un-patched wounds. The incidence of behaviours indicating pain was high in the 2-3 days after surgery and abated over 2 weeks. Behavioural data indicated that dehorned calves should be segregated from other cattle after surgery and that pasture feeding is recommended over hand feeding in this period. Patches had no impact on pain. Use of patches is recommended, though a cost-effective method to increase adherence will improve their efficacy.

Executive Summary

Even though there is a major shift in the north Australian beef industry towards breeding of polled cattle and disbudding when young, dehorning by amputation, which may result in frontal sinus exposure, will continue to occur. This project tested whether patching of the wound immediately after dehorning by application of a dry 7.5 cm square cotton gauze surgical swab enhances healing. A patch was anticipated to enable more rapid clotting and would form the matrix for a large scab which would cover and protect the sinus. The scab would slough as the wound heals and because swabs are made of pure cotton, they are fully degradable in the environment. Fifty tropically-adapted heifers weighing 180-200 kg on a Northern Territory station were selected for the experiment. Five weeks after surgery, the heifers were transferred to a feedlot in south-east Queensland where observations continued for a further 8 weeks. Observations were twice daily for 2 weeks and then each 7-16 days (average 10-daily) to the end of the experiment.

Dehorning created sinus exposure averaging 3.5 cm in diameter which was half the width of the full wound. Gauze swabs were placed on the dehorning wounds of 24 heifers immediately after surgery. Half the patches were dislodged immediately after surgery or within a day, and the remaining half sloughed between 10 and 44 days after surgery.

If the proportion of the distance away from a de-horning wound to the angle of the jaw where clotted blood on the skin was observed was indicative of the degree of post-surgical haemorrhage, patching reduced haemorrhage, irrespective of whether the patch was lost immediately or remained for at least 2 weeks (0.55 ±0.26 *v* 0.39 ±0.23; $P<0.01$). This simple 14-second procedure may typically cost in the vicinity of $0.50 per animal (mostly labour). This cost may be recouped if it can reduce the reported 2% loss of calves caused by dehorning.

There was no difference in healing between dehorning wounds that had not been patched and those that had lost their patch within 24 hours of surgery. Therefore, all comparisons were between patched (n=31) or un-patched wounds (n=69). In the month following surgery, patches reduced all exudation from the dehorning wound from 22% to 3% and reduced significant secondary bacterial infection from 11% to 1% of wounds ($P<0.01$). Healing of 96% of un-patched dehorning wounds progressed to a scab that sealed the exposed sinus within 4 weeks of dehorning. Healing progressed to the post-scab healing phase for 98% of wounds between 6 and 13 weeks after surgery. Patching did not affect the rate of closure of the sinus wound, or affect the rate of contraction of the wound area, but there was a non-significant trend ($P=0.19$) for patched wounds to reach the post-scab healing phase earlier than un-patched wounds. Fly larvae infestation occurred in two un-patched dehorning wounds, but in no patched wounds. This infestation of an unknown species appeared to have no detrimental effect on healing under these conditions.

Dehorning, but not ear notching or fire branding conducted at the same time, elicited vocalisation in all but one heifer suggesting this is a painful procedure. Incidence of behaviours not usually expressed and previously associated with pain, and changes from normal digestive behaviours, were high during the 2-3 days after surgery, highest during afternoon observations, and abated over 2 weeks, suggesting pain caused by dehorning was being experienced during this period. Resumption of normal digestive behaviours within a week after surgery was associated with partial recovery of body condition loss observed immediately after surgery when feed intake was completely suppressed. There was no discernable effect of patching on behaviour. Given the prolonged pain associated with dehorning by amputation that exposes the frontal sinus, this procedure should be avoided where possible.

The heifers' avoidance of other unbranded animals with which they were cohabiting continued for at least 4 weeks. This may have been a normal social behaviour when groups unfamiliar with each other mix, but based on our observations, appeared more likely to have enabled avoidance of agonistic behaviour associated with feed competition. No agonistic behaviours were noted by the trial heifers. This supports a recommendation that after surgery, mixing of dehorned and non-dehorned calves is contraindicated. The heifers expressed innate grazing behaviour irrespective of feed availability after surgery, supporting a further recommendation that, wherever possible, dehorned calves should be allowed access to pastures that readily satisfy feed intake requirements. This may reduce energy wasted, and reduce any requirement for agonistic behaviour in competitive situations.

It was concluded that patching with a gauze swab of dehorning wounds in which there has been exposure of the frontal sinus, does not appear to significantly increase either the rate of healing or the healing outcome. However, it does reduce post-surgical haemorrhage and the incidence of secondary infections. It may reduce the chance of fly strike, and may slightly increase the time taken to reach the post-scab healing phase. Patching of dehorning wounds may assist in reducing the mortalities caused by dehorning. Developing a cost-effective method to increase adherence of swabs is recommended.

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Background

Best practice for dehorning is well described (Newman 2007). Horns develop from specialised cells, commonly referred to as the horn bud, that differentiate after birth. Removal of the dermis prior to, or in early differentiation, prevents horn growth. Even though there is a major shift towards breeding of polled cattle and disbudding when young, dehorning by amputation which may result in frontal sinus exposure, will continue to occur. Standard practice for when the frontal sinus is exposed during dehorning is to apply insect repellents and to use pre- and post-operative management such as transferring cattle to a low-dust situation that limits the risk of agents either entering or infecting the surgical site.

Amputation of a growing horn removes the corneal process, which is an extension of the frontal bone that covers the frontal sinus. The corneal process is the anchor for the horn (Sisson 1975). The base of the rigid corneal process is continuous with the skin, and it is here that keratin is formed and grows in the same way as hooves. The caudal frontal sinus (the major compartment within this sinus) becomes exposed at dehorning when there is trans-section of the corneal diverticulum, the hollow part of the corneal process. The floor of the frontal sinus is part of the cranial cavity that houses the brain. The frontal sinus has a small opening at its rostral (forward) aspect through to the ethmoidal meatus that is part of the nasal cavity (Habel 1975). The corneal nerve supply emanates from branches of the trigeminal nerve (5^{th} cranial nerve) and its ophthalmic and maxillary branches (Godinho and Getty 1975). The cornual artery supplies the horn after branching from the superficial temporal artery that comes off the common carotid artery (Ghoshal 1975).

It is difficult to control cattle and the environment to achieve ideal dehorning outcomes of low pain and rapid aseptic healing, especially under extensive grazing situations where husbandry to improve the general welfare of cattle may partially compromise post-operative requirements. An example is where calves are branded at the end of weaning and then need to be trucked to a site that provides adequate nutrition. Accelerated healthy healing is needed in these situations. This situation existed in 2013 in north Australia where large numbers of cattle had to be shifted out of regions where the wet season completely failed.

Application of topical anti-microbial agents to dehorning wounds at the time of surgery are not expected to have any effect because they would either be washed away in blood, or bound in clots and unavailable to act at healthy tissue surfaces. There appears to be no published literature that demonstrates impact of topical anti-microbial agents on post-dehorning infections. There appears to have been no major recent advances in standard practice for post-operative exposed sinus management to prevent infections and accelerate healing. Improvements in exposed sinus management will have welfare benefits, and may improve calf performance, eg, growth and survival rates.

A simple process to enhance healing of exposed sinuses may be to apply a dry cotton patch such as a 7.5 cm square cotton gauze surgical swab to the wound immediately after surgery. A patch is likely to improve bleeding control by enabling more rapid clotting, and would form the matrix for a large clot which would cover and protect the sinus. The clot would become a scab which would slough as the wound heals. Because swabs are made of pure cotton, they are fully degradable in the environment.

The efficacy of a patch has not previously been tested in a commercial situation. A preliminary small study has been conducted in which the swabs came away too readily in the days after application, but it was considered that the post-operative handling and measurements in an intensive environment may have caused this outcome (Carol Petherick, pers comm).

There are two primary insect control methods that may be useful in managing healing after dehorning. Overspray with a repellent targeted at buffalo fly can be applied before branding so that the repellent is dried on the hair before dehorning. A new product, Extinosad®, which has been produced specifically for mulesing wounds in sheep (Rothwell *et al*. 2005) contains both an antiseptic (chlorhexidine) and an insecticide (spinosad), and may be efficacious in reducing wound infection and fly strike, with both welfare and production benefits.

Solid evidence is needed to support any advice in the use of patches or insecticides post-dehorning.

Research questions

Will a gauze swab placed over an exposed sinus after dehorning remain in place as a matrix for sealing the sinus and promoting healing?

Does application of a topical insecticide assist the healing of exposed sinuses after dehorning?

Hypothesis

A gauze swab placed over the exposed sinus will significantly improve both the rate of healing and the healing outcome following dehorning of calves.

Project objective

Assess the effects on calf behaviour and growth, and on wound healing, when a patch and or insecticidal spray are applied to exposed sinuses at dehorning.

Note: Due to the absence of significant insect populations at commencement of the experiment, no treatment to assess the impact of insecticidal spray was applied.

Methods

Ethics

The experiment was approved by the University of Queensland Animal Welfare Unit, with approval number QAAFI/144/13/MLA.

Research group

Group	Person	Prepare	Support	Cattle	Surgery	Measures
The University of Queensland						
Charters Towers	Geoffry Fordyce*	x			x	x
Gatton	Nicky McGrath				x	x
	Sophia Edwards					x
Rockhampton	Carol Petherick	x	x			

* Contact for further details: QAAFI; g.fordyce@uq.edu.au

Department of Primary Industry and Fisheries, NT						
Tenant Creek	Helen McMillan	x			x	x
Darwin	Mark Hearnden		x			

The North Australian Pastoral Company Pty Ltd

Group	Person	Prepare	Support	Cattle	Surgery	Measures
Brisbane	Geoff Kingston	x	x			
Mittiebah	Marty Doyle	x	x	x		
	Danielle Doyle		x			
	Aileen Falvey		x			
	Eddie		x			
	Scott Hayes		x	x	x	
	Mick Thompson			x	x	
	Georgie Knight			x	x	
	Tom McBride			x	x	
	Yarraki Dodd			x	x	
Wainui	Geoff Cornford		x			
	Howard Elliot			x		

Sites, animals and management

The study commenced at Mittiebah Station (North Australian Pastoral Company Pty Ltd) in the Northern Territory, 268 km north-west of Camooweal by road (18.8^{O} South 137.1^{O} East). The minimum and maximum temperatures during the study at Mittiebah were 7-18^{O}C and 30-36^{O}C, respectively. On 20 July 2013, 50 heifer calves that were approximately 6 months of age and weighing 180-200 kg were selected at weaning for the study; routine management of contemporary male cattle precluded their availability. The calves were a tropically-adapted composite breed composed primarily of Brahman and Beef Shorthorn. The selected heifers had horns of approximately 1-12 cm in length with basal areas of 9±4cm^{2} (Figure 1). The heifers were held in a cattle yard for 18 days and fed good-quality hay *ad libitum* in the form of large square bales placed on the ground in the yards until the study commenced. During this period, they experienced short periods of handling through the yards. On 03 August 2013, the heifers were vaccinated against botulism (SIngVac ®, Virbac).

Treatment allocation occurred during branding on 07 August 2013 (Day 0, 18 days after weaning). After dehorning, the heifers were released into an 8 ha paddock beside the yards where approximately 100 small unbranded weaners were held. The paddock had very little standing pasture. Here the cattle were offered hay in the same manner as prior to the study. In addition they had access to high-protein calf pellets from standard grain feeders. On the 20 August (Day 13), the calves were allowed access to a second grassed paddock of approximately 200 ha through an open gate from their small paddock. Water sourced from a bore was available *ad libitum* in a trough within the 8 ha paddock throughout the study period at Mittiebah.

On 09 September 2013, 33 days after dehorning, the heifers were mustered into a cattle yard, along with 1,800 others for transport to Wainui feedlot. The cattle travelled by road train after loading on 10 September 2013 to the feedlot (27.3^{O} South 151.5^{O} East), 68 km west of Toowoomba in south-east Queensland. The 3-day trip to the feedlot included a day of yard rest at approximately the halfway point. On arrival at the feedlot, the heifers were offered *ad libitum* hay and water. On the morning following arrival (Fri 13 September) at 06:30-07:00, the heifers were weighed in a veterinary crush and received a pour-on insecticide (Coopers Easy Dose ®), with each being briefly restrained with a hydraulic head bail. The trial heifers were within a group of 1,080 that were drafted on 20 kg live weight ranges into 3 feed pens, where they were then transitioned to a low-growth (0.6 kg/day target) ration. The heifers were monitored at Wainui till 03 November 2013 during which time

the average minimum and maximum temperatures were 11 ^{O}C (3-18^{O}C range) and 30 ^{O}C (23-38^{O}C range), respectively. Four rainfall events in this period produced a total of 37 mm.

Experimental treatment

At 07:00-0:900 on 07 August 2013, the 50 calves were caught and restrained in lateral recumbence on their right side to be ear tagged, ear notched, branded and dehorned. Large numbered ear tags were placed in the left ear. All procedures, including dehorning, were conducted by stockmen with considerable experience in the techniques. The cup dehorners used (Figure 1) were rinsed and soaked in a chorhexidine solution between animals. Care was taken to remove the horn growing tissue at the base of each horn.

Because of the relatively cool dry prevailing conditions, there was a very low insect (including flies) presence. Therefore, no insect deterrent treatment was applied. The calves were randomly allocated to have no treatment (n=26) or to have their dehorning wounds patched (n=24). To patch, immediately after dehorning, a dry 7.5 x 7.5 cm non-sterile 8-ply open-weave compress (Euro Gauze Swabs, Henry Schien ®) was applied over the exposed sinus. The swab was held on the wound, without pushing any part into the exposed sinus, until it soaked up blood and appeared it would remain in position (Figure 1). If the calf shook its head and dislodged a patch before release, a new patch was immediately applied.

After surgery (Figure 2) each calf was released into an adjacent yard. When the procedure was completed for all calves, they were released into the 8 ha paddock adjacent to the yards.

Pre-dehorning Dehorning Patched wounds

Figure 1. Surgery and treatment

Day 0 Day 4 Day 62

Figure 2. Post-dehorning patches

Measurements

Immediately prior to surgery, each calf was held separately in a panel of the race where its temperament was assessed by describing its movement: 1=Stand stills; 2=minor movement; 3=continuous movement; 4=vigorous movement. At this time, calves were weighed (immediately off feed and water). Visual inspection was used to measure body condition score (1-5 scale) and horn dimensions (length, base width). The heifers were weighed again at feedlot induction immediately off access to feed and water, but no further weights were recorded.

During dehorning, the data recorded for each animal were: whether and when the animal vocalised, and on each side, the diameter of sinus exposure, number of artery squirts, and presence or absence of sinus bone fragmentation.

For calves allocated to dehorning patches, additional data for each side recorded was time taken to apply the patch (including re-patching if done), whether the patch was replaced, and whether the patch was lost during release or in the first hour after release.

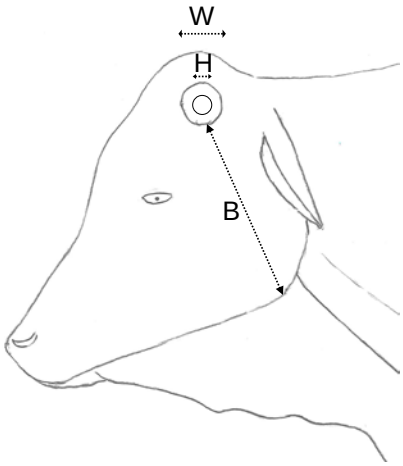
For 13 days in the morning and afternoon, detailed behavioural observations (Table 1) were conducted on each calf as it was located at approximately 08:00 and 16:00, with observations of all heifers taking about 2 hours. Each animal was observed with or without the aid of binoculars for approximately 30 seconds and all behaviours in this period recorded. The same observations of behaviour were taken in the morning 3 and 4 weeks post-surgery. Visual assessment of body condition score and dehorning wounds (Table 2) occurred at the same time and continued beyond day 13 at 7-16 day intervals (10 days average) to day 88 post-surgery.

Table 1. Ethogram used, with a record made of which behaviours were observed during a ~30 sec observation

Posture	Standing, lying or walking. It was also noted whether the animal was: • Relaxed. Head in flexion (sleepy) or not extended and not acting warily. • Alert. Watchful, wary and poised to move. • Neck extended. The nose held high relative to the poll. • Walking backwards.
Diet	It was noted whether the animal was drinking, grazing, eating hay, eating pellets, ruminating or none of these.
Tonguing	Usually the animal had its head in extension. In the most extreme form, up to 20cm of tongue protruded from the mouth. Most usually the tongue was protruded to the side in an apparent attempt to lick the side of the head or was used to lick the muzzle.
Head scratching	The animal raised a hind leg and passed it near the poll. Rarely did there appear to be any contact with the poll.
Head shaking	This behaviour varied from an obvious shake to a twisting of the head from the normal relaxed position.
Ear flicking	The ears were flicked, often in association with head shaking.
Tail flicking	The tail was flicked.
Self grooming	Licking any part of its own body.
Head rubbing	Rubbing their head on trees, hay bales, fences or each other
Other	Other behaviours noted were urinating, defaecating, and agonistic encounters.

All day 0-5 assessments were conducted by 3 people together (HM, NM, GF; calibrating each other) either at dehorning or from a vehicle driving slowly around the small paddock. All day 5.5-28 assessments were conducted by one of these people (HM) from a vehicle. At the feedlot, observations were conducted by three different people (NM, GF, SE), each time alone.

Table 2. Assessments of dehorning wounds by visual inspection

Blood crusting	Proportion of the distance with blood clots attached to the skin between the horn base and the angle of the jaw – assessed 2.5 days after surgery = Proportion of B in the adjacent figure	
Dehorning wound diameter	Average distance across the tissues affected by surgery = W in the adjacent figure	
Hole exposing sinus	Average diameter of the hole = H in the adjacent figure	
Degree of patch attachment	0-100%	
Presence of irritants	Nil, hay, flies, or fly larvae	
Exudate	Nil, blood, clear, muco-purulent, purulent, or purulent with blood	
Stage of healing	Patched, hole remains, sealed with scab at bone level ("scab inside"), sealed with scab at skin level ("scab over"), sealing scab depressed/split ("scab damage"; beyond this stage = post-scab), fibrous tissue with or without crusting, or mature skin	

Analyses

Descriptive analyses of all behaviours and healing were conducted and differences due to patching were compared using t tests.

The difference between patched and un-patched wounds in the proportion that had reached the post-scab stage of healing was compared using logistic regression models that fitted the proportion of healed wounds over the 88 days following surgery.

Results

The distributions in horn size and temperament score prior to surgery and diameter of holes to exposed sinuses (average of 3.5 cm) are shown in Figure 3. At dehorning, 40% of heifers had some evidence of bone fragmentation at the edge of the exposed sinus. Arterial squirting occurred in 23% of heifers, but none was large and discontinued mostly within 5 seconds of surgery. None of these factors had any discernible association with either the post-surgical behaviour of the calves or the rate of healing.

It took 14±3 seconds (range 6-18) to place both swabs on the dehorning wounds, including the time to re-patch when required.

Half of the patches were dislodged within a day of application, 21% within an hour (80% of this loss occurred when the heifers rose quickly from the lateral prone position after surgery) and 29% within a further 23 hours (Figures 2 and 4). Of the 24 heifers patched, 7 lost both patches and 10 lost one patch (4 from the left side, and 6 from the right) within the first day.

Of the patches that remained, 4% came away after 10 days (both from one heifer), 8% between 2 and 3 weeks, and the remaining 38% by 6 weeks post-surgery.

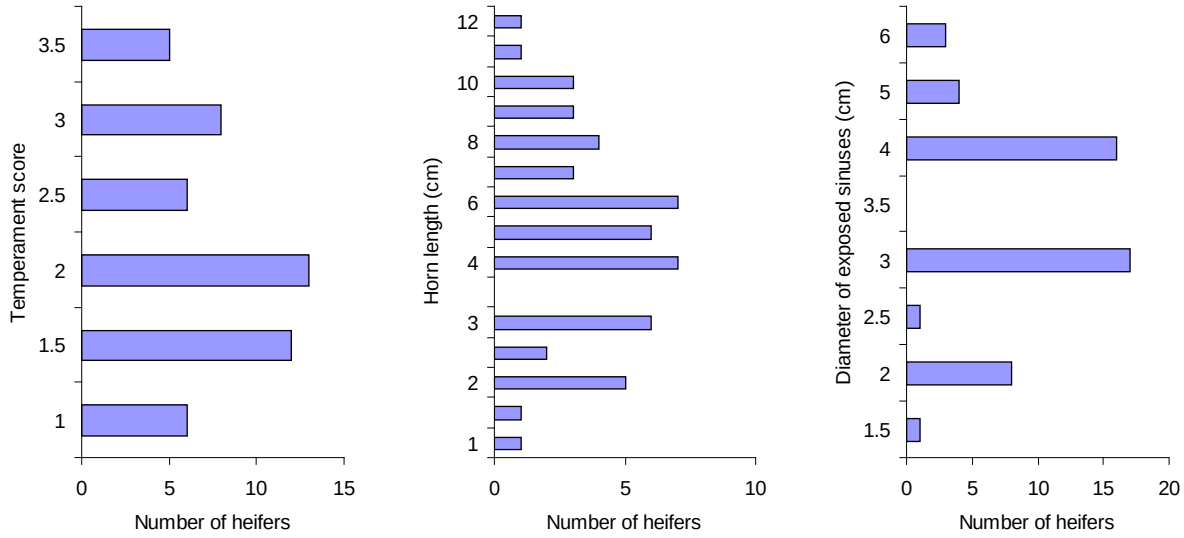


Figure 3. Distribution of heifers at allocation and treatment on temperament score, horn length and diameter of exposed sinuses

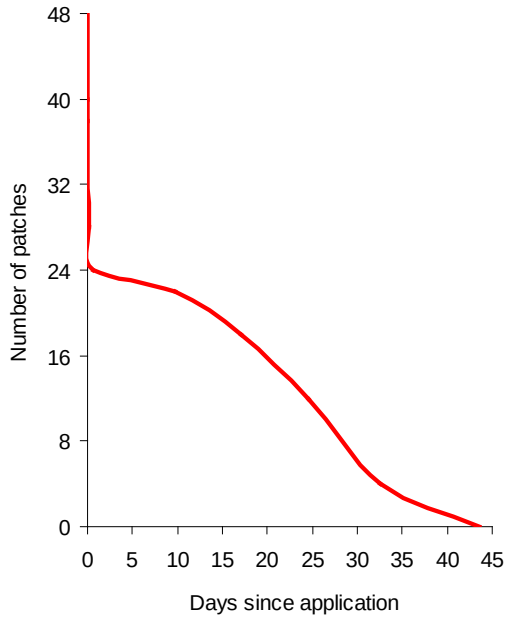


Figure 4. Retention of patches

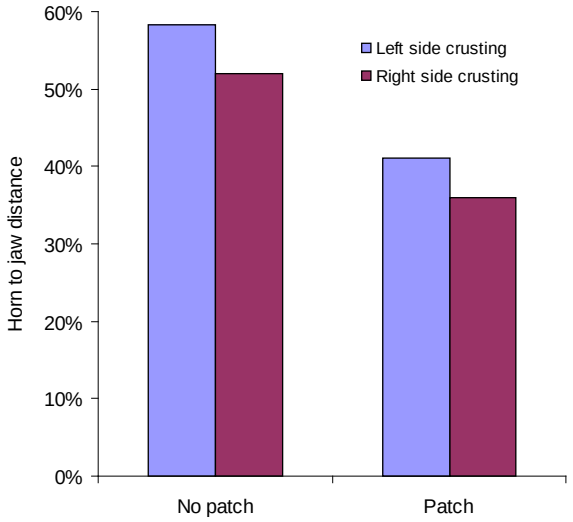


Figure 5. Average proportion of the distance to which clotted blood on the skin extended between patched and un-patched de-horning wounds and the angle of the jaw

If the distance observed of clotted blood on the skin away from the de-horning wounds was indicative of the degree of post-surgical haemorrhage, patching reduced haemorrhage, irrespective of whether the patch was lost soon after dehorning or not (0.55 ±0.26 *v* 0.39 ±0.23 of the distance to the angle of the jaw; P<0.01; Figure 5). This measure did not differ significantly between sides. If the distance of adhering clots away from the wounds is proportional to the square of blood volume lost, the calculated reduction in bleeding was

49%; note that this may be a very unreliable figure as there is no evidence that the assumption used in the calculation is accurate.

There were no significant differences in incidence of any diet or non-diet behaviours between heifers in which no patch had been applied, those that retained both patches, and those in which one or both patch had been lost within 24 hours of surgery. Therefore all behaviour data are descriptions for the experimental group.

Whether heifers were found to be walking, standing or lying did not appear to alter over time (Figure 6). Neck extension was noted in 10-20% of heifers up to 3 days post-surgery. Up to this time, no heifers appeared to have a relaxed posture, but between days 3 and 10 post-surgery, the proportion of heifers with a relaxed posture gradually increased to approximately 90% where it then remained constant.

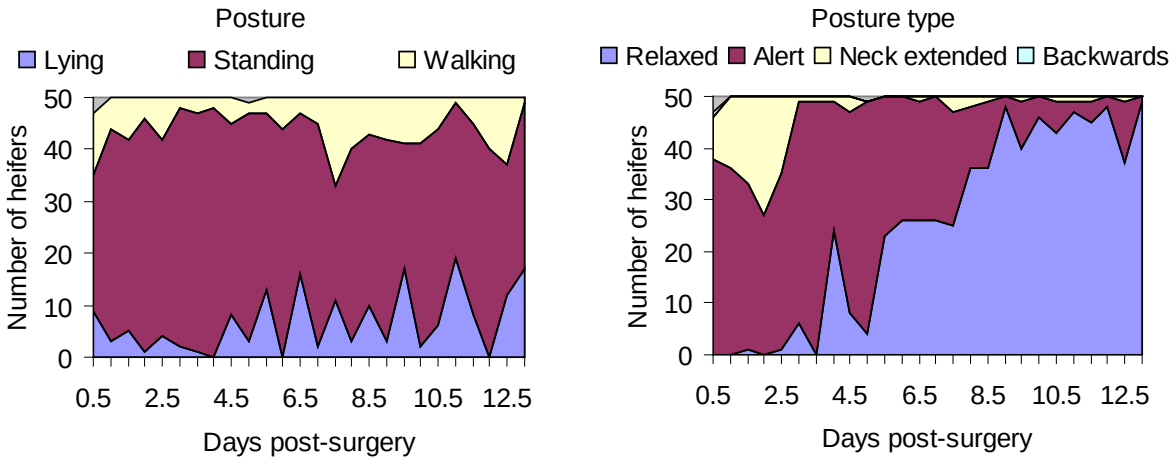


Figure 6. Posture of animals post-surgery in the experimental group

All heifers except one vocalised during dehorning. Vocalisation was almost exclusively associated with dehorning, and not branding, ear notching or ear tagging.

“Tonguing”, head shaking, head scratching and ear flicking were the main non-diet behaviours noted the morning after surgery (Figure 7) with approximately half the heifers showing each these behaviours, except head scratching. Tonguing was the most obvious of the behaviours observed, especially in the days immediate after surgery when the tongue was extended and writhing well beyond the mouth while the animal usually had its head in an extended lowered position. Head scratching was most usually the rear hoof held near the poll without touching the area, presumably because of the pain. Between 2 and 14 days post-surgery, the incidence of most non-diet behaviours was low in the morning and much higher at the end of the day. These behaviours subsided to steady levels within 10-14 days post-surgery.

The incidence of tail flicking was low (Figure 7). Between days 5 and 13 post-surgery, the incidence of self grooming was 6%, up from 1% between days 0 and 4.5 post-surgery. A similar trend for heifers using trees, fence posts, hay bales or each other to rub their head occurred with the incidence increasing from 1% to 4% during the same time periods.

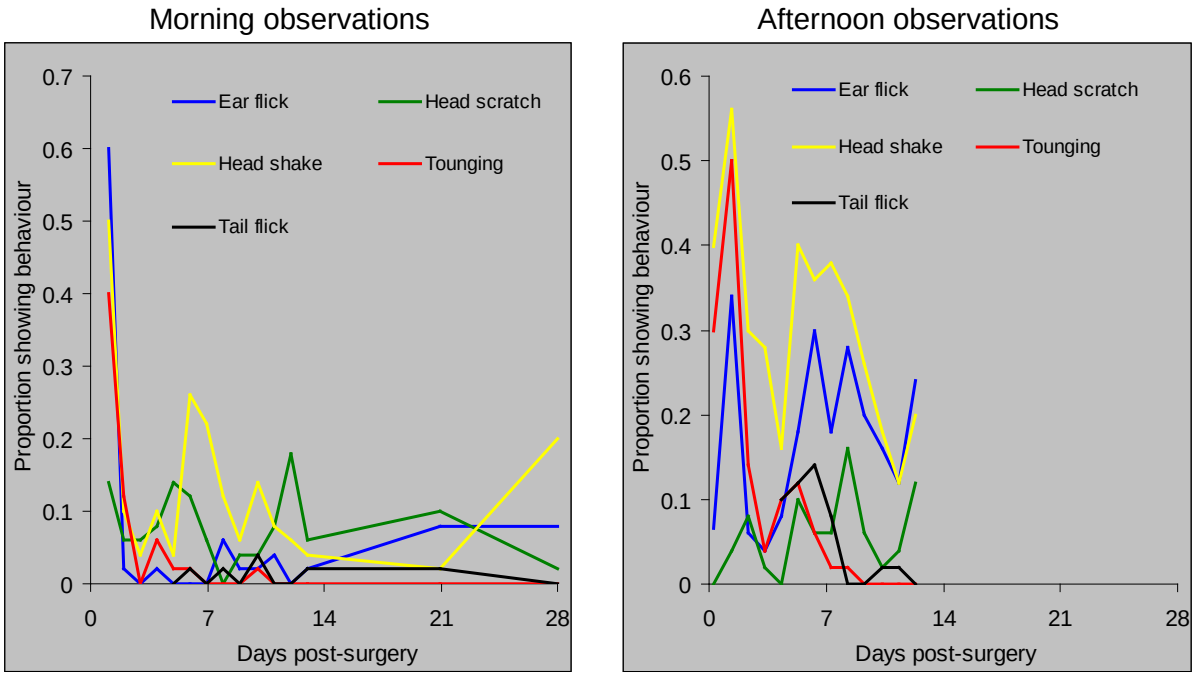


Figure 7. Incidence of most frequently expressed non-diet behaviours in the experimental group

No agonistic behaviours were recorded in the month after surgery.

There was little feed intake or rumination for 2 days post-dehorning (Figure 8). Grazing behaviour was exhibited once the heifers started to move around significantly after 2 days, even though there was almost no grass. This behaviour appeared to be innate, ie, they moved and chewed at whatever they could as they would in normal group grazing, even though there was plenty of hay available in the small holding paddock. Relatively-normal digestive (eating, drinking, rumination) behaviour was resumed beyond a week post-surgery.

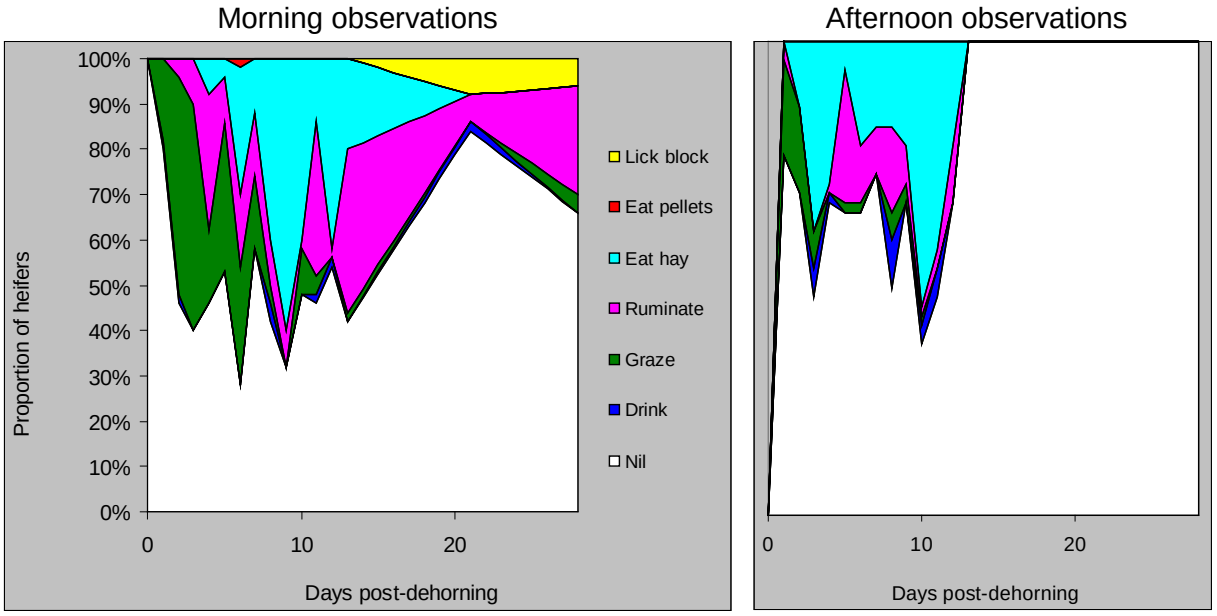


Figure 8. Diet-associated behaviours in the experimental group.
Note: Even though "grazing", no significant pasture to consume

No significant mixing with other weaners post-dehorning occurred till 4 weeks post-surgery. As well, only one instance of a heifer at the pellet (grain) feeder was recorded.

Growth as measured by both change in both weight and body condition did not differ between heifers that were un-patched, had lost one or two patches within a day of surgery, or retained patches for 10-44 days. Rapid condition loss occurred immediately post-dehorning with gradual recovery and then loss when given access to the adjacent paddock (Figure 9). The condition loss experienced of about half a score in days following surgery suggests weight loss of about 12 kg (6%) based on the predictions of Fordyce e*t al*. (2013). The heifers weighed 20 kg less at their Wainui feedlot induction than at the start of experiment, though this difference would have been affected by differences in weighing protocols, ie, differences in pre-weighing water and feed intake caused by differences in environments and handling.

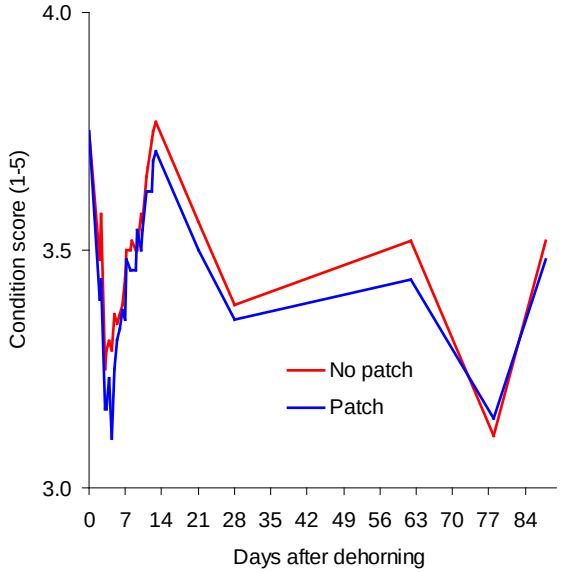


Figure 9. Body condition score in heifers allocated to receive a dehorning patch or not

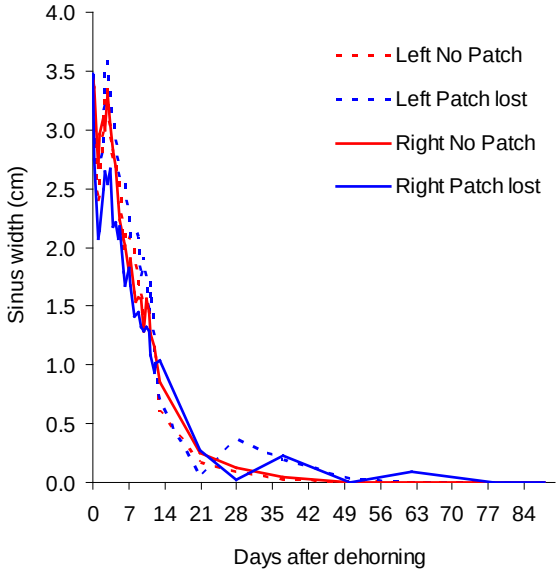


Figure 10. Average width of exposed sinuses in wounds where no patch had been applied or an applied patch was lost within 24 hours of surgery

One day after surgery, 4 heifers were noted to be bleeding from the nose. A further 4 heifers had nose bleeds on days 2-3.5. Incidence of nose bleeding was unrelated to whether patching occurred, or whether patches were retained for a day or more. It is unknown if this blood seen was from the dehorning wound passing through the frontal sinus and into the nasal cavity of these heifers.

There was no difference in healing between dehorning wounds that had not been patched and those that had lost their patch within a day of surgery, nor between wounds on the left or right side. Therefore, all comparisons were between patched (n=31) or un-patched wounds (n=69).

A majority of sinuses in un-patched heifers appeared to close by about 4 weeks post-dehorning (Figure 10). When patches sloughed, some small holes remained and healing was associated with an increase in the incidence of muco-purulent, but not purulent exudation; one hole remained at 9 weeks but had closed by 11 weeks.

When comparing wounds in which patches remained after 24 hours with un-patched wounds, a generalised linear model for the binomial response (using a logit link) indicated there was no significant difference between the overall healing response for the two treatments (P=0.19); there was a non-significant trend for an average of 14% more patched wounds at the post-scab healing stage (see Table 2 for stage of healing description) between 6 and 10 weeks post-surgery (Figure 11).

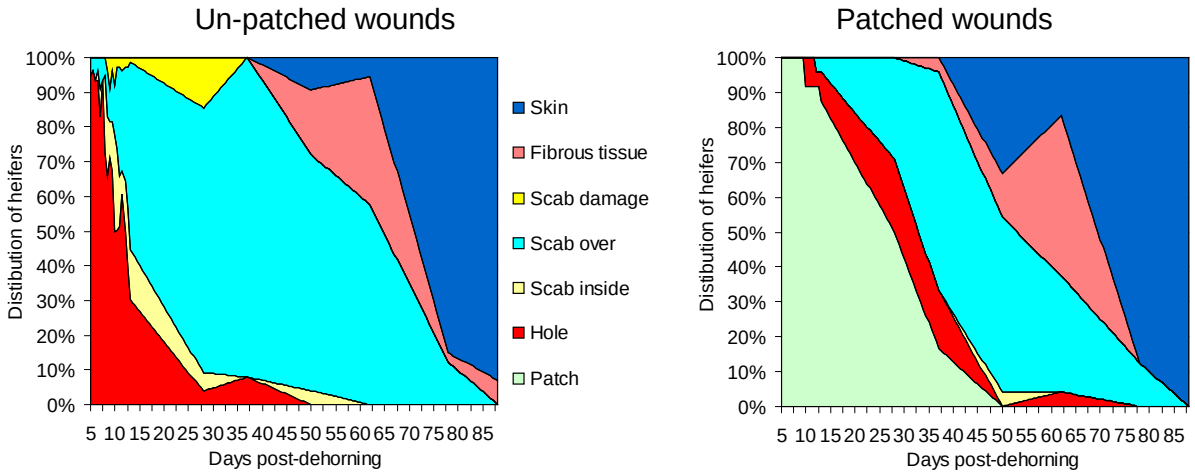


Figure 11. Distribution of healing stages in dehorning wounds that were patched and un-patched at Day 1

The average diameter of full dehorning wounds (between edges of intact skin with hair) at surgery was approximately double the width of the hole into the sinus, ie, 7cm. Based on final observations, full contraction of this area was expected to occur by 13-14 weeks (91-98 days) post-surgery (Figure 2). There was no effect due to patching on area of affected healing tissue (Figure 12).

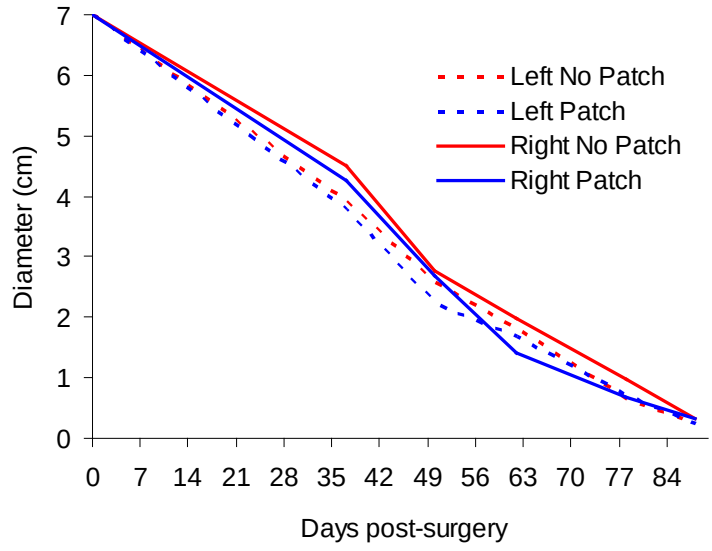


Figure 12. Diameter of healing tissue in dehorning wounds that were patched and un-patched at Day 1

Between 1 and 4 weeks post-surgery, exudation from an average of 22% of un-patched wounds was 18% units higher than from patched wounds (P=<0.01; Figure 13). Purulent exudation (pus ± blood) occurred in an average of 1% of patched wounds and 11% of non-

patched wounds in this period (P<0.01). Exudation increased in patched wounds after the patches sloughed. Exudation reduced from about 10% to nil between 5 and 12 weeks post-surgery for the experimental group. Most exudates in un-patched sinuses reduced to low levels within 5 weeks of surgery.

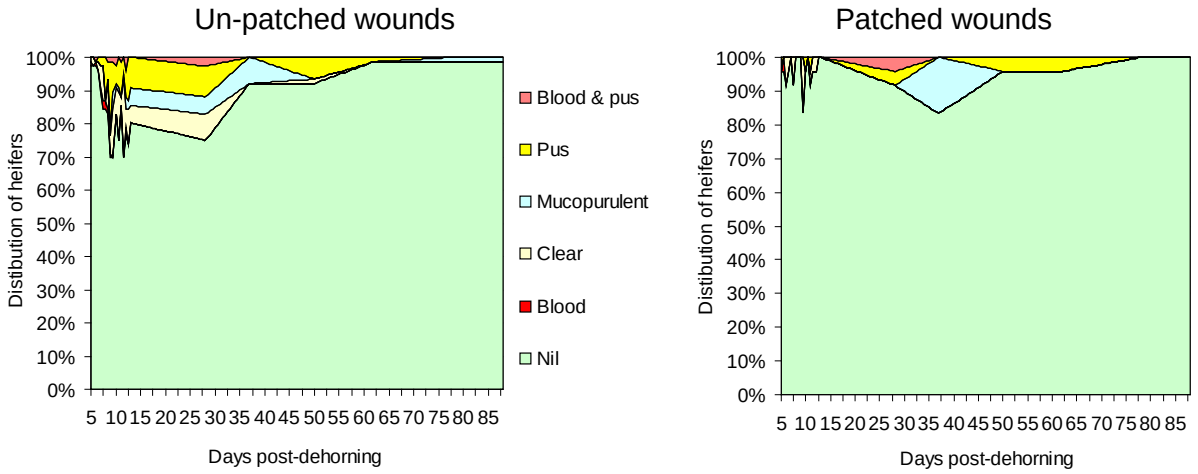


Figure 13. Prevalence of exudates from sinuses that were patched and un-patched at Day 1

Fly larvae were noted in two un-patched sinuses (different heifers) when they arrived at the feedlot. The comparison with no infestation in patched wounds was not statistically significant. One sinus had one previous incidence of a clear exudate, though the other had regular previous purulent exudation. Ten days later, healing in these two heifers was progressing well with no evidence of negative impacts due to the larvae.

Discussion

This experiment has demonstrated that patching of dehorning wounds in weaner heifers with a gauze swab immediately after surgery reduces blood loss and reduces the incidence of secondary bacterial infection. Neither rate of healing nor heifer growth was affected by patching. Despite the potential advantages of patching dehorning wounds, research is required to find a cost-effective way to keep patches in place. The heifers in this experiment dislodged half the patches within 24 hours of surgery, and most of this occurred during release from restraint for surgery. Patches that were not dislodged remained fixed for 10-44 days.

The reduction in haemorrhage when placing the swabs on the dehorning wounds was not unexpected as it is a standard surgical practice (Kihurani *et al*. 1989). Sinclair (2012) reported that arterial squirting immediately after surgical dehorning of Brahman heifers was reduced from an average of 40% to 13% when a swab soaked in topical analgesic was applied to the wound. The swabs cost 2 cents each. Patching increased the time taken to dehorn (14 seconds average), which, for a typical branding team would cost approximately $0.50 per animal. A method to increase adherence of the swabs would further increase cost. In a study of 6,750 calves in north Australia, Bunter *et al*. (2013) reported that dehorning caused a loss of 2.1% of calves compared to deaths of only 3 of 1,598 polled calves (0.2%) after branding. The reason for loss was not defined, but presumably included associated haemorrhage and secondary infections. Effective patching may have a role in reducing these losses, thereby compensating for the cost of this procedure; research is required to quantify this potential benefit. Patching appeared to have no effect on pain experienced by the calves following surgery. Despite this, and even without good adherence, patching may be a useful addition to routine practice if for no other reason than to reduce haemorrhage.

Patching almost completely prevented significant secondary bacterial infection as indicated by purulent exudation in the month after surgery. However, as patches sloughed, temporary mucopurulent exudation occurred. Fly larvae infestation occurred in two un-patched dehorning wounds, but in no patched wounds. Though patching did not affect the rate of closure of the exposed sinuses, or affect the rate of contraction of the wound area, there was a non-significant trend for patched wounds to reach the post-scab healing phase earlier.

This experiment has provided additional data on pain and healing following dehorning where frontal sinuses are exposed. Healing of un-patched dehorning wounds progressed to a scab that sealed the exposed sinus within 3 weeks for almost all heifers. We found that healing progressed to the post-scab healing phase for most heifers between 6 and 13 weeks after surgery. This is consistent with a series of experiments with primarily Brahman heifers in which Sinclair (2012) found nil and approximately two-thirds reached the post-scab stage of healing at 4 and 8 weeks after surgery, respectively. Kihurani et al. (1989) also reported that epithelisation took 14 weeks to complete in 1- to 5-year-old cattle dehorned with a cutting wire. Loxton et al (1982) reported that healing following dehorning was complete for most calves within 4 weeks. However, the dehorning in that report will have included disbudding for many animals as well as an undefined proportion in which horns were amputated to expose frontal sinuses.

The lack of effects due to either temperament score, horn size, diameter of holes to exposed sinuses, incidence of bone fragmentation at the edge of the exposed sinus, or incidence of arterial squirting on behaviour or healing after dehorning indicates that these are minor effects relative to the major procedure of dehorning.

The temporary infestation of the frontal sinus with fly larvae in two heifers appeared to have no short- or long-term consequences. Maggots can have severe deleterious effects but can be curative, depending on the situation, the species of fly and numbers of maggots (Sherman *et al*. 2007; Jones and Wall 2008). In our observation it appears the maggot infestation was not deleterious. The relative incidence of deleterious or beneficial effects in the range of situations that occur across north Australia is unknown.

Anecdotal evidence indicates that beef producers apply a range of commercial products that have insect repellent properties to dehorning wounds, either prior to or after surgery. Low insect populations precluded testing the efficacy of this strategy in this experiment. However, it is hypothesised that effective patching of dehorning wounds, which prevents direct insect access, may be just as effective in preventing fly strike as application of medicated products.

Acute pain in domestic animals is assessed using a range of indicators including vocalisation, absence of normal behaviour, changes in behaviour, change in degree of activity, weight loss, a lack of indicators of well-being, and range of physiological and biochemical measures (Anil *et al*. 2002). Dehorning, but not ear notching or fire branding conducted at the same time, elicited vocalisation in all but one heifer suggesting this is a painful procedure. Incidence of behaviours not usually expressed and previously associated with pain, and changes from normal digestive behaviours, were high during the 2-3 days after surgery, highest during afternoon observations, and abated over 2 weeks, suggesting pain caused by dehorning was being experienced during this period; eg, self grooming and scratching behaviour were suppressed for 5 days following surgery. Resumption of normal digestive behaviours within a week after surgery was associated with partial recovery of body condition loss observed immediately after surgery when feed intake was completely suppressed. Loxton *et al*. (1982) previously showed that dehorning of calves causes temporary weight loss. Some previous reports of pain associated with amputation dehorning only studied the animals for short periods (eg, <1 day; Sylvester *et al*. 2004) and did not

provide the opportunity to observe the prolonged pain associated with this procedure. However, Sinclair (2012) reported that the incidence of "comfort" behaviours during instantaneous observations, that is, behaviours associated with pain relief, reduced from approximately 20% to 5-10% in the two weeks following surgery.

"Tonguing" behaviour has not previously been reported. This unusual behaviour, which was observed in 16% of heifers in the two days after surgery, may have been related either to pain and or to blood travelling directly into the nasal cavity from the dehorning wound via the frontal sinuses, from where it could have been in contact with the tongue; ie, the behaviour may have been in response to the taste of blood.

The reason for a higher incidence of head shaking and scratching, ear and tail flicking, and tonguing in the afternoon compared to the morning is unclear. There may be some effect of the higher temperatures during the day than at night. Evening temperatures were mild, but maximum day time temperatures exceeded $30^{O}C$; the morning and afternoon observations were 1-2 hours after the times of minimum and maximum temperatures.

The heifers' avoidance of other unbranded animals with which they were cohabiting (eg, they avoided eating pellets) continued for at least 4 weeks. This may have been a normal social behaviour when groups unfamiliar with each other mix, but based on our observations, appeared more likely to have enabled avoidance of agonistic behaviour associated with feed competition. No agonistic behaviours were noted by the trial heifers. This supports a recommendation that in the month after surgery, mixing of dehorned and non-dehorned calves is contraindicated. The heifers expressed innate grazing behaviour irrespective of feed availability after surgery, supporting a further recommendation that, wherever possible, dehorned calves should be allowed access to pastures that readily satisfy feed intake requirements. This may reduce energy wasted, and reduce any requirement for agonistic behaviour in competitive situations.

Given the prolonged pain associated with dehorning by amputation that exposes the frontal sinus, this procedure should be avoided where possible. This is occurring with the rapid uptake of breeding for polled cattle, and dehorning as young as possible when only horn bud removal is required. Whether to dehorn by amputation should be balanced against the known impacts of horn status on intra-specific behaviour and injury, handling, meat quality and carcass quality. These impacts are not well defined in cattle aged less than 2.5 years.

Conclusions

Patching with a gauze swab of dehorning wounds in which there has been exposure of the frontal sinus, does not appear to significantly increase either the rate of healing or the healing outcome. However, it does reduce post-surgical haemorrhage and the incidence of secondary infections. It may reduce the chance of fly strike, and may slightly increase the time taken to reach the post-scab healing phase. Patching of dehorning wounds may assist in reducing the mortalities caused by dehorning. A recommendation is to develop a cost-effective method to increase adherence of swabs.

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