# CHAPTER 4

## THE SHEEP BLOWFLY AND ITS CONTROL

### Introduction

4.1 All external parasites, including flies, keds, lice and itchmite, present major problems for sheep welfare. However, most witnesses who appeared before the Committee singled out blowfly strike as the most important problem confronting the wool and sheepmeat industries in Australia today, in both economic and welfare terms.[1] For the sheep, blowfly strike means the extreme discomfort of maggots eating away at its skin and flesh; a rising temperature, pulse and respiratory rate; a disinclination to feed; and if death does not occur, the stresses of handling, crutching and jetting associated with treatment.[2] For the sheep producer, blowfly strike has been calculated to cost $1.05 (at 1985 prices) per sheep in an average season, or an average of approximately $2 300 per farm.[3] In a high-risk year, this can rise to $3 500. The cost to Australia in a normal year was estimated at one million dollars in 1980. These costs are derived from reduced wool growth or wool loss from the struck region, reduced bodyweight, impaired fertility, deaths and treatment.[4]

4.2 Funding for research into methods of control from the Australian Wool Corporation alone amounted to $1 424 970 in the present financial year, reflecting the seriousness with which the Corporation views blowfly strike.[5] Nineteen research projects are supported, including work into the development of vaccines, improved insecticide application, alternatives to mulesing and genetic control of blowfly populations.[6] The Australian Meat and Livestock Research and Development Corporation similarly supports research into the prevention of blowfly strike and control of the sheep blowfly.

4.3 In this chapter, the Committee will consider the flies responsible for primary and other strikes, and their epidemiology, along with the factors which predispose sheep to flystrike and how flystrike affects sheep. It will then consider prevention and control measures, including chemicals, biological control and management strategies such as mulesing.

## Sheep blowflies

4.4 Nineteen species of fly are known to be involved in flystrike in Australia.[7] One, *Lucilia cuprina*, initiates up to 90 per cent of all strikes, while *L. sericata* and the native flies *Calliphora stygia*, *C. augur* and *C. nociva* may also act as primary strike flies. Other flies can invade and extend the wound area created by the primary strike fly. Given the predominance of *L. cuprina* in initiating strikes, the Committee will particularly consider this fly and its control.

4.5 It is thought that *L. cuprina* was introduced into Australia in the late nineteenth century, probably from South Africa or India, and probably on struck sheep.[8] Cutaneous myiasis, or the invasion of sheep skin by fly larvae (flystrike), was recognised as a problem in 1901-02.[9] Blowfly strike occurs most commonly in the breech area of the sheep, although other parts of the animal may also be affected ("body strike"). Strikes around the poll, the pizzle, or in wounds also occur.

### The life cycle of *L. cuprina*

4.6 *L. Cuprina*, a small, metallic green fly, breeds almost entirely on the living sheep. The female fly is attracted to a moist liquid protein environment, such as that provided by faeces, urine-saturated breeches, fleece rot, dermatophilosis or wounds, and there she lays her eggs, depositing them in batches of 50-250. During her two-to-three week life, she can lay up to three batches of eggs, if conditions are suitable.

4.7 The eggs hatch in as little as eight hours in hot humid weather, but take up to three days when the temperature drops to 15°C. When protein, warmth and humidity are present, the larvae (maggots) pass through three stages of development, called instars, becoming fully developed in four to six days. At the second and third instar stages, they can break the sheep's skin to feed on exudate.

4.8 The mature third instar drops to the ground, usually at night, to pupate at an average depth of 1.5 cm in the soil. Pupation may take only one to three days in summer, but when soil temperatures drop below about 10°C, development is halted and the fly overwinters in the prepupal stage.

4.9 Development recommences when the soil temperature rises, although high pupal mortality is recorded in midsummer when soil temperature becomes too high. Summer rains increase the survival rate of larvae and pupae, and also predispose sheep to fleecerot and dermatophilosis, making them attractive to flies. Females can mate and produce eggs within a week of emerging from the soil.

4.10 Flies have been recorded as travelling 7.5 km within 47 hours,[10] though the majority are thought to remain within two kilometres of where they emerge from the soil.

**Susceptibility of sheep to blowfly strike**

4.11 Sheep become attractive to flies for a variety of reasons, all related to the presence of moisture. This may be in the form of rain, urine, wound exudate, diarrhoea or skin inflammation. If the moistened part is conducive to the retention of moisture (for example a wrinkly breech), the likelihood of strike is increased, provided that the temperature is also suitable.[11]

4.12 Merino sheep are the breed most susceptible to flystrike, while plain open-fleeced British breeds are least affected. The dense, compact Merino fleece deflects light rain but persistent heavy rain reaches the skin and the fleece takes a long time to dry out.[12]

Breech strike

4.13 Breech strike involves the perineum, the tail and surrounding areas, and is the most common form of blowfly strike, particularly in ewes.[13] The breech region of ewes is regularly made wet with urine. Ewes with a wrinkly rear end conformation, or ewes which have not been mulesed or crutched, are particularly susceptible to breech soiling, especially if they are carrying more than six months' wool. A soiled breech in turn attracts primary strike flies.

4.14 Worm infestations have been shown to cause diarrhoea, which is in turn associated with breech strike. Research by Morley and colleagues has shown that if worm infestations are controlled, the incidence of breech strike in weaner sheep can be reduced by 90 per cent.[14]

4.15 Diarrhoea may also be induced by grazing sheep on lush pastures, by changing feed, by bacterial infection and by other causes. Any management practices which reduce the incidence of diarrhoea also lessen the predisposition of the sheep to breech strike.

Body strike

4.16 Body strike refers to blowfly strike on all parts of the sheep except the breech, pizzle and head. Bacterial infections of the skin, such as fleece rot and dermatophilosis, associated with prolonged wetting from persistent summer rain, high humidity, or long wet grass, are the major predisposing conditions for body strike.

Other strikes

4.17 Poll strike, or strike around the horns, is generally confined to rams. It results from moisture trapped beneath the horns and the accumulation of skin secretions in the area.[15] In wethers and rams, pizzle strike occurs when the long hair around the preputial opening becomes soiled with urine. Sheath rot is also a predisposing condition. Any infected wound on a sheep is susceptible to flystrike, and these may include shearing cuts, footrot sites, scabby mouth or conjunctivitis.

**Effects of blowfly strike on the sheep**

4.18 Blowfly strike is a disease process which is accompanied by inflammation and often by systemic changes. Crutch strike, while the most common strike, is not necessarily the most severe, as body strike is not so readily detected and tends to be further advanced when it is noticed.[16]

4.19 Little evidence of disturbance is noted during the first two days after the female fly has laid her eggs, except for tail-twitching, feet-stamping and attempts to bite the affected part by the sheep. However, once the second and third instars burrow into the flesh and extend the wound, the infected sheep reduces its feed intake, its rectal temperature rises to about 41°C, its pulse and respiratory rates increase and it loses weight rapidly.[17] Broadmeadow and colleagues considered that these changes were consistent with severe toxaemia, due either to toxins produced by the larvae or by bacteria proliferating on the wound site.[18]

4.20 Many sheep die from the effects of strike. In high-risk years, an extension officer survey showed this to be, on average, 3.2 per cent of the flock,[19] while during a flywave in the Charleville and Quilpie districts in early 1974, mortalities in excess of 35 per cent in ewes and 45 per cent in wethers were recorded.

4.21 The rapid decline in food intake was demonstrated by Heath and colleagues, who subjected sheep to a single, artificially-induced flystrike. The sheep lost up to 5.5 kg over four to six days and took up to 36 days to regain their original bodyweight.[20]

4.22 Wool production has also been shown to be reduced by blowfly strike by up to 26 per cent, and this is thought to be stress-related.[21]

4.23 The common method of treating flystruck sheep is by cutting the wool away from the affected area and applying a larvicidal dressing,[22] a procedure which, when combined with the stresses of being rounded up and caught, makes for a most unpleasant and painful episode for the sheep and one which may need to be frequently repeated.

4.24 Sheep may recover without treatment, with the maggots dropping off and a scab forming over the wound. Some of the fleece may be shed from around the wound. The incidence of "covert" strikes, that is, those which go undetected by the sheep producer, have been shown to be up to 14 times more frequent than the "overt" or conspicuous strikes.[23] In one study, 72 per cent of properties were found to have covert strikes, some of which remained active for more than two months. The Committee concluded that, in all probability, a great many more sheep suffer from flystrike than are ever treated for it, and while they may recover, their welfare in the process has been seriously jeopardised.

**Prevention and control of flystrike**

4.25 Broadly speaking, the flystrike problem can be addressed in two ways: by reducing the fly population; or by rendering the sheep less susceptible to its attacks. Frequently both methods

are used in combination, as on present evidence, it seems unlikely that either, alone, will be the ultimate solution.

4.26 Fly densities may be reduced by trapping, by biological control methods, or by genetic control, either using the sterile male technique or by introducing lethal genes. Sheep susceptibility to flystrike may be reduced by selective breeding programmes, by mulesing, by crutching, by pizzle dropping, by the use of chemicals or by vaccination, or by combinations of these methods.

Fly trapping

4.27 Trapping or baiting of flies has frequently been tried as a method of reducing the fly population. University of New South Wales researchers at the Fowlers Gap Arid Zone Research Station have used a variety of traps to identify where flies congregate, and to bait selectively in those places.[24] Combined with mulesing and chemical control, the approach has resulted in low blowfly strike rates compared with neighbouring properties. Professor Kennedy assessed the results so far as "promising".[25]

4.28 Trapping has been used as part of an early warning system for the timing of insecticide application in Western Australia. By using traps, officers of the Department of Agriculture have been able to ascertain when sufficient flies are present to sustain a strike. This information, combined with data on wind speed, temperature, and sheep susceptibility, provide the basis for a predictability model for "flystrike alerts".[26]

4.29 Trapping per se would seem to be of limited effect in reducing the fly population, but it may have a place in combined strategies as outlined above.

Biological control

4.30 A natural enemy for *L. cuprina* has not yet been found. Some initial work by Cooper and colleagues has shown that the microsporidian pathogen, *Octosporea muscaedomesticae*, may have a role in suppressing field populations of *L. cuprina*. Bacterial pathogens, principally *Bacillus thuringiensis*, have been used as larvicides as a preventative measure, with some success.[27]

Genetic control

4.31 Genetic control involves the transfer of deleterious genetic material from released flies to wild flies by mating. The material in question can be either inherited, in the case of genetically altered strains, or induced each generation by chemical or radiation treatment.[28]

4.32 Research into the use of genetic control methods has been underway in Australia since the late 1960s. It was clearly inspired by the success of the sterile male technique in eradicating the screw-worm fly from the southern States of the USA.[29]

4.33 The classic sterile insect release method (SIRM) involves the release of irradiated flies whose progeny all carry dominant lethal mutations. This does not produce a persisting genetic load to reduce the fly population, however, and repeated releases are required to achieve low fly densities. The vastness of the sheep-raising areas of Australia and the costs of breeding, rearing, irradiating and releasing the flies have made this method of genetic control biologically feasible but economically and logistically unsuitable.[30]

4.34 The CSIRO Division of Entomology is currently producing blowflies which carry chromosomal defects such as compound chromosomes and sex-linked eye colour mutations, which cause blindness and sterility in subsequent generations. Field trials

have shown the sex-linked translocation strains are competitive with wild blowflies and can lead to 90 per cent genetic deaths by reducing the fitness of the wild *L. cuprina* population.[31]

4.35 Trials to investigate the feasibility of this technique over a broad area have been conducted in the Shoalhaven district of New South Wales, on Flinders Island and currently on all the Furneaux group of islands in Bass Strait. In the Furneaux experiment, researchers will endeavour to suppress the native fly population on the islands by releasing sex-linked translocation males, and when the population reaches a manageable level, fully sterile males will be introduced in an attempt to eradicate the fly population.[32] The cost-benefits of this form of blowfly control will also be examined in detail in this latest study.

4.36 The limitations of genetic control methods were outlined by Dr Mahon, Senior Research Scientist with the CSIRO Division of Entomology:

> while eradication is considered a viable option in the Furneaux group, and perhaps even in Tasmania, the absence of comparable barriers to immigration on the mainland probably makes eradication not feasible.[33]

He further indicated that the more appropriate approach on the mainland would be the suppression of the indigeneous blowfly population by the continual release of sex-linked males. In low-density sheep areas, he considered the costs of release of the flies (from light aircraft) would be far more than the potential returns to the industry. However, in the more intensive sheep-raising areas, he considered the number of sheep per hectare warranted the use of genetic control methods and he believed they could be cost-effective there.[34]

4.37 Many witnesses were most supportive of fly-centred research. Mr Peden, representing AFWA, considered it should have top priority because of the extent of the flystrike problem and the suffering and loss it causes.[35]

4.38 The Committee supports the continuation of research into methods of genetic control of the sheep blowfly and the cost-benefit parameters involved. While the method has logistic and economic problems, it has been shown to be effective and it has the added welfare attraction of being fly-centred rather than involving the sheep.

Selective breeding programmes

4.39 Selective breeding has been advanced as a method of making sheep less susceptible to flystrike. This is not a new development, for as early as 1937, Belschner concluded:

> Body strike in sheep depends almost entirely upon the pre-existence of fleece rot, and it is obvious that there exists a type of sheep definitely predisposed to the latter condition ... the prevention of body strike depends principally on reducing the susceptibility of our flocks by selective breeding.[36]

4.40 Fleece characteristics and also body conformation are important in determining a sheep's susceptibility to flystrike. Fleeces which are dense, compact, soft-handling, thick-stapled, and white and bright in colour are associated with resistant sheep. Similarly, plain-bodied sheep, without devil's grip (prominent hocks) or wrinkly breeches, are more resistant to flystrike.[37]

4.41 The ease with which these desirable characteristics can be bred into a flock depends on their heritability, which has been calculated on the basis of experimental evidence to be 0.40 for fleece rot.[38] New South Wales Agriculture and Fisheries has

run an experimental flock at Trangie in which the fleece rot incidence in hoggets has been reduced from 60 per cent to 17 per cent in 20 years, under the same environmental conditions.[39]

4.42 Selection for fleece rot resistance is made more difficult in dry environments, where the problem of fleece rot does not regularly occur. However, as Mr Butt, Principal Livestock Officer of the Department, pointed out, an active selection programme is feasible in other areas.[40]

4.43 In Western Australia dermatophilosis (mycotic dermatitis, or lumpy wool) is as significantly correlated with flystrike as is fleece rot, and officers of the Western Australian Department of Agriculture were sceptical as to the likely success of direct selection. Dr Monzu pointed out that a flock with 80 per cent incidence of dermatitis will not get an 80 per cent incidence of flystrike, and it is not feasible to cull such a number of sheep.[41]

4.44 Plain-bodied sheep, such as the British breeds, are far more resistant to flystrike than the Merino in general, and wrinkly Merinos in particular. However, as Dr Meischke and others pointed out to the Committee, breeding wrinkles off sheep reduces, but does not eliminate, the flystrike problem.[42] In addition, breeding for plainness of body or breech presents an economic problem, in that it also tends to select against a heavy-cutting fleece and other desirable traits. Dr Meischke further implied that the practice of mulesing removed the evidence of a faultily-conformed breech, rendering the selection process more difficult.[43]

4.45 The Committee concludes that selection for resistance to flystrike is an important tool in the effort to reduce the welfare horror that flystrike represents for our sheep flocks. Such selective breeding has the added advantage that it in itself is not inimical to the welfare of individual sheep. The Committee

recommends continued research into flystrike resistance characteristics, as one of a range of methods designed to reduce the suffering caused by flystrike.

Mulesing

4.46 Of all the issues which were raised by critics of the sheep and wool industry, the practice of mulesing was the one which attracted the most vigorous condemnation. Dr Auty referred to it as "the partial flaying" of the sheep and indicated that in his view, mulesing did not lie within the parameters of acceptable interference with animals.[44] ANZFAS considered the mules operation "a crude and barbaric substitute for good husbandry" and quoted a Mr Douglass of the RSPCA (UK) who described mulesing as a "particularly abhorrent and quite unnecessary and unacceptable mutilation of an animal".[45]

4.47 The industry, academics and the departments of agriculture, on the other hand, were unanimous in their support for the practice, perceiving that the benefits which accrued from it far outweighed the disadvantages.[46] Clearly, though, they agreed that mulesing was a painful procedure, and one which should and would be replaced as soon as acceptable and effective alternatives were found.[47]

4.48 Mulesing is an operation which consists of the surgical removal of strips of loose, wool-bearing skin from the breech and tail of the sheep. Its purpose is to remove the skin folds which accumulate moisture and fragments of excreta and which in turn attract the sheep blowfly. When the cuts heal, the naturally bare area around the vulva and anus is stretched and enlarged, reducing the dampness of the surrounding wool. An advocate described the mules operation as "simple skin surgery, causing little blood loss or surgical shock".[48]

4.49 The operation was first advocated by Mr J.H.W. Mules of South Australia, who outlined his answer to breech strike in a letter to the *Adelaide Advertiser* in 1931. Its subsequent history has been extensively reviewed elsewhere.[49] Radical and modified forms of the operation evolved, with most present-day advocates recommending a crescent-shaped cut on each side of the vulva and the removal of all but a "V" of wool-bearing skin extending one third of the way down the docked tail.[50]

4.50 The mulesing operation is most commonly performed at lamb marking. Reasons given for this timing are that the lamb only has to endure the stress of being mustered once; that wounds heal more quickly on a young animal; and that the lamb will be able to go immediately to its mother for comfort and a drink. New South Wales Agriculture and Fisheries recommends the mulesing of appropriate sheep at marking time, when lambs are from one to seven weeks of age, in most situations.[51] This recommendation is echoed by most extension services.[52] The *Prevention of Cruelty to Animals Act 1979* requires mulesing to be undertaken before the sheep is 12 months of age. When mulesing is delayed until weaning or later, the animal suffers more of a setback in growth. However, mulesing is clearly not indicated in the middle of a flywave or when lambs are already weakened by poor nutrition during drought.[53]

4.51 Mulesing is performed either by farm labour or by mulesing contractors. New South Wales estimates were that 60 per cent was done by contractors and that this percentage was dropping.[54] Highly sharpened, modified shears are used and are disinfected between uses. The operation is performed on restrained, unanaesthetised animals.

4.52 The precise numbers of animals mulesed are unknown. Recent New South Wales surveys indicate that 80 per cent of Merinos and 45 per cent of other breeds and crosses born in that State are mulesed.[55] In the western district of Victoria, 56 per cent of wool-producing sheep were mulesed, according to a survey

by Morley, compared with only 11 per cent of meat sheep, while in Western Australia, 75 per cent of respondents to a 1983 survey mulesed, and the larger the flock, the more likely it was to be mulesed.[56]

4.53 Mr Bowman, representing the Wool Council, suggested that mulesing rates were in part dependent on location. In the high rainfall areas where more meat-producing sheep were raised, he considered there was no need to mules prime lambs.[57] Mr Coombes, Executive Director of the Sheepmeat Council, suggested that there was a correlation between the presence of good contractors in an area and the percentage of mulesed sheep.[58]

4.54 Even the opponents of mulesing did not query the fact that it was effective in significantly reducing the incidence of breech strike. Two studies provided as examples by Kevin Bell showed strike rates of 0.4 per cent in mulesed sheep compared with 27 per cent in unmulesed; and none with 60 per cent.[59]

4.55 Clearly, mulesing is a practice which has gained widespread acceptance among sheep producers, and particularly amongst those who raise sheep primarily for wool. It is a practice widely promoted by the departments of agriculture, and one which can be seen to achieve its aim of reducing the incidence of breech strike. Two issues remain to be addressed, however: firstly, whether the practice is so painful for the sheep (and so inhumane) that it should be banned on welfare grounds; and secondly, whether the pain and suffering caused by mulesing is justifiable compared with the pain and suffering which may eventuate from breech strike.

4.56 As the Committee has discovered in its previous inquiries, it is all but impossible to quantify the degree of pain experienced by a given animal. As Dr Meischke reminded the Committee, pain is a subjective experience.[60] It seems likely also that there is a spectrum of pain susceptibility in sheep,

and what is painful for one may not necessarily be painful, or as painful, to the next.[61] The best objective indicators of pain that exist at present appear to be hormonal responses, such as cortisol and beta endorphin levels, which when elevated and when combined with behavioural indicators, probably suggest the presence of pain, and certainly point to the relative effects of different stressors.

4.57 On this premise, recent research by Shutt, Fell and colleagues from the New South Wales Agriculture and Fisheries indicates that mulesing is indeed an unpleasant experience for the lamb, albeit a short-lived one. Lambs aged four weeks had significantly raised plasma free cortisol levels 15 minutes after either tail docking and mulesing, or tail docking, castration and mulesing, compared with the control lambs (46, 61 and 13 nmol/l respectively). Severe flystrike was associated with similar plasma cortisol values to the maximum recorded from the surgical procedures.[62]

4.58 In a later study by the same team, the responses to mulesing of six-to-seven months old weaners was assessed. Five to fifteen minutes after the operation, plasma cortisol and beta endorphin levels were markedly raised (from pre-operational levels of 70 nmol/l and 95 pg/ml respectively to 207 nmol/l and 209 pg/ml), reaching their highest levels (233 nmol/l and 266 pg/ml respectively) 24 hours after surgery. For up to two hours after surgery, an analgesic effect associated with the release of beta endorphin was observed, but thereafter the sheep evidenced abnormal posture and locomotion and grazed less than usual. After three days their behaviour was back to normal and wound healing was evident, but was not regarded as complete for another 19 days. No significant effect on growth rate was recorded.[63]

4.59 An interesting behavioural aspect of this study was the marked aversion the mulesed sheep showed to the presence of the person who handled them during the operation, an aversion which persisted for five weeks. The researchers caution that this may have been a reaction to their having being handled in their post-operative state, or it may have been a residual effect of the operation itself. The researchers concluded that mulesing of weaners by contractors rather than owners, and minimal post-operative handling, were indicated as a means of reducing stress.

4.60 Some evidence was presented to the Committee on whether mulesing should be carried out by contractors or by owner-operators or other farm labour, and how best these persons should gain the necessary skills for the task. If it is to be done at all, there is no question that it needs to be done quickly and well. New South Wales departmental officers suggested that owner operators tended to do the job themselves at marking time, but that training was offered by departmental regional officers. On the other hand, the larger flocks were more likely to be mulesed by contractors, who again could have the benefit of departmental training and the experience gained by repeating the operation many thousands of times.[64] Dr Osborne, representing the Australian Veterinary Association, considered "it would be impractical and perhaps even not especially desirable to have rigid rules and certifications" covering owner-operators and their performance of surgical procedures. However, in the case of contractors who mulesed for fees, he considered some form of certification was desirable.[65] The Committee agrees. It considers that the training offered by departmental regional officers is quite adequate to provide a person with the requisite skills to mules sheep, and suggests that any person wishing to mules for financial gain should be able to prove, by way of a certificate from the training officer, that he has been trained and has

reached an appropriate level of competence in the procedure. The Committee considers that this would not become a burden for departmental officers. Indeed one department indicated it perceived an organisational and co-ordinating role for the departments in this regard.[66]

4.61 Another suggestion put to the Committee was that, to alleviate pain, sheep should be anaesthetised for the mules operation.[67] Most witnesses who commented on the use of anaesthetics disagreed with their use on lambs at mulesing. It was felt that the whole mulesing operation would be slowed down, lambs would be away from their mothers longer and could become disoriented, thus increasing the risk of mismothering.[68] An AFWA representative, Mr Plant, pointed out that experimental work with anaesthetics had been done at the Orange Agricultural College, with fairly undesirable results.[69] It was also suggested that the post-operative period was the most painful, at which time the effect of the anaesthetic would have worn off. The Committee considers that the use of anaesthetics at lamb marking is inadvisable and impracticable.

4.62 From the work by Shutt and Fell and other studies, from evidence it received, and from its own observations of mulesing at the property of Mr Robert Campbell at Tarago, the Committee concluded that mulesing is an unpleasant practice, one which is generally performed with distaste and one which certainly causes sheep and lambs pain, although pain which is temporarily alleviated by the analgesic effect of the release of beta endorphins. This pain and discomfort is, however, of short duration, and the operation appears to have no long-term adverse consequences.

4.63 The Committee then considered whether the infliction of such pain in the short term could be justified, in view of the perceived long-term benefits mulesing provides by way of reduced susceptibility to breech strike.

4.64 It reviewed the arguments of Dr Meischke and others, who pointed out that sheep are individuals, many of whom are naturally quite resistant to flystrike and for whom mulesing is an unnecessary and painful indignity.[70]

4.65 The Committee noted that in areas of higher sheep density and smaller flocks, there was evidence that some producers were able and willing to put in the extra time and effort to breed out faults in sheep, to select resistant sheep, to control worms, to inspect and crutch and jet with chemicals more frequently to ensure a healthy flock without recourse to mulesing. It also noted, however, that some were not. In cases where sheep are going to be managed with less than optimum care and attention, the Committee would prefer to see the sheep mulesed than unmulesed. The Committee considers that the "all or none" approach to mulesing is probably inevitable in extensive environments, and on balance considers that "all" is the preferred option.

4.66 In the absence of effective alternatives to mulesing, the Committee decided that the practice should continue. The Committee **recommends** continued research into all means of preventing blowfly strike, so that the need for mulesing is removed. In the interim, it considers that mulesing should be performed where possible on lambs at marking rather than later.

Crutching

4.67 Crutching, or the removal (by clipping or shearing) of wool from around the breech area of sheep, is standard practice throughout the sheep industry. Short wool on the breech soils less and dries more quickly, hence reduces the sheep's susceptibility to breech strike. Crutching serves other purposes than blowfly strike control, and is routinely performed prior to mating and sale of sheep, and sometimes pre-lambing. Extension services recommend at least one thorough crutching between annual shearings, even for mulesed sheep.[71]

4.68 Crutching alone does not prevent the wetting or soiling of the breech.[72] If it is carried out just before likely flywave periods, it can reduce, but not eliminate the incidence of breech strike.

Pizzle dropping

4.69 Pizzle dropping is a simple technique which involves the severing of the tissues between the sheep's belly and sheath enclosing the penis so that following healing, the prepuce hangs some 50 mm below the wool. The tissue is severed some 60 mm with hand shears, mulesing shears or surgical scissors. The procedure can be carried out at lamb marking but is best carried out at six to 14 months of age, according to New South Wales Agriculture and Fisheries.[73]

4.70 The procedure of pizzle dropping has been advocated to reduce urine staining and flystrike in belly wool. Urine staining is an economic, rather than a welfare issue, as stained wool is considerably less valuable than unstained. Pizzle strike, however, is facilitated by urine staining, and is clearly a welfare issue, although some have claimed its prevalence is not sufficiently high to justify treatment.[74] Wardhaugh and colleagues found otherwise in their 1978-80 study, considering it the main form of covert strike.[75]

4.71 Staining can be reduced by ringing (the removal of wool from around the prepuce using a shearing handpiece). New South Wales field trials have shown that when ringing and pizzle dropping were both performed, urine staining was reduced by 67 per cent and belly flystrike by better than 90 per cent. Pizzle dropping alone resulted in a 26 per cent reduction in staining and 88 per cent reduction in belly strike. In conjunction with testosterone treatment, pizzle dropping had the added advantage of reducing the incidence of sheath rot.[76]

4.72 The use of insecticides to treat the area is a viable alternative to pizzle dropping in reducing the incidence of flystrike, though it has no effect on the proportion of stained wool.

4.73 Pizzle dropping has not gained wide acceptance in Australia, despite its advocacy by the New South Wales Agriculture and Fisheries. The reason most probably lies in the fact that shearers are said to dislike shearing pizzle-dropped animals.[77]

4.74 Welfare and production benefits both seem to accrue from pizzle dropping. Little evidence was available on the stress levels induced by the procedure, however. The Committee is not opposed per se to pizzle dropping as a method of reducing the incidence of flystrike, but as with all surgical interventions in sheep, it would prefer to see viable, safe and effective alternatives in use.

Chemical control

4.75 Insecticides have been available for protecting sheep against flystrike since the sheep blowfly problem arose. They are applied to the sheep by dipping or jetting. Three groups of insecticides offer control against blowfly strike: the organophosphates; the triazines, of which Vetrazin is the only commercially available product; and synthetic pyrethroid-based products which are oviposition suppressants.[78]

4.76 One of the problems with the use of insecticides is the speed with which *L. cuprina* develops resistance to them. The organophosphate insecticides were first introduced in 1957, but by 1965 resistance was reported,[79] and they now offer at best one to three weeks protection. Vetrazin and the oviposition suppressants still offer from six to twelve weeks protection, but as Dr Mahon pointed out:

> There is little doubt that increased use of chemicals would hasten the evolution of resistance to that chemical and reduce its useful life.[80]

4.77 The problem of resistance is acknowledged by the agricultural and veterinary chemicals industry, which supports an Insecticide Resistance Action Committee to monitor the onset of resistance and to minimise its impact.[81] It was suggested there was a very real danger of the present chemicals becoming ineffective through overuse before alternatives could be developed.

4.78 Another problem with insecticides is the method of application. Formerly dipping was the preferred method, but now jetting, either by hand or through a jetting race, is more common. The efficacy of an insecticide is largely dependent on the thoroughness with which it is applied.[82] Hand jetting can be less reliable in this regard, unless slowly and carefully done, while automated jetting may not ensure an exact dose of chemical per sheep.

4.79 The timing of the application of chemicals is a vexed matter, and one which will be largely solved if accurate predictions of flywaves can be made. If treatment is delayed until many overt strikes are observed, many sheep may be lost because they cannot be mustered and treated quickly enough. Fly numbers may also be at a maximum when treatment takes place, thus increasing selection pressure for insecticide resistence. An early preventive spraying may be wasted if conditions inimical to the development of a flywave occur.

4.80 The Committee does not oppose the sensible use of the new low-toxicity insecticides against flystrike. Unlike their predecessors, their environmental impact is negligible. The

Committee received no evidence indicating that their application was stressful to the sheep. It appears, however, that the problem of resistance to chemicals is not unique. As the United States Council for Agricultural Science and Technology reported:

> The loss of effectiveness of pest-control measures is not unique to chemicals. An analogous process occurs when crops and animals are bred with built-in genetic resistance to destructive pests. When confronted with a resistant host, the pest eventually evolves into new race or strain with counter-resistance or virulence. Thus, many resistant crops and animals do not remain resistant indefinitely. Additionally, pests may evolve resistance, but generally at a relatively slow rate, to introduced biological controls, including pathogens, parasites and predators; to control measures based upon physical factors and mechanical action; and to managerial practices ... [83]

4.81 The Committee considers chemicals still have an important role in an overall strike-minimisation programme, but should not be seen as the ultimate solution.

Vaccination

4.82 Modern techniques of molecular biology may eventually allow the production of protective antigens against flystrike. Research is also in progress to find ways of immunising sheep against the bacterium *Pseudomonas aeruginosa* which is implicated in the development of fleece rot. Preliminary field studies have indicated the feasibility of the approach.

4.83 In line with its "broad brush" approach to flystrike prevention, the Committee **recommends** the continuation of research into immunological approaches to flystrike prevention. For the present, however, and in the immediate future, the Committee considers many welfare gains can be made by the inplementation of better, more scientific and less hit-and-miss flystrike prevention and control management programmes by individual producers.