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Review of Wound Treatments Available for Routine Husbandry Procedures of Grazing Animals

Abstract

The complex nature of wound healing means that a single application of dressings at the time of routine on-farm surgical husbandry procedures is unlikely to contribute directly to wound healing or to prevent infection of the wound. A review of wound dressing recommendations for use in grazing animals indicates that the most common reason for application is to prevent flystrike after routine husbandry procedures such as mulesing or dehorning.

This review highlights the need to follow best practice guidelines for routine husbandry procedures to reduce the risk of subsequent complications, and to use, if necessary, only products registered for the intended purpose according to label directions.

Executive Summary

The aim of this review was to examine the current recommendations for the use of wound dressings in grazing animals (excluding mulesing) and to provide a concise summary and comparison of the benefits, costs, effectiveness and recommendations for each of the wound preparations accessible to producers and lay operators. Further the intention was to produce a small durable booklet for use at the workplace which gave pertinent information for producers regarding the main attributes and benefits of each dressing for procedures applied to grazing livestock.

There is abundant literature covering the complex nature of wound healing in small animals and horses. The best type of topical medication to aid wound healing differs depending on the stage of wound healing. Such medications tend to be expensive and require very frequent application and intensive wound monitoring. It is rarely practical to provide more than a "one-off" application of a wound dressing after routine husbandry procedures in cattle and sheep in a grazing situation.

Most literature related to wounds in grazing animals is focussed on the prevention of blowfly strike after mulesing in sheep. The "National Mulesing Accreditation Manual", the "Best Practice Guidelines for Branding, Castration and Dehorning of Cattle".and state Department of Primary Industry (DPI) advisory literature all recommend in general that no wound dressing should be applied to mules wounds, or other specific wounds after routine husbandry procedures such as dehorning or castration. If flystrike is considered a potential risk, then only products registered for application to wounds should be used and then only in accordance with label recommendations.

Three different chemicals are registered for use in sheep after mulesing: spinosad (for example, Extinosad^{R}), dicyclanil (for example, CLik^{R}) or organophosphate (OP)based products. No recommendation is made in the National Mulesing Accreditation Manual as to which, if any, product is preferred. Spinosad and dicyclanil are not registered for cattle in Australia, but have been shown overseas to be effective against strike caused by Old and New World Screwworm infestation. However, many of the organophosphate products used in sheep are also registered for cattle for dehorning and general wounds. Current reviews in progress by the Australian Pest and Veterinary Medicine Authority (APVMA) suggest there will be further restrictions on use of OPs based around occupational health and safety issues

In general there are no recommendations for prevention of infection by use of topical dressings in this advisory literature . Any real benefit of wound treatments in grazing animals are mostly after the event (that is, infection has established) and would necessitate more intensive daily care after flushing the wound and perhaps administration of systemic antibiotics. This should also indicate the need for review of on-farm husbandry practice. In the case of wound dressings for infected wounds, evidence suggests it probably makes little difference what product is used as a dressing, provided there is effective flushing of exudate and debriding of the the wound prior to application of the dressing and regular application of a fly repellent. In any event, it is usually not a "one-off" treatment at the time of the procedure. If wound hygiene is compromised during husbandry procedures it is unlikely that products currently registered for wound treatment in pastoral animals and applied once only at the time of wounding will be sufficient to counteract the hygiene breakdown, if contamination and infection is sufficient to overcome the body's own defence mechanisms.

Recommendations to use insecticidal ear tags to control nuisance or flies strike around dehorning wounds would seem inappropriate. This would be not a registered recommendation and

indiscriminate use may enhance resistance in the species of insects for which the product is mainly intended (for example, buffalo fly, MLA 2005)

"Best practice" guides have been published for routine cattle husbandry procedures and for mulesing in sheep. Both these documents recommend that routine dressings not be applied; except perhaps in the face of heavy fly challenge. Even after application of insecticide, regular monitoring of cattle or sheep for several weeks after routine husbandry procedures is an integral part of this advice. If producers consistently need to apply a wound dressing, then it seems that they should be reconsidering their "best practice" rather than considering the type of wound dressing. There is no substitute for following best practice guidelines in relation to routine husbandry procedures.

The principal recommendation of this review is that no wound dressing handbook or publication be produced for graziers. The only practical recommendation regarding wound dressings that can be made is to adopt "best practice"for all routine animal husbandry procedures, to monitor animals for several weeks after routine procedures and to use only registered products according to label directions if complications arise. Given that the National Mulesing Accreditation Manual makes no specific recommendation regarding which chemicals might be superior for the control of flystrike post-mulesing, it is also inappropriate to make any other recommendation here regarding preferred products for use on specific (like dehorning or castration) wounds or general wounds in cattle and sheep.

Contents

1 Background

Husbandry procedures such as castration and dehorning in cattle and mulesing, castration, and tail docking in sheep result in open wound0s which take several weeks to heal. Particularly in relation to cattle, there is little specific advice regarding the use of wound dressings either as aids to wound healing, to control infection or prevent and/or treat blowfly strike. Most specific research had been carried out with regard to the prevention of flystrike following the mules operation in sheep. The majority of literature relating to the subject makes no specific recommendation regarding wound dressings except to advise use of a product registered for the specific purpose, according to label instructions and only when there is sufficient risk of blowfly strike.

2 Project Objectives (to check if as per the contract schedule)

The objectives were:

1. to identify all products currently available to producers from commercial suppliers, and all products registered as wound dressings; and develop a list of the major products currently used,
2. to produce a detailed summary of the major products in use for common husbandry procedures such as branding, castration and dehorning of cattle with particular reference to benefits, cost, efficacy, withholding periods, duration of activity, fly repellent attributes, availability to producers and special instructions
3. to produce a small durable booklet for use at the workplace which gives pertinent information for producers regarding the main attributes and benefits of each dressing for beef cattle procedures.

3 Methodology

Data and information has been sourced from MIMS Index of Veterinary Specialities (IVS) Annual (2006), the Australian Pesticides and Veterinary Medicines Authority MIMS IVS Annual (2006), APVMA (Pubcris 2006) and rural merchandise house (Elders Ltd) in order to compile lists of registered products for the various husbandry procedures. Current APVMA reviews (APVMA 2006a, 2006b) were an important source of information. A concurrent literature search was made, and the publications “National Mulesing Accreditation Manual” and “Best Practice Guidelines for Branding, Castration and Dehorning of Cattle” have been used as the most current references for “best practice” in husbandry procedures where open wounds are a sequelae of the procedure.

This information was used to determine whether to proceed with the workplace booklet

4 Results and Discussion

4.1 The process of wound healing.

Dart, Dowling and Smith (2005) describe wound repair as “a complex temporally and spatially co-ordinated series of cellular, molecular, physiologic and biochemical events regulated by a delicately orchestrated cascade of mediators”. This process is summarised below (see Wheeler 2004), who

notes that wound healing is a "continuum of overlapping events described…as four stages: inflammation, debridement, repair and maturation". Each of these stages is a critical component of the repair process.

Inflammation is the process whereby the body attempts to control haemorrhage and prevent infection by local vascular and immune responses. The inflammatory process is an important part of wound repair. It is indicated by heat, redness, swelling and pain and should not be entirely eliminated in the treatment regime. Some inflammation is necessary to avoid delays in wound healing.

Debridement is the phase of organisation of the by-products of the inflammatory process, when scabs form to protect the wound and provide an environment that encourages the ongoing proliferation of fibroblasts. The scab also helps maintain conditions that aid the control of infection and provides a framework for factors that attract cells to remove necrotic debris, foreign material and bacteria.

The repair process occurs via a variety of mechanisms. Fibroblasts migrate over the wound and lay down ground substance and collagen, the basis of the scar tissue. A highly vascular bed of granulation tissue nourishes the cells working towards repair; epithelial cells migrate over this granulation bed towards the centre of the wound; and finally wound contraction occurs as the full thickness of the skin is pulled together to minimise scar tissue formation.

Maturation of the wound occurs then over several months by conversion of collagen and development of cross linkage to increase scar strength.

Wheeler (2004) also lists a number of factors that might delay wound healing. These include foreign bodies and wound contamination, necrotic tissue, infection, movement (for example, wounds over joints), pH changes, inadequate blood supply, lower temperatures, altered oxygen tension, and poor nutrition. In terms of pastoral animals, wound contamination, handling animals too soon after procedures such as dehorning or castration and insect worry or blowfly presence contributing to delayed wound healing and/or maggot infestation of the wound, are real possibilities.

In particular, dehorning wounds are quite unique because of the opening of the horn into the frontal sinus of the older animal and the presence of the stump of the horn processes (Kihurani, Mbiuki and Ngatia 1989)

4.2 The purpose of wound treatments and dressings.

The expectation is that wound dressings would contribute to one or more of the following functions:

- Aid wound healing by enhancing one or more of the wound healing processes
- Aid wound healing by counteracting factors that might interfere with wound healing (for example, flushing of foreign bodies or necrotic tissue)
- Protect the wound from further injury or damage (for example, bandages)
- Prevent and/or treat infection
- Act as an insect and/or fly repellent

- Prevent and/or treat myiasis (meaning flystrike?)

The most advanced medications now available for wound care in the fields of human, small animal and equine medicine usually enhance some phase of wound healing. The most appropriate type of medication will therefore differ depending on the stage of wound healing. Such medications also tend to be expensive and require very frequent application and intensive monitoring. At best, these medications and treatment regimes have been shown to provide only a few days advantage in wound healing compared to a saline or medication vehicle control (Krahwinkel and Boothe 2006). Importantly, in discussing the management of wounds in cats and dogs, they also note that most wounds heal without the intervention of veterinarians. It therefore seems most likely that the only cost effective dressing applied to wounds on pastoral animals are likely to function either to prevent or treat infection and/or flystrike. (Is this correct? Already recognise that treating infection in pastoral animals is not practical.)

Further to this, Krahwinkel and Boothe (2006) in their review of wound medications, cite research indicating:

- Topical preparations are more effective in preventing wound infection than in treating it,
- Topical antimicrobials are most appropriate when used to reduce the bacterial burden in chronic wounds with active but localised infection,
- The use of antiseptics remains controversial in human wound care,
- Wounds most likely to benefit from topical antiseptic treatment are those with or without signs of infection, that are of an atraumatic or chronic nature, that are heavily contaminated with a variety of organisms and that are failing to heal.

In a review of the topical management of wounds, Liptak (1997) also notes the controversy surrounding the use of topical antimicrobials, but concludes that:

- Topical antimicrobials may be useful to prevent or control infection prior to the development of the granulation bed and when devitalised tissue or foreign material may be still present in the wound. However, when administered at concentrations that are bactericidal, topical antimicrobials have been shown to be cytotoxic or impair local cell function,
- Topical and systemic antibiotics have less benefit once infection has become established as wound coagulum interferes with effective concentrations being reached in deep or superficial layers depending on route of administration.

Liptak (1997) also states:

- That wounds should be thoroughly irrigated under adequate pressure and judiciously debrided as necessary.
- That the use of antibiotics or antiseptics in lavage solutions is debatable. and should be avoided unless infection is likely as a result of a wound such as a bite or a burn.
- That chlorhexidine is the preferred antiseptic solution because of longer residual activity, even in the presence of organic matter.
- That wound dressings should be chosen according to the stage of healing.

The question then remains: “is any dressing that we apply to a wound at the time of procedure likely to be beneficial in preventing infection or strike and not harm the healing process?” It may be that application of a dressing for a particular purpose (for example, to prevent myiasis) does not have a

beneficial effect on the wound repair process itself, and in fact may be detrimental. The complex nature of wound healing, and the body's response to wounds in different sites or with different levels of contamination, means that a single agent or a single method of wound treatment is unlikely to provide the optimum environment for wound healing throughout the entire process (Liptak 1997, Theoret 2005). There are also differences in wound healing noted between species (dogs vs cats: Bohling and Henderson 2006) and even between breeds within species (ponies vs horses: Wilmink and van Weeren 2005).

4.3 Best practice for dressing wounds.

The problem of finding a suitable wound dressing is exacerbated when dealing with wounds in farm animals because the nature of most wound dressings is usually such that regular daily application is required. In the field, a single application of a dressing at the time of the procedure may be the only practical opportunity, unless complications arise which necessitate more intensive treatment of the wound.

Heinz and Clem (1988) observe "there are no magic potions that will accelerate wound healing, but there are acceptable procedures that assist rather than interfere with the reparative process". They outline the process of dealing with open wounds and the first objective is the prevention of wound infection and the preparation of the wound site. Vital components of this process include early removal of dead and devitalised tissue, foreign bodies, and other contaminants; preservation of blood supply; and prevention of further secondary contamination. The second objective noted by Heinz and Clem (1988) is to assist the normal healing process by eliminating any adverse factors and assisting physiological repair.

Newman (2007, in press) outlines best practice procedures for castration, dehorning and branding in cattle. Of note is the recommendation that wound dressings are rarely required providing adherence to some basic principlesThese principles are aimed at reducing the risk of infection and nuisance fly worry or blowfly strike, and include:

- minimising the dust in the work area,
- avoiding performing procedures in wet and humid weather,
- minimising stress before, during and after surgery,
- cleaning instruments after each use, and keeping them in a solution of an effective antiseptic mixed at the correct dilution,
- ensuring the surgical site is clean and free of any contamination such as faecal material
- using good technique,
- minimising haemorrhage during the procedure,
- ensuring adequate drainage of open wounds can occur – this is especially important with castration,
- avoiding the fly "season",
- regular monitoring of stock for several weeks after the procedure if possible,
- performing the procedures while stock are young.

Others also conclude that dehorning wounds usually heal well without any dressing at all (Hoffsis 1995, Ryan and Taylor 2004, Wheeler 2004). Recommendations in current advisory and other literature include dehorning on dry cool days, and not in rainy or dusty conditions or during the fly

season. If these basic principles are adhered to, then any advantage for wound dressings is largely removed. Recommendations also note that the application of appropriate fly control or fly repellent may be needed on occasions in the fly season. The frequency of application of beneficial wound dressings, however, is likely to be substantially less than optimal, as a single application at the time of the procedure is often the only practical option.

The major wounds that may require dressing in sheep follow the marking and mulesing operations, including tail docking and castration in male lambs. Recommendations to ensure the best outcome in terms of animal production and welfare are not dissimilar to those recommendations which pertain to cattle procedures (Levot 1999; Armstrong, Knights and McLeish 2001, Evans 2006).

Although mulesing and dressing of mules wounds is not a subject of this review, some important principles in relation to the need for dressings on open wounds can be gleaned from the way that mules wounds are treated. The need for wound dressings after mulesing has been the subject of much debate (Levot 1999). In general, wounds heal satisfactorily after mulesing without applying a dressing, provided best practice recommendations are followed, i.e. the lambs are left quietly in the paddock for 3-4 weeks after mulesing (as knocking scabs off, or causing scabs to be broken during handling, will increase the likelihood of flystrike in these wounds) and it is carried out when bush flies and blowflies are not likely to be active. In certain circumstances, where fly activity is expected, insecticide application to the mules wound is recommended using a product registered for that purpose (Levot 1999; Armstrong, Knights and McLeish 2001; Evans 2004; Evans 2006, Livestock Contractors Association President Ed Langron pers comm 2006). However, Levot (1999) warns against expecting too much from insecticide products applied to mules wounds in the face of blowfly activity; and suggests most benefit is derived from good preparation, technique and timing of mulesing. Diligent checking of stock to look for untoward sequelae in the first few weeks after procedures such as mulesing, dehorning and castration will also be an important part of the process.

Note that two products currently registered for dressing mules wound (dicyclanil and spinosad) were not available at the time of these investigations (why?). These products are currently recommended by the Livestock Contractors Association (E. Langron pers comm 2006) for application immediately post-mulesing, but neither are currently registered for use on cattle in Australia. Both spinosad and dicyclanil have been shown overseas to be effective in preventing infestation of wounds with New World and Old World Screwworm infestation (Anziani et al 1998, Snyder et al 2005). Anziani et al (1998) evaluated the efficacy of dicyclanil against *C. hominovorax* in Argentina in preventing myiasis after castration of 5-6 month-old male calves. The incidence of egg masses on the scrotal wounds was similar, but 16 of 20 untreated controls developed active myiasis compared to just 1 of 20 calves treated with a ready to use dicyclanil product.

Both powder and liquid dressings have variously been shown to assist and delay healing compared to untreated controls (reference?). Primary Industry Standing Committee Report 89 (PISC 2006) makes several recommendations in relation to application of insecticide to mules wounds:

- “Dry powder dressings should not be used as they may delay healing”.
- “If an insecticide wound dressing is necessary, spray equipment should be used to apply a registered product according to label instructions immediately after completion of the procedure and before releasing the lamb from the cradle”

- “”Dunking” containers must not be used for insecticide application to the animal because the solution becomes contaminated with blood, faeces and urine, which can then be transferred to subsequent animals.”
- “Paint brushes must not be used for application of insecticide dressings because they gather and transfer blood, faeces and urine to subsequent animals.”

The National Mulesing Accreditation Manual (Evans 2006) notes the following:

- “Three different chemicals are currently registered for treating mulesing wounds. These are the insect growth regulator dicyclanil (for example, CLik), spinosad (for example, Extinosad) and organophosphates (OPs). Take all possible steps to mules when flies are not active to avoid the need to use an insecticide”
- “If products are registered for application in long wool for fly protection, but are not registered for application to wounds, use extreme care to avoid contact with the wound”
- “Use the appropriate and recommended *spraying or jetting equipment* to apply wound dressings to or around the mulesing wound immediately after completion of the procedure and before releasing the lamb from the cradle”
- “Do not allow the equipment to touch the animal to avoid cross contamination of blood, faeces or urine between animals”

The general principles would be no different in relation to treatment of cattle wounds.

The preliminary findings of the Australian Pesticides and Veterinary Medicines Authority review into products containing diazinon (APVMA 2006a) notes the following with regard to the use of liquid diazinon-based products (OP products) for flystrike and wound dressing on sheep:

- “Methods of application include brush, swab, hand spray, jetting plant and non-aerosol pressure sprayer”
- “There are no exposure data for flystrike or wound dressing. On the basis that only a small area of the wound is treated and the volume applied per animal is low, it is reasonable to assume that user exposure will be largely limited to the hands”
- “…..the application of products by hand spraying, jetting plant or non-aerosol pressure sprayer is not supported. Virbac Kleen-Dok with Diazinon^{R} and KFM Blowfly Dressing^{R} are expected to have low acute toxicity, but the excipients in Kleen-Dok indicate that it is likely to be a severe eye irritant and a moderate skin irritant. The other products are also expected to be irritating to the eyes and skin. *If labels are amended to specify low volume applications by brush or swab only*, overalls and gloves are expected to be sufficient to protect the workers during application of the diluted product or in the case of Virbac Kleen-Dok, the undiluted product to the animal. However, as Kleen-Dok is a severe eye irritant, eye protection will also be required when using this product”
- “..the APVMA proposes to find that it will not be satisfied that the use of liquid products containing diazinon for flystrike treatment and wound dressing application to sheep would not be an undue hazard to the safety of people exposed to them during their handling unless gloves are worn when handling these products. If wearing gloves is not practical then the APVMA proposes to conclude that the continued use of these products for these purposes is not supported.”

Further to this, the APVMA (2006a) report states that:

"Based on OCS (*Office of Chemical Safety*) advice, the APVMA proposes to be satisfied that products containing diazinon would not be an undue hazard to the safety of people exposed to them during their handling when used as below (among other things):

- Liquid formulations for flystrike treatment in sheep and wound dressing in sheep and cattle *provided label instructions are amended*
- Powder formulations for flystrike treatment and wound dressing in sheep, general wound dressing in animals (not specified) and dehorning".

It is therefore difficult to make a recommendation for the use of liquid diazinon-based wound dressings. The APVMA report (2006a) recommends use of these products by "*brush or swab only*", based on OH&S concerns. This is not consistent with either the recommendations of (?)PISC Report 89 (2006) with regard to mulesing, where such application methods are discouraged under the heading "Equipment NOT to be used", or the recommendations by Evans (2006) in the National Mulesing Accreditation Manual, because of the potential to transfer infection between animals. In the PISC report, powder formulations are noted to delay wound healing.

Formulation of product is also important. Levot and Barchia (1995) demonstrated different larvicidal activity against *Lucilia cuprina* with two products containing equals concentrations of diazinon, but in different formulations They also made similar findings with two products containing equal concentrations of propetamphos in different formulations. The use of "home-brews" for wound dressing is not condoned, both because of this uncertainty in efficacy, and also because of OH&S implications and unknown residue status after application of such "home-brews".

Note that the work cited above did not include two products currently registered for dressing mules wound (dicyclanil and spinosad), which were not available at the time of those investigations. Knowles et al (2005) described the use of spinosad as a suspension concentrate (SC) and aerosol formulation to prevent myiasis and enhance the healing of mulesing wounds. They claimed that application of the product reduced haemorrhage, and improved scab formation and wound retraction, even in the absence of fly pressure. In several mulesing and tail-docking trials using spinosad as SC and as aerosol, although *Lucilia cuprina* larvae were present at both day 8 and day 14 (different trials) in one spinosad (SC) treated lamb in at least two of the trials, myiasis and wound infection rates were reduced compared to control lambs. Snyder et al (2005) also demonstrated the efficacy of spinosad for both prevention against infestation of and treatment of wounds infested with New World screwworm (*Cochliomyia hominovorax)* in Brazil and Old World screwworm (*Chrysomyia bezziana)* in Malaysia.

A local anaesthetic agent (Tri-Solfen^{R}) has recently been released for use in lambs as a post-mulesing topical wound application, which may also be applied in conjunction with other dressings (for example, fly dressings). The aim of application (is it registered to reduce pain?) is to reduce the pain response post-mulesing (Allworth 2006; Paull et al 2007). Tri-Solfen^{R} is also not currently registered for use in cattle but it is available for use on sheep on an APVMA permit through veterinarians.

A search of the literature did not reveal any specific treatment comparisons for the effect of reducing flystrike in wounds on cattle, except those concerning screw-worm infestation.

4.4 Common complications of wounds in pastoral animals

Haemorrhage and infection of the frontal sinus are described as the major complications of dehorning (Ryan and Taylor 2004, Wheeler 2004, Newman 2007). Flystrike may also occur if flies are attracted to an infected discharge from the sinus. Ryan and Taylor (2004) note the major disadvantage of dehorning adult cattle is that any associated infection (perhaps with purulent discharge from the horn wound) may require intensive antibiotic injections for 5 days, with daily flushing to remove debris and pus. The infection is often accompanied by head irritation, weight loss, and flystrike.

Ward and Rebhun (1992) also note that treatment of frontal sinusitis in 12 cattle associated with dehorning wounds or respiratory tract disease was a complicated process involving trephination of the sinuses, drainage and lavage, and antibiotic and analgesic administration. Only 8 of the 12 cattle were successfully treated in this case study.

After castration, swelling of the scrotum and subsequent infection may result if environmental conditions are poor (wet, or dusty yards and faecal contamination of the surgical site), technique is poor (especially inadequate length of incision leading to poor drainage) or attention to basic hygiene is poor (Newman 2007).

Infection, fly irritation and flystrike are problems if conditions are adverse after mulesing in sheep (Levot 1999).

Descriptions of procedures such dehorning, castration and mulesing often conclude with a statement that indicates appropriate fly control or application of a suitable insecticide is necessary if blowflies are active (Armstrong, Knights and McLeish 2001, Ryan and Taylor 2004, Evans 2006, Newman 2007).

A retrospective study of post-surgical complications in small ruminants was conducted on records of student Large Animal Surgical Laboratories in Nigeria from 1989 to 1993. The surgical procedures recorded were dehorning, castration, vasectomy, rumenotomy and enterotomy. There were 311 complications recorded: wound dehiscence (25%), sinusitis (17%), haemorrhage (14%), fever (11%), and oedema (11%). Of the less frequent complications, wound infection accounted for 5%, and myiasis just 0.3%. Post-surgical complications were attributed to the poor health status of goats and sheep used, broken asepsis, wrong use of instruments, poor surgical technique and dirty pens in which the animals were kept (Sanni et al 2002). Does the original paper have the data so that can just show complications for castration and dehorning. What was the total number of ops?

4.5 Parasites that infest or irritate wounds

Arundel and Sutherland (1988) record the following parasites as having the potential to irritate or infest open wounds:

- The bush fly (*Musca vetustissima*) and domestic fly (*Musca domestica*) are reported to play a part in extending the lesions due to the buffalo fly and delaying healing in castration, docking and mulesing wounds. The flies are attracted to eyes, nostrils, vulva and wounds in search of

moisture and protein, which are essential for survival and reproduction of the fly, and cause irritation in the process.

- The stable fly (*Stomoxys calcitrans*) may cause marked reaction on the legs of cattle which become oozing sores and buffalo fly (*Haematobia irritans exigua*) may cause sufficient irritation that sores are produced from self-trauma. In both cases, bush flies may subsequently be attracted to the resulting wounds.
- The larvae of the blowflies infest wounds. A number of fly species have been identified as important. These species are able to infest a wide range of wounds on animals, and are particularly important as a cause of blowfly strike in sheep.

In addition, Waltisbuhl, Farnsworth and Kemp (2005) note the severe irritation caused by ectoparasites in cattle. If the irritation occurs during the phase of wound healing and rubbing disrupts the scab or wound surface, delayed wound healing may result.

4.6 The function of the wound treatment products

Wound dressings may be divided into a number of categories according to function and/or action. These categories include products for wound cleansing, those that aid wound healing, anti-infectives, insect repellents, insecticidal products and those used specifically for the prevention and treatment of myiasis.

A summary of all registered products for use in wounds on pastoral animals obtained from IVS Annual (2006) and APVMA (APVMA Pubcris 2006) reveals a substantial list and a range of active ingredients. Although label claims are made for particular products, most recent wound treatment reviews do not mention many of these products or chemical compounds, let alone comment on their function or potential use (Liptak 1997; Wheeler 2004; Dart, Dowling and Smith 2005; Krahwinkel and Boothe 2006)

It is known that debridement of wounds that are contaminated or infected is an important part of the wound healing process. Flushing of the wounds with physiological saline (0.9% NaCl) or aqueous solutions of chemical antiseptic is recommended (for example, chlorhexidine gluconate 0.05% or povidone-iodine 1% solutions). Even clean tap water is suggested by some to remove debris and exudate from the wound surface in grossly contaminated wounds. Chlorhexidine in particular has a long residual activity, leaving a persistent residue for 48 hours even in the presence of organic matter. However, too high a concentration might also result in compromised wound healing by an effect on epithelialisation (formation of a covering over the wound?), granulation tissue formation and wound contraction (Liptak 1997). Povidone-iodine has a residual activity of only 4-6 hours and is inhibited by organic matter, so effective debridement and flushing and frequent application are necessary for useful antisepsis. The addition of chlorhexidine or povidone-iodine to flushing solutions is considered unnecessary by many authors (Liptak 1997). Importantly, inadequate application pressure does not achieve adequate debridement and excessive pressure may drive bacteria deeper into the wound, cause further wound trauma, and perhaps even decrease resistance to further infection (Liptak 1997, Wheeler 2004). Correct pressure is that which can be applied by forcing the flushing solution through an 18G needle attached to a 60 ml syringe. The solution is also best warmed to about 45^{o}C to stimulate circulation to the area. Flushing serves to remove wound exudate, non-viable tissue and bacteria from the surface of the wound without damaging viable tissue or driving bacteria into underlying tissue (Wheeler 2004).

There are a variety of chemical compounds incorporated into products registered for wound treatment, and into products registered for insecticide and repellent activity. There is little or no evidence in the general scientific literature of comparisons of many of these products or their general efficacy.

Those compounds noted in various sources as aids to wound healing include the following active ingredients: benzoic acid, boric acid, malic acid, propionic acid, salicylic acid, titanium oxide, trypsin and zinc oxide. Propionic and malic acid are chemical debriding agents which are claimed to remove scab and necrotic tissue from wounds and skin lesions. Liptak (1997) notes that enzymatic debridement agents, such as trypsin, may be effective in dissolving wound exudate, coagulum and necrotic debris without directly harming living tissue. Other registered products for wound treatment contain ingredients including metacresol disulphonic acid/formaldehyde combination, lanolin, castor oil, pine oil, propylene glycol (which has an emulsifying action), lavender oil, aloe vera, sea minerals, stockholm tar, methyl hydroxybenzoate, propyl hydroxybenzoate, balsam peru, and nonoxynol-9. Little or no information concerning these products (formulations, mode of action, or efficacy) is available in literature searches.

Chemicals that act as anti-infection agents include the antibiotics oxytetracycline, zinc bacitracin, neomycin sulphate and polymixin B sulphate; and antiseptic agents cetrimide, chlorhexidine gluconate, cresol, benzalkonium chloride, povidone-iodine, proflavin hemisulfate, phenol and triclosan.

Insecticides are products which kill parasites, including blowflies and nuisance flies. The insecticide class includes such compounds as organophosphates (for example, chlorfenvinphos, diazinon and propetamphos); spinosad; pyrethrins and synthetic pyrethroids; and permethrin. Pyrethrins and synthetic pyrethroids also have repellent activity. Some ingredients are commonly used to enhance the efficacy of insecticidal products. Piperonyl butoxide and N-octyl bicycloheptene dicarboximide are pyrethrin synergists which help prolong the action of pyrethrins. In particular, the application of insecticides via ear tags, or products with residual activity against buffalo and other nuisance flies, appears to be an effective way of reducing insect worry; and thus may also reduce the amount of insect irritation experienced by cattle on routine husbandry wounds.

Insect growth regulators, such as dicyclanil, do have insecticidal activity, but do not kill on contact. They act by disrupting the growth of immature insects, and usually kill during the next moult stage.

Insect repellents include pyrethrins and synthetic pyrethroids (commonly in concert with piperonyl butoxide and di-N-propyl isocinchomeronate which enhances the insect repellent actions of the pyrethrins), permethrins, citronella oil, diethyl toluamide, dibutyl phthalate, eucalyptus oil, naphthalene and benzene formulations.

4.7 Failure of some wound treatments.

Expectation of the performance of most wound dressings exceeds the ability of those products to deliver the desired outcome, especially with typical single application scenarios at the time of procedures such as dehorning and castration. Discussion in the previous sections indicates that for useful effect on wound healing, most wound treatments are based on regular once daily minimum

application. The exception is in the case of some insecticides applied to wounds where useful effect may extend for longer than this, or with insecticides or repellents applied in longer acting formulations, or via ear tags, in cattle to reduce insect worry.

Following “best practice” advice in relation to husbandry procedures is the most important component of successful outcome subsequent to these procedures. In particular, this involves attention to hygiene, good technique, correct stock handling, avoidance of adverse conditions including dusty yards and wet weather, and timing to avoid insect worry and the fly season. Topical wound dressings cannot be expected to overcome poor technique (for example, failure to provide adequate drainage in castration wounds), contamination of wounds with dirt or faeces, or excessive insect irritation or high blowfly challenge. Excessive delay in wound healing, or high level of fly worry or blowfly strike subsequent to procedures, should lead to re-evaluation of the way in which these procedures are performed, or the timing of such, rather than blame being directed towards the inadequacy of wound treatments.

Resistance to parasiticides is a widely recognised phenomenon in both internal and external parasite populations. This may also contribute to failure of, or reduced periods of protection, from insecticidal products.

5 Conclusions and Recommendations

The following conclusions are made with regards to the application of wound dressings in pastoral sheep and cattle:

- There is no substitute for following best practice guidelines in relation to routine husbandry procedures,
- Best practice includes care in animal handling to minimise stress, minimising dust in the work area, avoiding wet weather where possible, maintaining cleanliness of instruments, using good technique, ensuring adequate wound drainage and avoiding the fly season. This is outlined in “Best Practice Guidelines for Branding, Castration and Dehorning of Cattle” (Newman 2007) and the National Mulesing Accreditation Manual (Evans 2006),
- If wound hygiene is compromised during husbandry procedures it is unlikely that products currently registered for wound treatment in pastoral animals and applied once only at the time of wounding will be sufficient to counteract the hygiene breakdown if contamination and infection is sufficient to overcome the body’s own defence mechanisms,
- The most important initial wound treatment in cases of gross contamination or infection is flushing to remove dirt, debris, wound exudate and other wound contaminants. Choice of a particular wound treatment over another is not likely to be important in the outcome under field situations. Systemic antibiotics may be required for deeper or more extensive infection, particularly in the case of frontal sinus infections after dehorning or where adequate drainage was not established during castration
- Cook and Steiner (1990) and Levot (1999) both caution against expecting too much in the face of heavy fly challenge of insecticides applied to mules wounds at the time of wounding. This work was based mainly on organosphosphate products. It is difficult to make recommendations regarding the use of diazinon-based liquid and powder wound dressings as there are conflicting recommendations between the two reports (Evans 2006, PISC 2006)

with a focus on the effect of application method on wound healing and the APVMA report (2006a) with a focus on OH&S concerns.

- At that time of the above work on fly dressings, neither dicyclanil or spinosad were commercially available for application to mules wounds. These products are currently recommended by NMAP (Evans 2006, E. Langron pers comm 2006) for application immediately post-mulesing, but neither are currently registered for use on cattle in Australia. Both spinosad and dicyclanil have been shown overseas to be effective in preventing infestation of wounds with New World and Old World Screwworm infestation.
- Treatment of myiasis in individual animals will also involve flushing of wounds to remove wound exudate and some maggots, and application of a product registered for the treatment of flystrike in wounds
- Application of eartags or pour-on products to reduce fly worry around the head following dehorning may be advantageous if heavy fly worry or blowfly activity is expected. The danger of such a practice is the build-up of resistance in buffalo and nuisance fly populations, and thus reduced efficacy when fly worry rather than wound healing is the main concern. (Is the danger of resistance in these circumstances really significant balanced against the immediate advantages?)

Producers concerned about the possibility of blowfly strike to dehorning and castration wounds in the immediate post-procedure period can only be advised to use a product registered for the control of blowfly strike in such wounds, and to use those products according to label directions.

6 Addendum

6.1 General notes regarding chemical use

At the time of writing of this report (Oct 2006), APVMA had published Preliminary Review Findings and called for comments on proposed changes to registration affecting the use of diazinon and sheep ectoparasticides (APVMA 2006a, APVMA 2006b). After this process, changes to use of these chemicals would be as prescribed in the draft document, unless further information was provided to counter the arguments put forward in the Preliminary Review Findings. Therefore, the use of some chemicals outlined here may be suspended, or current recommendations superseded by the final reports from APVMA. In addition, registration of particular chemicals are constantly under review as new information is available, or as tolerance for chemical residues changes in export markets. For example, diazinon use in cattle may come under scrutiny in some circumstances because of nil tolerance in the USA for diazinon in milk destined for cheese manufacture (J. Ashton pers comm. 2006).

Residue information is critical to the supply of appropriate animal product to the domestic and export markets. Failure to observe recommendations when treating animals can result in severe backlash in both domestic and international trade. Current terminology applicable to the use of chemical products on animals includes:

- Withholding period (WHP) is the period of time that must pass for a chemical in meat or milk to degrade to a level based in scientific evidence that is safe to the consumer.

- Export slaughter interval (ESI) is the withholding period (WHP) prior to slaughter for selling meat to export markets.
- Wool harvesting interval (WHI) is the recommended interval between the treatment of the animal with the ectoparasiticide and the harvesting of wool. This is proposed as a change in terminology and is synonymous with the term "wool withholding period". It is intended to differentiate wool residue information from other withholding period information pertaining to chemical residues in food (Ashton 2006).
- Sheep rehandling intervals? (SRI) or (SRP) will be new label information. It refers to the period after the application of pesticide during which people should not handle the sheep or wool for OH&S reasons, unless wearing appropriate personal protective equipment (Ashton 2006)

Note that up-to-date information on WHP and ESI is maintained on the APVMA website. Regularly up-dated versions of this information is also found on the MLA website (MLA 2006). Other sources of information about WHI and Sheep Rehandling Intervals include APVMA website (Pubcris 2006) and product manufacturers and distributors.

Discussion during the compilation of this report indicated that some producers mixed a "home-brew" (for instance, involving an insecticide such as diazinon and a vehicle like Stockholm tar). Such "brews" cannot be condoned as acceptable practice on the grounds of efficacy (see above), possible implication for residues in animal product and for occupational health and safety reasons. (This is a serious threat if the residue implications are real, as I suspect the use of "home-brews" is very common as producers perceive that they work.)

Note also that recommendations regarding expiry date and storage conditions are based on both efficacy and OH&S parameters. Breakdown in products consisting of aged organophosphate-based parasiticides used after expiry date have been known to cause acute toxicity and fatalities in cattle herds (P Rolls unpublished.) and to represent increased danger to the public and environment (APVMA 2006a).

Appropriate storage and disposal of chemical containers is also paramount to reduce environmental contamination with pesticides. Label guidelines regarding the use of personal protective equipment (PPE) and other procedures to ensure operator safety must also be adhered to.

As part of further regulatory approach to the use of chemical products, *ChemCert* Australia is recognised by governments and industry bodies as the peak body for co-ordination of national training and accreditation in agricultural and veterinary (agvet) chemical management. *ChemCert* training is designed to assist farm chemical users and managers demonstrate duty of care to comply with the requirements of legislation related to chemical use, occupational health and protection of the environment. Although *ChemCert* is currently a voluntary program, it may be that in the future such training is mandatory for the purchase and use of agricultural and veterinary chemicals (Chemcert 2006).

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8 Appendices (the appendices should be referred to in the body of the report)

8.1 Appendix 1 - Table of products registered for wound dressing according to procedure (general wounds, castration, dehorning etc)

8.2 Appendix 2 - Table of products showing active ingredient in relation to function of the product

8.3 Appendix 3 - Table of the products in alphabetical order by trade name