FLEECE MOISTURE AND BLOWFLY STRIKE

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HISTORY OF FLEECE MOISTURE

An investigation into the moisture content in the fleece of Merino sheep was commenced after proposing the hypothesis that moisture and relative humidity were required at the skin surface for the survival of the 1st instar larvae and the initiation of a strike. A method for drying wool was developed which created a minimal disturbance to its normal constituents. It was shown that, in dry weather conditions (no rain during the previous 48 hours), distal wool was significantly drier ($P<0.001$) than either the medial or proximal sections. The data from the experiments on wool moisture (Hall *et al.1980)* were collected from proximal wool only, unless otherwise indicated. Proximal wool was defined as the section of the staple within 1.5 cm of the skin and was chosen since it could be easily measured and was less likely to be affected by the weather.

The increase in moisture found in proximal wool may be due to any or all of the following conditions:

- increased moisture from the natural secretions of the skin;
- an ability of suint to absorb (or adsorb) moisture from the environment and retain it; and
- a reduced rate of evaporation at the base of the fleece.

The experimental data showed:

- wool from the shoulder was significantly wetter ($P<0.05$) than similar wool from the ribs;
- moisture content in wool from 4 age groups (weaners, 2 tooths, 4 tooths and 6 tooths) declines ($P<0.05$) in a linear regression with increased
- moisture content in shoulder wool was significantly different between strains ($P<0.001$) for both ewes and rams, and rams were consistently drier than ewes ($P<0.01$) regardless of strain. The moisture content of strong wool strains > medium wool > fine wool strains;
- after commencing wetting with artificial rain at the rate of 50 mm each a level of 20% moisture content was recorded in shoulder wool of ewes and rams between 3 and 8 days (Hall 1977), while in rib wool the time for ewes was 3-5 days and for rams l-8 days; and

  the moisture content in wool removed from flystrike lesions varied between 68-75% with no difference between sections of the staple.

OBSERVATIONS OF NATURAL FLYSTRIKE

The frequency of natural flystrike was obtained from data in a survey conducted in New South Wales at the same time as moisture content was being investigated from properties on which fleece moisture data were obtained:

In a survey between 1972 and 1974 Watts (pers. comm.) found that 62% of body strike occurred on the shoulder and the data on moisture showed that

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shoulder wool was wetter than wool from the ribs. Surveys on insecticide use (Hall unpublished data) showed that insecticide treatment of animals older than three years was rarely practised and, in the study on the effect of age on wool moisture content, that older animals had lower moisture levels.

In the study of moisture content in different strains of Merino sheep the incidence of natural strike was less than 1% in the drier fine wools, greater than 30% in the wetter strong wools, with medium wools in the intermediate position. The rams in the same test had a total of 30% less strike than their ewe counterparts.

Where moisture is increased to higher levels, as in lesions of fleece rot, bacterial stain and flystrike, the attractiveness of the fleece is well documented (Joint Blowfly Committee Report 1933).

CONTROL OF WOOL MOISTURE

Having shown that there was a positive correlation between higher levels of moisture in the fleece and the incidence of flystrike the reverse hypothesis was proposed, i.e. that if wool moisture could be reduced it may offer another method for controlling blowfly strike.

A mixture composed of two metallic oxides mixed with sterols and fatty acids was available. This mixture was dissolved in equal amounts of two anhydrous petro-chemical solvents to produce a 20% formulation. Since the formulation polymerises in the presence of water to form a gel it was impossible to treat sheep by jetting. Instead, the formulation was applied to the fleece as a mist in compressed air with a single-nozzle hand piece.

The effect of the drying agent was assessed by treating one side of the animal with up to 100 ml of the formulation and comparing it with the untreated opposite side. The drying effect was recorded from day 7 after treatment and by day 14 reached a level of 30% less moisture than untreated wool. The drying effect lasted for 11-12 weeks after treatment.

In another trial, a group of 25 sheep was treated with up to 150 ml of the desiccant formulation and compared with a similar group of untreated sheep. After 14 days, when the moisture in the treated wool was reduced by 30%, each group was exposed to wetting with artificial rain for 8 days at the rate of 50 mm per day. For the first 7 days the moisture level increased in both groups, but at a slower rate in the treated group. At day 8 both groups were equally wet, but dried in the next 14 days to their pretreatment levels.

After day 8 of wetting both groups were examined for the extent and intensity of lesions of fleece rot. Watts and Hall (unpublished data) showed that in treated sheep there was a reduction of approximately 60% in the number and severity of fleece rot lesions compared with the untreated animals. The effect of the desiccating agent in reducing blowfly strike may therefore be partly the result of *a* reduction in fleece rot lesions.

In a field trial (Table 4) groups of sheep were treated with an average of 100-120 ml of the desiccant agent and compared with untreated sheep and a standard jetting treatment with diazinon at a concentration of 0.04%. After five weeks when the animals were shorn there was a significant difference ($P<0.05$) between the incidence of strike in untreated sheep and desiccant treatment, but no significant difference between diazinon and untreated sheep.

TABLE 4 Recorded incidence of blowfly strike following treatment under field conditions

Treatment	Number of sheep	Number of sheep struck weeks post treatment					Total % struck
		1	2	3	4	5	
Dessicant 100-120 ml/animal	125	0	0	2	2	3	5.6
Diazinon 0.04%	125	0	3	4	4	2	10.4
Controls Nil	247	0	11	15	15	11	20.8

There is therefore encouragement to develop this concept further, either by evaluating other dessicating compounds, making formulation changes, or adding bacteriostats to control bacterial growth. The advantage that may be considered for this method of flystrike control is that it would be difficult for the larvae to evolve an adaptation to survive in the drier microclimate of the fleece.

PRESENT & FUTURE TRENDS IN THE CHEMICAL CONTROL OF SHEEP BLOWFLY

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HISTORY OF BLOWFLY CONTROL

In the last 80 years a succession of insecticide types have been used for control of blowfly strike on sheep. Sodium and calcium arsenite were popular until the introduction of DDT and gamma BHC in the late 1940's. These compounds were superseded by dieldrin and aldrin which were superior and, in hindsight, gave a high degree of control regardless of the thoroughness of insecticide application due to the systemic translocation of the insecticides and persistent residues in the animal. However, an increasing awareness of the problem of pesticide residues would have resulted in their replacement even if the very high insecticide resistance to the cyclodiene insecticides (Shanahan 1958) had not occurred in 1957 which made dieldrin useless for blowfly control. Organophosphorus insecticides, predominantly diazinon, fenthion-ethyl and chlorfenvinphos, replaced dieldrin and gave efficient control of blowfly strike until OP resistance occurred in 1966 (Shanahan and Hart 1966). Even after the occurrence of OP resistance however, these compounds continued to be used. In contrast to dieldrin, the OP resistance level in the blowfly population was relatively low allowing a reasonable level of control and secondly there were few, if any, alternatives. Butacarb, a carbamate insecticide, was introduced in 1966 (Harrison 1967) but high level resistance occurred in 1967 which made it virtually useless (Roxburgh and Shanahan 1973b).

NEW GENERATION PESTICIDES

In 1979 CIBA-GEIGY introduced Vetrazin(R) for blowfly control (Hart *et al.* 1979). It is from the triazine chemical group and is the first compound for blowfly control from the so-called "new generation" of pesticides. Much attention is currently focused on these new chemical types, not only for control

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(R) Registered trade name

of sheep blowfly but also for the control of many other pests of crop and animals. These "new types" of insecticides come from diverse chemical groups such as juvenile hormone mimics, other insect growth regulators (IGR) such as triazines and ureas, and formamidines, thioureas, organo-metal compounds and synthetic pyrethroids.

These types of compounds act in many ways but, in contrast to earlier synthetic insecticides such as the chlorinated hydrocarbons or the OP insecticides tend to be fairly specific to only one stage of the insect or to only fairly specific orders of insects. This does enable a "prescription approach" to insect control but often requires the use of combinations of different compounds in order to control different insect species which occur together. The specificity of action of many of these compounds, however, although desirable, does place restrictions on their commercial use because their market potential is limited. Many of these insecticides have insufficient activity against sheep blowfly larvae.

The introduction of new technology involving novel application procedures for some of the new compounds may also offer better possibilities for control.

BIOLOGICAL INSECTICIDES

Bacterial insecticides (e.g. *Bacillus thurigensis*) or other "living insecticides" could be among the other agents for controlling sheep blowfly larvae which offer some promise. This is because the fleece is probably able to provide a satisfactory environment for the multiplication of bacteria or other micro-organisms which may be capable of destroying blowfly larvae.

REQUIREMENTS FOR AN EFFICIENT BLOWFLY INSECTICIDE

The pre-requisites of an efficient compound for blowfly control include the following:

- Ability to kill all blowfly species and known resistant strains.
- Ability to persist at toxic levels in the fleece for long periods and in all weather conditions.
- Safety to animals and operators.
- Economical to manufacture and use.
- No deleterious effect on the wool of sheep.
- No undesirable residues in edible tissue.
- Environmentally safe.
- Chemical stability in the concentrate and in use.

This list is essentially the same as that enunciated at a similar meeting on blowfly control in 1974 (Hart 1974) and today these requirements are met by Vetrazin(R), the first of the new generation synthetic insecticides marketed in Australia. Since it is important to understand how these various factors influence the choice of a product by a chemical manufacturer and its success in controlling the blowfly, Vetrazin(R) will be used as an example to demonstrate the various points and their influence on blowfly control.

VETRAZIN(R) - A NEW SHEEP BLOWFLY INSECTICIDE

It is probably true that any pesticide capable of controlling *L. cuprina* larvae can control larvae of the other species which attack sheep. Also *L. cuprina* is the most important myiasis-producing fly in Australia (Mackerras and Fuller 1937; Watts et aZ.1976). Hence control of *L. cuprina* only will be discussed.

Vetrazin(R) acts as a larvicide principally by stomach action against first stage *L. cuprina* larvae, but on older larvae acts as an IGR, disrupting larval feeding and growth (Hart et aZ.1979). In addition Vetrazin (R) exerts a novel action on larvae via contact with the female. It is not certain if this action has much influence on blowfly control in practice but, in fly/sheep cage exposure trials, untreated sheep run together with Vetrazin(R)-treated sheep are protected from strike even under very high blowfly pressure.

Ability to kill blowfly larvae must be coupled with the ability to persist at toxic levels in the fleece for long periods if a sheep blowfly protectant is to meet market requirements. Vetrazin(R) has been found to be persistent in wool, however the mechanism for this is unknown.

It is clear that products should be safe to use. However it is often the way in which a product is used that determines the hazard it poses to the target animal or operator. Thus a chemical used as a jetting fluid may be relatively safe to the sheep but more hazardous to the operator. Operator exposure of the sheep may be reduced by dipping instead of jetting but the additional exposure of the sheep may reduce the safety margin of the product. In general, industry is striving to achieve a high degree of safety.

The development of many chemicals must be rejected by manufacturers simply on the grounds that they will be too expensive to use. The farmer'must be able to gain a return on his investment when buying the chemical. However it should be understood that it is not likely that new chemicals will be cheaper to market than insecticides already in use, mostly because of the high cost of research, registration procedures and capital costs associated with manufacture.

It is self-evident that chemicals should not harm wool when applied to sheep.

Insecticidal residues in edible tissue should of course be minimal and not affect the normal marketing pattern of lambs or older sheep following use of the product. Withholding periods of up to 14 days would normally be quite acceptable.

Environmental safety is important. Products should not harm flora or fauna which mightaccidentallybe exposed to the product.

Chemical stability of the insecticide concentrate is essential to allow safe storage for long period. Good dip stability is less important for sheep dips than cattle dips but nevertheless is a useful property. Stability in the dip contributes to ease of use as does the ability of a chemical to maintain an effective concentration in dip wash (i.e. does not strip). Vetrazin(R) has the above properties which simplifies dipping recommendations..

This list is not exhaustive but covers the main features necessary for an insecticide to be marketed for protection of sheep against blowfly strike.

WHAT OF THE FUTURE?

As can be seen from the foregoing, there are a number of chemical groups from which new blowfly products might emerge. In addition, it is not beyond possibility that compounds from more traditional insecticidal groups such as new derivatives of OP insecticides and carbamates may prove satisfactory. Market potential is relatively small because the problem is virtually limited to Australia and the high cost of research and development with exhaustive requirements for toxicology may preclude manufacturers taking the risk of developing specific compounds. However it is very likely that efficient compounds can be made available as demand requires them.

SUMMARY AND CONCLUSIONS

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The results from the most current organophosphorus resistance studies throughout Australia indicate that the average resistance factors have not varied significantly from those originally derived in 1966. The variation in resistance factors between the States of Australia can probably be explained in terms of the frequency of insecticide usage. In fact it was shown for Western Australia that in the wetter southern ~~areas where~~ insecticides were used more frequently, the resistance factor is double that in the drier inland areas. It was concluded that future control programmes should be based primarily on management with insecticides being used for the strategic control of body strike.

The efficacy of an insecticide is very dependent on the efficiency with which it is applied. Handjetting has traditionally been accepted as the most effective method of insecticide application, but it is slow and labour intensive. The increasing labour costs and the costs from loss of sheep and wool production which result from delays in insecticide application, have lead to the development of automated systems of application. The automatic jetting races are current labour saving devices available to the woolgrower. These require further field evaluation before their comparative effectiveness with handjetting can be determined. Another technique recently developed is the air mist system. This has the added ability of being able to'deposit a fine insecticide mist at the skin level. A remote possibility for the future is the development of systemic administration of chemicals for blowfly control.

A novel approach to the control of body strike is currently being investigated. The control of fleece moisture which favours the development of fleece rot and flystrike is being tested with a drying agent. This compound was shown to reduce fleece moisture on the sheep for a duration of 11-12 weeks after treatment. It has been hypothesised that the larvae would need to develop an adaptation to survive in the dry microclimate of the fleece and it is therefore unlikely that there would be inherent problems of resistance.

It is apparent that insecticides offer the only effective method for controlling body strike in the foreseeable future. This has encouraged the screening of a wide range of compounds, for possible blowfly activity. Vetrazin(R) is the first compound to be released from the so-called "new generation" of pesticides. It acts as a larvicide on first instar *L. cuprina* larvae but on older larvae it acts as an insect growth regulator, disrupting larval feeding and growth. A number of "new type" compounds from diverse chemical groups are also being evaluated. These should fulfil the requirements for an efficient blowfly insecticide, if they are to be commercially acceptable.

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