Sustainable sheep ectoparasite control using IPM

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Summary
Economic pressures for increasing production and reducing returns have made farmers receptive to the expanding array of chemical pest control agents. The development of resistance in pest species to the chemical control agents has encouraged a rethink about the sustainability of the high input, high dependency on pesticide farming systems. There is a growing public awareness and concern about collateral effects of pesticides on the general environment and a growing consumer demand for products that are produced in an environmentally friendly and sustainable manner. The Australian wool industry must be proactive and adopt IPM and promote wool as a product that is produced in an environmentally friendly and sustainable way.

Keywords
Sheep, ectoparasites, IPM, sustainability

Introduction

Pesticides have been used in modern commercial agricultural production for over 100 years, with elemental compounds such as sulphur being used initially. A rapid expansion of the chemical industry in the 1940s generated a range of potent pesticides. Wide spread adoption and usage of initially very potent pesticides gave protection against pest damage but usually resulted in selection of pesticide resistance in the target population.

From a general public point of view the widespread use of chemicals in the 40s and 50s resulted in a public debate on a range of non-targeted environmental effects. One of the milestones in this groundswell of public concern was Rachel Carson's popular book 'Silent Spring' which was published in 1962.

Lagging a few steps behind was the political response, which resulted in government regulations covering environmental and human health aspects of pesticide usage. These regulations generally operate in two areas, registration of products and monitoring their usage.

Some aspects of the public debate have moved beyond the area covered by minimum regulatory standards. This has led to movements or changes to farming systems such as organic farming, 'clean and green' product promotion, eco-labelling etc.

Chemical control practices used for sheep ectoparasites initially escaped much of the public debate because there is less collateral environmental damage during the application process and wool is not a food product. However, some chemicals that leave residues on harvested wool have raised concerns relating to the environmental implications following early-stage wool processing. This issue is now receiving considerable attention through environmental regulators and monitoring organisations, both government and non-government.

Occupational health and safety is also a potential concern with some of the current sheep ectoparasiticides, especially the organophosphates, with this concern likely to increase in the future.

In addition, consumer demands for products generated by environmentally friendly agricultural production systems can be expected to increase. This should be used as a marketing advantage in the promotion of wool as 'a natural fibre from a renewable resource with a clean and green image'.

Sustainable Sheep Ectoparasite Control

To be wholly sustainable, sheep ectoparasite control should encompass the following areas -
- Ecological preservation;
- Environmental protection;
- Public health and operator safety;
- Processing requirements;
- Production efficiency; and,
- Consumer preferences/Marketing strategies.

Ecological preservation

A heavy reliance on very potent chemical control agents results in strong genetic selection in the target pest population of genetically resistant individuals. When this is combined with the generally high reproductive potential of most pest species, there may be a rapid increase in the frequency of resistant genes.

Frequent indiscriminate exposure of non-targeted insects is generally not acceptable, especially if they are not harmful or pests (from our point of view). Some of the non-targeted insects may be important or potentially useful as competitors or predators of the pest species (Malan *et al*., 1997). In other instances frequent use against one pest species may select for resistance in a second non-target species. For example, widespread use of some chemicals for controlling lice is thought to have contributed to the rapid development of resistance in sheep blowflies.

Indiscriminate or non-selective use of pesticides can result in many instances of unforeseen damage to the ecosystem and this consequence will become increasingly unacceptable in the future, e.g. ectoparasiticides and aquatic ecosystems near scouring plants. The basis of sustainable control is that it will have minimal effect on the general ecosystem and exert minimal selection pressure on the target species for pesticide resistance.

Environmental pollution

Some of the agricultural chemicals used in the past have been too stable with a very slow breakdown or inactivation which has resulted in long term pollution of surface plants, soil and water, as well as reaching sub-surface water sources.

Most of the current pesticides are broken down by either ultraviolet light or by soil microorganisms. However, even chemicals that have a relatively short breakdown period can result in significant environmental damage, and this is becoming increasingly unacceptable.

Public health and operator safety

Acute toxic effects of pesticides are generally well documented and appropriate safety recommendations are stated on labels by law. However, this does not ensure operator compliance or prevention of product misuse. Further improvements in this area will probably have to rely on a user/purchaser license system based on proof of competency.

Individual sensitivity reactions (allergies etc.) will probably continue to be handled through the existing medical/public health system.

It will always be difficult to provide 100% assurance against chronic toxicity or delayed effects such as carcinogenesis. This is a potential area of concern particularly when linked with the trend towards more litigation and class actions. Taking responsibility for this is a major cost or disincentive for chemical manufacturers to undertake research and development.

A stronger push towards selective use of chemicals will reduce problems associated with all of these aspects.

Processing requirements

It is inevitable that the regulatory authorities will continue to increase the requirements for nil or minimal impact on the ecosystem.

The processors basically have two choices; more investment in low pollution processing systems; or in the case of wool scouring, source nil or low pesticide residue wool.

In some cases it is technically and economically possible to remove unwanted pesticide residues from the outputs of the processing plant. However, the need for processors to install chemical filtering systems will reduce the cost competitiveness of wool. Consumers are likely to prefer processes where there are minimal pesticide residues in the input end of the process.

Production efficiency

The initial impetus for increasing pesticide usage was to increase efficiency of production. However, it is being recognised that the net return can be greater for the lower input, lower pesticide usage systems compared to high input, high pesticide usage systems.

Some high chemical input systems may be economical in the short term but due to development of resistant pests etc. and escalating treatment costs, these systems are likely to become both ecologically and financially unsustainable in the medium to long term.

The challenge for sustainable production systems is to achieve both economic and ecological sustainability within practically achievable bounds.

Consumer preference/Marketing strategies

Consumers are increasingly motivated by personal and family concerns in their selection of agricultural produce that they believe are good for their health. In addition, in some parts of the world there is now strong public debate about the environmental impacts of the way people live in their own society, as well as the rest of the world. These consumers want safe, healthy agricultural produce as well as an assurance that the production process is sustainable and environmentally friendly. In addition, some consumers also want assurances about animal welfare and ethical standards.

Integrated Parasite Management (IPM)

‘Sustainable sheep ectoparasite control’ *per se* does not provide the exact method(s) of how it can be achieved. However, an examination of the factors influencing selection for pesticide resistance will provide a good framework on how to achieve a more sustainable system.

Heavy reliance on control agents that are target specific to a biological process, have a high probability of favouring individuals that are genetically able to survive these treatments. Thus, it is better to utilise a range of control agents as this greatly reduces the probability that an individual will develop genetic resistance to any one of them.

Another way of reducing the selection pressure for resistance is to only target a small proportion of the pest population at any given time and leave the majority unselected or in *refugia* (van Wyk, 2001).

It is now generally accepted that the best method for sustainable parasite control is Integrated Pest/Parasite Management (IPM).

Generic IPM

The four main components of IPM are:

- Increased host resistance;
- Improved management;
- Biological/physical control; and,
- Selective use of chemicals.

The relative emphasis on each component of IPM will vary according to the host/parasite system involved. It will also vary over time. For example, short-term requirements may place a greater emphasis on the selective chemical control components. The longer-term approach places a greater emphasis on increasing host resistance.

1. Increased host resistance

This covers a complex area of interactions ranging from nutrition, stress, the acquired immune response and innate resistance. The first is mainly non-genetic, whereas the last three have a genetic component. There is increasing interest in the use of nutritional supplements and pro- and pre-biotics to enhance disease resistance, particularly in intensive livestock production systems. The non-genetic components can make a significant contribution to increased host resistance. However, breeding for enhanced host resistance offers a permanent long-term solution to this problem (Karlsson, 1999).

Blowflies

In the case of resistance to blowfly strike, the whole Merino population would benefit from a genetic improvement in this trait. Susceptibility to blowflies is influenced by several component traits such as dermotophilosis (dermo), fleece rot, the wax to suint ratio, general waterproofing of the fleece, wool colour etc. Most of these traits are also valued from a wool quality perspective and should therefore be included in selection criteria. The advantage of this approach compared to some artificial blowfly challenge methodologies is that it has fewer potential ethical /welfare complications. It is anticipated that the new Sheep CRC will cover some of the direct challenge selection aspects.

There is a need to demonstrate the practical and the economic benefits of selection for blowfly resistance component traits. This can be done using existing genetic resource flocks such as the Rylington Merino flock which is located in a high dermo and fleece rot challenged environment and the Katanning resource flocks.

Lice

Increasing host resistance to the sheep body louse has not been investigated to the same degree as for blowflies. However, James *et al*. (1998) has demonstrated variability in resistance to a louse infestation both between and within American breeds of sheep. Preliminary investigations have also demonstrated significant phenotypic variability in Merinos (James *et al.*

2. Improved management

Maximum benefits and success with IPM control systems require a good understanding of the target pest biology. This allows maximum exploitation of any weakness in the insect life cycle. The major aim is to prevent rapid and uncontrolled population increases. Monitoring and risk assessments are also important components for both strategic planning and tactical responses and should be incorporated into the management program.

Difficulty in detecting lice, particularly in the early stages of an infestation has resulted in both unnecessary annual off-shears treatments as well as undiagnosed infestations. An improvement in both areas is required to reduce the pesticide load in the Australian wool clip. If the ELISA based lice detection method can be developed into an in-shed test it would achieve a major improvement in this area. However, detecting infestations on purchased sheep or other sheep, which come onto the property and are not normally shorn remains a difficulty. Farmer training is required for best practice procedures.

Farmers need to make more use of risk assessment and risk management. All properties should have a quarantine procedure for bought in sheep of unconfirmed lice status. Also, better procedures are required for long-wool lice detection in relation to the time of shearing, between and within mob prevalence and the opportunity for selective rather than non-selective control options.

For blowflies, monitoring forms the basis for selective chemical preventative control options. Risk assessment and management will determine paddock challenge ranking and relative mob susceptibility ranking. Historical property records will form part of management planning, influencing timing of events such as lambing, crutching and shearing.

Evaluation of on-property genotypes as well as other genetic information should be part of the development of the individual flock breeding objectives, incorporating improvement in the blowfly resistance component traits. Risk management and quality assurance aspects are best covered by implementing a property specific HACCP (Hazard Analysis Critical Control Points) based management system. (Evans and Karlsson, 2001)

3. Biological/Physical control

Biological control is the epitome of IPM in that most biological agents reach a self-limiting equilibrium as the prevalence of the target pest decreases. This method will therefore usually not result in total eradication, but aims to maintain pest densities below economic thresholds.

In evolutionary terms it would be expected that most insects would have pathogens or natural enemies. However, these competitors may not be favoured by modern farming practices. For lice, biological control agents have not been prominent up to the present time. The bacterial insect pathogen *Bacillus thuringiensis* (Bt) has been employed world wide for more than 30 years to control insect pests of agriculture, forestry and public health (Hill and Pinnock, 1998). Research on the applicability of this technology to sheep lice and sheep blowfly control has been undertaken but to date has not resulted in any tangible tools for sheep farmers.

There is probably some limited scope to make use of environmental control of lice. One possibility is to shear at times when lice will suffer maximum exposure to unfavourable environmental elements, i.e. over a period of one or two months post-shearing at the climatic extremes of high solar radiation and cold wet conditions. However, this option would need to be tempered with host welfare considerations. In practice many other factors are likely to be more important in determining the time of shearing. The greatest potential benefit would be UV-induced breakdown of residues in the first couple of months following short wool pesticide applications. N.B. for some chemicals this may result in insufficient active to eradicate late hatchlings.

For blowflies there is considerable scope for physical control through blowfly trapping (see this conference). Biological control agents for blowflies were introduced into Australia in the early 1900s and two parasitoid wasps have been introduced to New Zealand (Heath and Bishop, 1989). However, the biology of sheep blowflies poses enormous difficulties for any innoculative biocontrol agent and it is difficult to envisage that this approach can cope with the acute and rapid progression of a flystrike, but it may contribute to IPM through the reduction in the number of flies. However, the use of inundative biocontrol agents such as Bt remains a possibility.

Mass production and release of sterile male blowflies has also been considered. This should work for smaller 'island' populations but is likely to be less effective and probably prohibitively costly for a 'continent' population.

Genetic manipulation using lethal genes has also been researched and may be a valuable control component if the responsible gene(s) will maintain or preferably increase in frequency in the wild population.

4. Selective use of chemicals

The main aims of using chemicals selectively include:

- Avoiding unnecessary use;
- Selecting effective chemicals with the lowest residues before rehandling and wool harvesting;
- Selecting and using chemicals to minimise selection pressure for resistance;
- Selecting and using chemicals to minimise collateral damage;
- Considering environmental, OH&S and marketing consequences; and,
- Integrating in the short, medium and long term IPM plan.

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