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1. Introduction and Objectives

1.1 Background to SCOPS

In March 2003, Defra facilitated a workshop to consider and agree what recommendations to make to the industry regarding strategies to slow the development of anthelmintic resistance in sheep nematodes. It was recognised that there had been a significant increase in the incidence of anthelmintic resistance in sheep nematodes on farms in the UK and that this was likely to get worse unless steps were taken to slow it down. Unchecked, anthelmintic resistance could prove to be one of the biggest challenges to sheep production and welfare ever seen in the UK. In September 2003, the process of rolling out these recommendations began, firstly to Vets and more recently to farmers.

To facilitate the dissemination of the workshop recommendations and provide a working forum, the SCOPS (Sustainable Control of Parasites in Sheep) group was formed. SCOPS is industry led, with Peter Baber, Chairman of NSA (National Sheep Association) in the Chair, with representatives from NOAH, RUMA, CSL, SVS, SAC, AHDA, Defra, Welsh Assembly Government, RVC and independent advisers.

1.2 SCOPS Terms of Reference

- Advise and disseminate new recommendations on sustainable parasite control to the sheep industry, initially concentrating on internal parasites.

- Provide a forum for feedback from the sheep and animal health industries, veterinary profession and allied groups.

- Consider new developments, feedback and information and revise the recommendations accordingly.

- Facilitate mechanisms to inform all stakeholders in the sheep industry. Ensure that the messages have consistency and clarity.

1.3 The Role of Macrocyclic-lactones

Since the formation of the group, it has become clear that if we want to maintain effective worm control in our sheep flocks our overriding objective has to be to retain the activity of the Macrocyclic-lactones (ML) for as long as possible. However, as the ML group is widely used to control sheep scab, the SCOPS group had to urgently consider the dual use of these products and the consequences in terms of managing resistance.

The workshop in February 2005, was set up with a remit to explore the issues regarding ectoparasite control in sheep that were linked to the use of MLs and consider ways of reducing the risk of selecting for resistance in endoparasites.
1.4 Objectives

The Objectives of the February 2005 workshop as outlined to the participants were:

- To review current ectoparasite control in sheep.
- Identify the current and future issues relating to ecto and endoparasite control with particular emphasis on the preservation of the activity of the Macrocyclic-lactones (MLs).
- Agree recommendations on how best to integrate endo and ectoparasite control strategies.
- Make suggestions on how this could be achieved.

The SCOPS group will now take the output of the workshop as described in this document, discuss the recommendations in more detail and formulate an implementation plan. The SCOPS group will seek to ensure that any plan is fully supported by all stakeholders in the sheep industry and that it is fully compatible with the initial objectives of the anthelmintic resistance workshop.

Lesley Stubbings
August 2005

SCOPS is very grateful to DEFRA who facilitated the workshop and the production of these proceedings.
The Control Sheep Chewing Lice and Sheep Scab in Great Britain: An Overview

Peter Bates
Parasitology Section, VLA Weybridge

Sheep Ectoparasites

Permanent
- Sheep Scab
- Ear Mites
- Chorioptic Mange
- Chewing Lice
- Sucking Lice
- Keds

Semi-Permanent
- Blowfly Strike
- Nasal Bot Flies
- Headflies
- Ticks
- Forage Mites

Ovine Psoroptic Mange
(Sheep Scab)

- *Psoroptes ovis* is an obligate, ectoparasitic mite.
- Causing a debilitating dermatitis involving wool loss and the formation of a progressive scab lesion.
- Ovine psoroptic mange can be the cause of considerable suffering, production loss and mortality within infested flocks.

Sheep Presenting with Scab in the Rapid Growth Phase

Sheep Presenting with Scab in the Regressive Phase.
Ovine Pediculosis (Chewing Lice)

- *Bovicola ovis* is an obligate, ectoparasitic louse.
- Generally causing a mild dermatitis and fleece derangement.
- Heavy infestations can be the cause of production (wool and leather) loss.

Lousy Sheep - VLA Culture

Lousy Sheep - Field Case

Wool “Grazing” Due to Lice

Scab - v - Lice

- **Scab**
  - Acute
  - Wool loss
  - Intense irritation
  - Fatalities - common
  - Definite crusty scab
  - Definite point of origin

- **Lice**
  - Chronic
  - Wool grazed
  - Irritated
  - Fatalities rare
  - Diffuse scaly scab
  - No definite point of origin.

Differential Diagnosis

- Differential diagnosis on clinical grounds can be difficult.
- Only certain way is the accurate identification of the parasite.
- Use of the wrong acaricide/insecticide or inappropriate application method could select for resistance
- - and could be very costly!
Chewing Lice and Sheep Scab

- Ovine psoroptic mange (sheep scab) was a notifiable disease in Great Britain since 1869.

- The disease was eventually eradicated in 1953, but returned in 1973.


- Between 1953 and 1973 (20 years) scab was eradicated - nobody looking!
- August 1962 scab was identified in consignment of sheep at Birkenhead Docks originating from Co. Down.
- There is only one VLA record of *B. ovis* during this period (March 1966 - Lancashire).
- Control using plunge dipping, spraying and showering in p-DCB, DDT, aldrin and dieldrin.
- Resistance to plunge dips containing p-DCB developed in populations of lice in Cumbria, Lancashire and Yorkshire in the mid-1960s.

Spray Race (VLA Pre - 1974).

Scab - 1974 to 1992

- Scab returned in 1974.
- 1974 to 1992 (18 years) - GB Scab Eradication Campaign.
- Intense inspection of all GB sheep.
- All suspect sheep isolated and sampled.
- All samples examined for scab.
- During this period there were 1466 flocks confirmed with scab and 22 flocks recorded with lice.
- 17 of these (77.3%) were recorded after the scab clearances of Dartmoor (Nov/Dec 1982) and the Pennines (Dec 83 to Feb 84).

Scab and Lice - 1974 to 1992

- The control of chewing lice in GB has been an adjunct to the compulsory scab dip and lice were almost eradicated from mainland GB.
- Pockets of infestation survived on some Scottish Islands (exempt from compulsory dipping) and on the common grazings of Dartmoor, Lake District and the Pennines.
- With the deregulation of scab, lice have become more prevalent and are not uncommon ectoparasites of hill and lowland grazings.

Scab and Lice - 1992 to 1997

- Sheep scab was not eradicated and was deregulated as a notifiable disease in June 1992.
- Then followed a 4.5 year period of inactivity with no official MAFF involvement with scab (or lice).
- Scab diagnosis still being carried out by the VLA.
1995 - 2002 VIDA Returns

Scab and Lice - 1997 to 2004

• Sheep Scab Order (1997).
• Project ED 1030 VLA Support to the Sheep Scab Order (1997).
• 286 samples were examined - scab accounted for 70% and lice 30%.

Where have the lice come from?

• Populations on GB mainland surviving compulsory dipping - thus exposed to insecticide (?).
• Populations migrating from the Scottish Islands - exempt from compulsory dipping - not as exposed to insecticide.

Effects on Body Condition

• Scab
  - Experimentally infested sheep can maintain active and progressing scab - regardless of BCS.

• Lice
  - Experimentally infested sheep need to be BCS 2 or below in order to maintain lice.

Body Condition Score and Louse Burdens.
Body Condition Score and Louse Burdens.

- Chewing lice can be reduced to insignificant levels - even eradicated - through the maintenance of good body condition.
- The majority of UK lice occur on hill sheep on common grazings - general poor body condition.
- Louse burdens on Australian sheep are considerably higher than the UK - wool producing wethers are generally on a lower plane of nutrition through extensive grazing.
- Thus BCS is more important than wool characteristics (sheep breed).

Irritation

Seasonality

Sheep Lice and Sheep Scab

- In comparison to sheep scab ewes can carry a louse infestation throughout their lives.
- Sheep can carry mixed infestations of *P. ovis* (scab) and *B. ovis* (lice).
- The sequence of colonisation is important.

Scab and Lice - Mutually Exclusive?

- If sheep have an existing louse infestation then scab mites have difficulty colonising.
- Lice can infest a scab infested sheep, using the scab lesion as food.
- Systemic endectocides will knock down louse populations temporarily, but will recover, often in larger populations.

Sheep
Control of Ectoparasites Post Scab-Deregulation (June 1992)

- Plunge Dipping
- Shower Dipping
- AJRs
- Backline Treatments
- Endectocides
  - HCH, diazinon, propetamphos, flumethrin, high cis cypermethrin
  - cypermethrin, high cis cypermethrin, deltamethrin, alpha cypermethrin, cyromazine, diclinal
  - doramectin, ivermectin, moxidectin

Why Control Ectoparasites

- Welfare.
- Production
  - wool
  - meat
  - milk
  - leather

The Farmers Dilemma

- Controlling ectoparasites is a legal requirement,
- But can be expensive,
- Labour intensive and time consuming - staff costs,
- Few broad spectrum products - expensive,
- Environmental responsibilities - disposal is expensive,
- Health and Safety responsibilities,
- Resistance,
- Too much paperwork,
- A lot to be aware of and understand - lack of advice.

Prevention

- Biosecurity (equipment/personnel).
- Quarantine/observe/treat.
- Fencing.
- Disinfestation (buildings/trailers).
- Education (Flockowners and Vets).
- Awareness - good integrated control strategy

Choice of Ectoparasiticide

- Accurate diagnosis
- Cure or protection.
- Resistance.
- Flock size.
- Sheep condition.
- End product.
- Labour and facilities.
- Other parasites.
- Concurrent medicines.
- Operator safety.
- Purchase.
- Post-treatment handling.
- Environment.
- Weather.
- Husbandry

Diagnosis

- Ectoparasite(s) must be accurately identified.
- More than one parasite may be present.
- Inappropriate treatment may select for resistance and may need to be repeated (expensive).
Cure or Protection?

- Sheep are best protected against blowfly and ticks - cure may be too late.
- *P. ovis* and *B. ovis* can remain infestive to sheep up to 17 days off the host.
- All OP dips, some SP dips and some endectocides will protect against re-infestation by scab mites for 21 to 28 days.
- If a product does not protect, sheep treated for scab or lice should not be returned to infested pasture/building following treatment - facilities!

Parasite Resistance

- Flockowners and vets should be aware of resistant scab or lice in their area.
- Use an alternative product.
- Use products strictly according to the manufacturers instructions,
- do not select for resistance.

Size of Flock

- Consider the time and costs of using a particular product.
- All contact sheep have to be treated, not just the ones presenting with clinical signs.
- Try to get the whole flock treated in one day - is it possible to muster and house the night before?
- Avoid inaccurate application at the expense of speed.

Physiological Condition of the Sheep

- Avoid stress to in-lamb ewes and young lambs.
- Read instructions for suitability.

End Product

- Withdrawal periods for meat or milk may not be acceptable - how close to market?
- Withdrawal periods for fleece - how close to shearing?

Labour and Facilities

- Some treatments may require extra labour, fixed equipment and waste disposal.
- Can you afford it for the full time required?
- Is mobile equipment available?
- Is there a good site with regard to effectiveness, health and the environment?
Other Parasites

- Anthelmintic activity of MLs could lead to a more cost effective flock treatment.
- Misuse could lead to anthelmintic and/or insecticide resistance.

Concurrent Medicines

- OP or imidazothiazole based anthelmintic drenches (e.g. levamisol) and OP based plunge dips should not be used within 14 days of each other.
- Moxidectin injections should not be used after the administration of certain foot rot vaccines.

Operator Safety

- OP's are acutely toxic to man
- 2000 the use of OP dips was reviewed in the UK and temporarily withdrawn.
- Only those with safe delivery systems returned to the market.
- SP formulations are also toxic!

Operator Safety

- Thoroughly read HSE booklet (AS 29) on safe dipping before starting.
- Do not use an OP dip if you are affected by OPs.
- Do you have the appropriate PPE?
- Is your dipbath area safe?

Purchase

- Calculate how much you will need.
- Ensure you have the full kit-including dispenser.
- Do not mix products.
- Are you certificated?

Post-Treatment Handling

- Avoid handling treated sheep.
- Foot trimming etc should be carried out before or as long as practically possible after treatment.
- Wear disposable gloves.
- Concerns for shearers and wool sorters/ graders.
**Facilities should be available for the safe disposal of unused concentrate and/or unused wash.**
- Either on farm or by a licenced contractor.
- Is your dipping set up environmentally safe?
- Site mobile dipbaths, showers or jetters away from watercourses or main drains.

**Plunge and shower dipping should be avoided in extremes of hot or cold as well as wet weather.**
- Treat sheep early in the day.
- Allow enough time for sheep to dry out before nightfall.

**Shearing, bloom dipping or washing should not be carried out for at least four weeks following treatment.**

**An active molecule or organism is useless unless it is formulated correctly**
- The formulation is correct for the chosen delivery system.

**Saturation**

- 
- 
- 
- 
-
Shower Dipping (National Trust/VLA Study)

- Shower dipping close wool breed sheep with a mean of 3.0cm of fleece.
- Monsoon type shower dip – 3 mins top boom and 1 min bottom jets.
- Diazinon wash (100 mg/l) – 100% effective.
- HCC wash (1000 mg/l) – 90% effective.

Delivery Systems

- Pour-on
  - Systemic
  - Translocatory

Delivery Systems

- Injection (sc or im).
  - Short acting.
  - long acting.
- Oral
  - drench.
  - bolus
- Impregnated ear tags
- Environmental (traps, baited bins etc).

Treatment Method (ADAS Pwllpeiran)

- Plunge Dipping
  - Organic 23%
  - Conventional 76%
- Shower Dipping
  - Organic 13%
  - Conventional 13%
- Pour-ons
  - Organic > 50%
  - Conventional > 15%
- Injectables
  - Organic < 20%
  - Conventional > 15%

Plunge/Shower Dip Actives (ADAS Pwllpeiran)

- OP
  - Organic 0%
  - Conventional > 55%
- SP
  - Organic > 70%
  - Conventional > 35%
- Other
  - Organic > 20%
  - Conventional < 5%

Lice: Insecticide Resistance

- Resistance to plunge dips containing γHCH developed in populations of lice in Cumbria, Lancashire and Yorkshire in the mid-1960s.
The development of resistance to current classes of ectoparasiticide presents a real threat to the long-term viability of the sheep industry.

Alternative control strategies - vaccines and biological control agents - are unlikely to be available in the near future, even then they may have to be integrated with conventional chemotherapy.

The significant cost of R & D of new therapeutics for food producing animals is a constraint.

The chemical actives that are currently available are all that we are likely to have for the foreseeable future.

They must be used sparingly and wisely.
Sheep blowfly strike

Professor Richard Wall
University of Bristol

Number of larvae
Lesion area (cm²)

Secondary factors
- Weather
- Wool length
- Parasitic worms

Primary factors
- Fleece humidity
- Faecal soiling

Development rate
- Birth rate
- Death rate

Fly abundance
Sheep susceptibility

Weather
- Wool length
- Parasitic worms

Food
- Natural enemies
- Breeding sites

Incidence of strike per 1000 sheep

Questionnaire study
1989

May June July Aug Sept Oct

Month of the year

Incidence of strike per 1000 sheep

Lambs Ewes
Questionnaire
2004
3,530 questionnaires
6 regions
1,067 usable returns

Percentage of farms with blowfly strike

Percentage of ewes struck

Percentage of lambs struck
Blowfly strike highly prevalent especially in southern and central England and Wales; no improvement in the last 15 years

500,000 – 750,000 animals struck each year, of which 2-3% die

Without appropriate insecticides strike rates will be about 5-10 times higher on average

Warmer wetter winters and wetter summer/autumn will increase the strike incidence

Alternative control and better management approaches are needed urgently

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Alternative control and better management approaches are needed urgently
UK SHEEP ENDECTOCIDES

<table>
<thead>
<tr>
<th>Active</th>
<th>Form</th>
<th>Dose</th>
<th>Route</th>
<th>Scab</th>
<th>Bot</th>
<th>Heat</th>
<th>wdp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doramectin</td>
<td>Inj.</td>
<td>300* mcg/kg</td>
<td>Oral</td>
<td></td>
<td></td>
<td>70 d</td>
<td></td>
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<tr>
<td>Ivermectin</td>
<td>Inj.</td>
<td>200 mcg/kg</td>
<td>Oral</td>
<td></td>
<td></td>
<td>42 d</td>
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<tr>
<td>Moxidectin</td>
<td>Inj.</td>
<td>200 mcg/kg</td>
<td>Oral</td>
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<td>70 d</td>
<td></td>
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<tr>
<td>Ivermectin</td>
<td>Drench</td>
<td>200 mcg/kg</td>
<td>Oral</td>
<td></td>
<td></td>
<td>14 d</td>
<td></td>
</tr>
<tr>
<td>Moxidectin</td>
<td>Drench</td>
<td>200 mcg/kg</td>
<td>Oral</td>
<td></td>
<td></td>
<td>14 d</td>
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</tbody>
</table>

* See Table B.1. Moxidectin 200 mcg/kg for other nematodes. & B.2 for other products with approved milk withhold.

ENDECTOCIDES & SCAB

<table>
<thead>
<tr>
<th>Active</th>
<th>Scab treatment/prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doramectin inj.</td>
<td>Treatment: 2 injections 10 days apart. Contact between treated infected and untreated uninfected sheep to be avoided until 12 days after treatment.</td>
</tr>
<tr>
<td>Ivermectin inj.</td>
<td>Treatment: 2 injections 7 days apart. Contact between treated infected and untreated uninfected sheep to be avoided until 7 days after the last treatment.</td>
</tr>
<tr>
<td>Moxidectin inj.</td>
<td>Treatment: 2 injections 10 days apart. Prevention: 1 injection protects for &gt;28 days. Contact between treated infected and untreated uninfected sheep to be avoided until 12 days after the last treatment.</td>
</tr>
</tbody>
</table>

PERSISTENT ACTIVITY

<table>
<thead>
<tr>
<th>Psoroptes ovis</th>
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</thead>
<tbody>
<tr>
<td>Challenge: days post treatment</td>
</tr>
<tr>
<td>P. ovis avg sheep</td>
</tr>
<tr>
<td>Doramectin inj.</td>
</tr>
<tr>
<td>Ivermectin inj.</td>
</tr>
<tr>
<td>Moxidectin inj.</td>
</tr>
</tbody>
</table>

Comparative Pharmacokinetics

From: Barber et al, J Vet Pharmacol Therap 2001

Persistent Activity: O'Brien et al, Vet Rec 2001
CHEWING LICE

ML COMMON FEATURES
• STRUCTURALLY SUPERIMPOSABLE
• BIND TO GLUTAMATE-GATED CHLORIDE CHANNEL RECEPTORS
• COMPETITIVELY DISPLACE EACH OTHER AT SUCH RECEPTORS
• EFFECT SUSCEPTIBLE INVERTEBRATES BY HYPERPOLARISATION AND FLACCID PARALYSIS
• SHOW CROSS/SIDE-RESISTANCE TO THE SAME DRUG-RESISTANT PARASITES

SELECTION FOR ML RESISTANCE
• DOES THE USE OF INJECTABLE MLS FOR SCAB SIMULTANEOUSLY IMPOSE A SELECTION PRESSURE FOR RESISTANCE IN NEMATODES?
• DOES THE USE OF ORAL MLS AS ANTHELMINTICS SIMULTANEOUSLY IMPOSE A SELECTION PRESSURE FOR RESISTANCE IN SCAB MITES?

COMPARATIVE ASPECTS OF ORAL & INJECTABLE MLS
• PHARMACOKINETICS
• SIGNIFICANCE OF PROLONGED EXPOSURE
• SIGNIFICANCE OF DECLINING DRUG CONCENTRATIONS
• EFFICACY PROFILES
• SEASONALITY OF USE

IVM PHARMACOKINETICS
200 mcg/kg ORAL vs. S/C

From: Marriner et al, J.Vet Pharmacol.Therap 1987
MOX PHARMACOKINETICS
200 mcg/kg ORAL vs. S/C


IVM PHARMACOKINETICS
CONTROL vs. MANGE


MOX PHARMACOKINETICS
ORAL: CONTROL vs. INFECTED

From: Lespine et al, Parasitol Res 2004

IVM PHARMACOKINETICS
ORAL: CONTROL vs. N.battus

From: McKellar et al, Vet Parasitol 1991

PHARMACOKINETICS

• NEMATODE INFECTION
• MANGE INFESTATION
• BODY CONDITION (FAT)
• FEED INTAKE (ORAL)
**IVM ORAL VS PSOROPTES OVIS**

![Graph showing the number of live mites over days post treatment for IVM oral versus Control.](image)

From: Bates & Groves, Vet Rec 1991

**MOX ORAL/INJECTION ANTHELMINTIC CLAIMS**

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Oral</th>
<th>Inj.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ostertagia circumcincta*</td>
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<td>✗</td>
</tr>
<tr>
<td>Haemonchus contortus*</td>
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<td>✗</td>
</tr>
<tr>
<td>Trichostrongylus spp.</td>
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<td>Cooperia spp.</td>
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</tr>
<tr>
<td>Nematodirus spp.</td>
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</tr>
<tr>
<td>Strongyloides papillosus</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Oesophagostomum spp.</td>
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<td>✗</td>
</tr>
<tr>
<td>Chabertia ovina</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Trichuris ovis</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Dictyocaulus filaria</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Protostrongylus rufescens</td>
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MOX ORAL/INJECTION PERSISTENCY CLAIMS

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<td>Protostrongylus rufescens</td>
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<td>14</td>
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**SCAB & WORMS**

![Graph showing the number of diagnoses for scab and worms.](image)

VIDA report 2002
The Role of Growth Regulators in the Control of Ectoparasites

- The use of various substances against insects and other arthropods is documented since Antiquity...

Homer
Pliny the Elder
Cato the Censor

The majority of modern insecticides / ectoparasiticides act on a limited number of targets located in the nervous system

Neurotoxic Compounds
The Role of Growth Regulators in the Control of Ectoparasites

Problems linked to the use of Neurotoxic Insecticides

SAFETY
RESISTANCE

Need for different modes of action
more specific, ‘safer’ substances

Growth Regulators constitute a good answer

Growth Regulators

Interfere with the development and reproduction of the target pest

Depositio
n of eggs in the fleece
Pupation
Larval stages
Fly emergence after 2 weeks

Are more specific, and ‘safer’

Aim at different receptors

Growth Regulators, can be classified in major categories

Substances interfering with the hormonal system
Juvenile hormone analogues

Substances interfering with the chitin metabolism
Benzoyl-phenylureas
Triazine derivatives
Pyrimidine derivatives

Regulation of vitellogenesis
Inhibition of metamorphosis
Induction of metamorphosis
The Role of Growth Regulators in the Control of Ectoparasites

- Interfere with the polymerisation and the deposit of N-acetylglucosamin
- Block development cycle at each moult and prevent larval hatch

**Mode of action clearly different from BPU's**

**Act mainly at the first larval moult**

**Marked specificity**

**Diptera**

- Diflubenzuron – louse and blowfly activity
- Triflumeron – louse and blowfly activity
- Typically demonstrate a broad spectrum of activity against insects and poor efficacy if any against acarines
- Fluazuron – single host tick – low and inconsistent control of multi host ticks

- Juvenile hormone analogues will extend the larval stages and are obviously not suited for myiasis control
- Benzoylphenylureas and triazine derivatives interrupt the lifecycle at each moult and are therefore suitable for myiasis control
- Due to their species- and stage-specificity, triazine and pyrimidine derivatives offer the most promising alternative

- Cyromazine
- Vetrazin Pour-on
**Vetrazin Pour-on**

- Very specifically a blowfly preventative
- Best suited to prophylactic use

**Larva 1**

**Eggs**

**Adult**

**Pupa**

**Larva 2**

**Larva 3**

---

**Vetrazin Pour-on**

- Launched in UK in 1989
- In 2004 alone sold enough Vetrazin to treat more than 6 million lambs
- Every year have reported inefficacies - low levels
- Monitored with field visits and re-application
- Inefficacies generally due to poor application or use of the product as a substitute to management
- To date no cases of resistance with Vetrazin

---

**CLiK Pour-on**

- Launched in UK in 2001
- In 2004 alone sold enough CLiK to treat almost 2 million lambs
- Only a very low level of inefficacies reported
- Monitored with field visits and re-application
- Inefficacies generally due to poor application or use of the product as a substitute to management
- No cases of resistance with CLiK

---

**The Role of Growth Regulators in the Control of Myiasis in Sheep**

**Dicyclanil**

**CLiK Pour-on**

**New IGR**

16 weeks protection
Control of Ectoparasites

Conclusions: Limitations

- Prophylactic use - Timing important
- Specific action – Narrow spectrum
- Require understanding of ectoparasite physiology and ecology

Conclusions: Benefits

- New classes of molecules, new modes of action
- Overcoming resistance
- ‘Safer molecules’

The Role of Growth Regulators in the Control of Ectoparasites

The Future?

Combination IGR’s e.g. Magik in Australia, combination of dicyclanil and diflubenzuron for blowfly and lice
Sheep scab control in the south-east of Scotland

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2. Merlin Veterinary Group, 120 Gala Park, Galashiels, Selkirkshire, TD1 1EZ

Sheep scab in flocks served by the Large Animal Practice

- Several outbreaks during autumn 1993.
- In 2002 sheep scab was diagnosed in about 50% of the flocks served.
- New outbreaks were diagnosed every month during 2003.
- The disease was diagnosed and treated at different times in neighbouring flocks.
- Between 2002 and 2004 some flocks required treatment 3 times between October and March.
- If this pattern of disease was present throughout the UK, then more than 12 million sheep would have been infected by a parasite capable of causing serious production loss and suffering.

Example -
- A flock of 1600 mixed aged ewes and ewe lambs.
- Every sheep in the flock was plunge dipped in diazinon during October 2003.
- Almost every sheep was injected with doramectin on 25th March 2003, following introduction of sheep scab from a neighbouring flock.
- The last 20 ewe lambs were misguidedly treated with a single injection of ivermectin.
- Sheep scab confirmed in two Greyface ewe lambs on 12th May 2003.

How should this disease outbreak be managed?
£2200 already spent on sheep scab control.

Example -
- 13th June 2003
- Sheep scab diagnosed in a May-lambing upland flock of 600 Greyface ewes and their lambs.

What factors govern the choice of acaricide and its application method?

National importance of sheep scab

- Animal welfare concern.
- Treatment and prevention costs.
- An important production limiting disease
  - loss of body condition
  - poor lamb birthweights
  - slaughterhouse condemnation of carcases
  - difficulties of removing the pelts
- Highly contagious.
- Rapidly progressive.
THE NEED FOR REGIONAL SHEEP SCAB CONTROL PROGRAMMES IS OBVIOUS

2003 - 2004 sheep scab control in the area around Heriot and the Pentland Hills

- All (~50 and ~40) sheep farmers within two geographically defined areas invited to meetings on scab control
- Involvement of six other local veterinary practices.
- Meetings during June and July
  - education about sheep scab
  - clarification and discussion of the treatment options
  - plan of action

Principles of sheep scab control

- All sheep must be gathered and correctly treated.
- Handling pens and fields should be considered as a source of re-infection for at least 17 days after removal of untreated sheep.
- A residual acaricide must be used whenever it is necessary to return sheep contaminated fields or pens after treatment.
- Whenever possible, acaricide treatment should be delayed until all replacement sheep have been introduced.
- Any additional introduced animals should be treated and quarantined for sufficient time to ensure that scab mites are killed before mixing with the flock.

Options for sheep scab control

- Closed flocks and biosecurity
- Plunge dipping
  - organophosphates
  - synthetic pyrethroids
    - flumethrin
  - high cis cypermethrin
- Systemic endectocides
  - ivermectin
  - doramectin
  - moxidectin

The choice of acaricide is governed by -

- persistence of protection against re-infection
- time taken to kill any scab mites present
- meat withdrawal period
- animal handling facilities
- available labour
- price

Plunge dips

- Organophosphates
  - cholinesterase inhibitors
  - muscle relaxants
- Pyrethroids
  - interfere with sodium channels
  - direct effect on nerve
- Approved plunge dips kill scab mites within 24 hours
- Organophosphate and some pyrethroid dips provide residual protection for several weeks

Sheep scab can be introduced to a flock with -

- Carrier sheep
  - purchased animals
  - strays
- Shared handling facilities and equipment.
- Sheep transport.
- Fomites on fences.
- Human contact.

Recently infected sheep may not show clinical signs of sheep scab, so apparently healthy introduced animals should always be considered to be a potential source of infection.

Management of sheep scab is problematic when young lambs are involved.
**Plunge dipping**

- Dip solutions should be correctly diluted and replenished.
- Sheeps must be immersed for one minute with their heads dipped twice.
- Sheep should be immersed for one minute with their heads dipped twice.
- Care should be taken to limit fecal or soil contamination of the dip solution.

**Effective plunge dipping**

- Stripping: sheeps are removed from the dip solution and allowed to air dry.
- Stripping: sheeps are removed from the dip solution and allowed to air dry.
- Dip dips: ivermectin (and doramectin?) injections used within 14 days of each other.

**Systemic endectocides**

- Two subcutaneous injections of ivermectin seven days apart.
- A single intramuscular injection of doramectin.
- A single subcutaneous injection of moxidectin.
- A sample of sheep should be weighed beforehand and automatic syringes calibrated.

**Sheep scab control - practical considerations**

- Pour-ons and dip solutions applied in shower dippers or spray races are ineffective for sheep scab control.
- Whenever it is necessary to return sheep to untreated areas, they must be treated with a systemic endectocide, they must not be mixed with the main flock, or placed in areas used by the main flock for at least 7 days after treatment.
- Contact with strays, neighbouring sheep, fomites or shared handling equipment should not be avoided.
- A single subcutaneous injection of ivermectin is recommended for scab control.
- A single intramuscular injection of doramectin provides residual protection for about 28 days.

**Products for sheep scab control listed in the 2004 National Office of Animal Health compendium**

<table>
<thead>
<tr>
<th>Product</th>
<th>Chemical</th>
<th>Application Method</th>
<th>Protection</th>
<th>Meat withdrawal</th>
</tr>
</thead>
<tbody>
<tr>
<td>COOPERS ECTOFORCE SHEEP CUP</td>
<td>Ivermectin</td>
<td>Plunge dip</td>
<td>&gt;28 days</td>
<td>35 days</td>
</tr>
<tr>
<td>DORAMECTIN FOR CATTLE, SHEEP</td>
<td>Doramectin</td>
<td>Plunge dip</td>
<td>&gt;28 days</td>
<td>35 days</td>
</tr>
<tr>
<td>PARADOX PLUS</td>
<td>Ivermectin</td>
<td>Plunge dip</td>
<td>&gt;28 days</td>
<td>35 days</td>
</tr>
<tr>
<td>ROBUST</td>
<td>Ivermectin</td>
<td>Plunge dip</td>
<td>&gt;17 days</td>
<td>18 days</td>
</tr>
<tr>
<td>AURIFLAK FLY AND SCAB CUP</td>
<td>Ivermectin</td>
<td>Plunge dip</td>
<td>&gt;17 days</td>
<td>12 days</td>
</tr>
<tr>
<td>AURIFLAK FLY AND SCAB CUP</td>
<td>Ivermectin</td>
<td>Plunge dip</td>
<td>&gt;17 days</td>
<td>12 days</td>
</tr>
<tr>
<td>ECOFLEECE SHEEP CUP</td>
<td>Ivermectin</td>
<td>Plunge dip</td>
<td>&gt;17 days</td>
<td>12 days</td>
</tr>
<tr>
<td>ECOFLEECE SHEEP CUP</td>
<td>Ivermectin</td>
<td>Plunge dip</td>
<td>&gt;17 days</td>
<td>12 days</td>
</tr>
<tr>
<td>MXIDECTIN INJECTABLE SOLUTION FOR C &amp; SHEEP</td>
<td>Moxidectin</td>
<td>I.m. injection</td>
<td>&gt;17 days</td>
<td>56 days</td>
</tr>
<tr>
<td>CYDECTIN 1% INJECTABLE SOLUTION FOR SHEEP</td>
<td>Moxidectin</td>
<td>i.m. injection</td>
<td>1 ml/25 kg</td>
<td>28 days</td>
</tr>
<tr>
<td>ROBUST</td>
<td>Moxidectin</td>
<td>i.m. injection</td>
<td>1 ml/50 kg</td>
<td>70 days</td>
</tr>
</tbody>
</table>

**Sheep scab control - biosecurity**

- All animals introduced after application of whole flock control measures should be treated on arrival. If these animals are treated with a systemic endectocide, they must not be mixed with the main flock, or placed in areas used by the main flock for at least 7 days after treatment.
- This also applies to sheep which are certified as dipped before sale – pour dipping or injection technique, or use of non-persistent dips or systemic endectocides injections may not protect against infection acquired during the sale.
- Shared handling equipment should not be allowed near to the sheep flock, unless it has been scrupulously cleaned beforehand.
- Contact with strays, neighbouring sheep, fomites or shared handling facilities such as shearing trailers or scanning races should be avoided.
- This may be impossible – HENCE THE NEED FOR A REGIONAL CONTROL PROGRAMME.
Potential problems raised during discussion of regional scab control

- Control options are complicated
  - explanatory leaflets
- Subsequent introduction of infection with stray or feral sheep
  - group action
- Disposal of spent dip solution
  - problems could be overcome
- Meat withdrawal periods for organic lambs
  - non-treatment, close monitoring and strict biosecurity
- Biosecurity on peripheral farms.
- Use of OP dips
  - alternative control strategies

Regional sheep scab control programmes - results

- 2003 - 4 Heriot district and Pentland hills
  - agreed plan of action - treatment period during the first 3 weeks of October
  - peer co-operation - remove stigma
  - letter summarising the different treatment options
  - reminders during September
  - continued discussions and feedback
  - investigation of any suspicious cases
  - NO CASES OF SHEEP SCAB
  - numerous outbreaks elsewhere
- 2004 - 5: every farm served by the Large Animal Practice
  - ONE CASE OF SHEEP SCAB IN A FLOCK NOT PREVIOUSLY KNOWN ABOUT AND NOT INVOLVED WITH THE PROGRAMME
  - one case in a hill flock owned by a client of the practice but outwith the control area

Conclusions

- Regional sheep scab control can be effective
  - problems such as farmer co-operation, withdrawal periods, feral sheep and dip disposal are all surmountable
- Voluntary programmes may not be sustainable
  - difficulty involving every sheep farmer in the region
  - biosecurity on peripheral farms
  - inherent difficulties associated with endectocides
  - emergence of pyrethroid (and OP?) resistant P. ovis mites (accelerated by the use of long-wool pour-ons for louse and blowfly control)

- NEED FOR RE-INTRODUCTION OF A STATUTORY SHEEP SCAB ERADICATION PROGRAMME

  - New Zealand experience
  - Eradication of sheep scab from the UK is possible.
  - Farmer support for an eradication programme?
  - Withhold SFP or land management contracts for non-compliance?
  - Control of chewing lice and chorioptic mange.

Veterinary aspects of ectoparasite control - Scottish experience

- Neil Sargison

Chorioptic mange

- Exudative dermatitis of woolless areas of the lower limbs and poll of both sexes of sheep and of the scrotum of rams
- Lesions are associated with a hypersensitivity reaction to Chorioptes bovis
- 1-2 mm diameter scab-covered erythematous lesions, which progress to exudative, haemorrhagic fissured lesions
- Absent from UK between 1970 and 2000?
- Re-emergence associated with withdrawal of compulsory dipping for sheep scab
  - not controlled by systemic endectocides

Chorioptic mange

- Back-syruped sucker on an unsegmented pedicel

Chorioptic mange

- Kelso ram sales
  10th September 2004
Scrotal mange

- Reduced ram breeding soundness if more than one third of the scrotum is affected
- Common problem in UK sheep flocks

Chorioptic mange

- no products licensed for treatment or prevention
- topical application of organophosphate dip
- systemic endectocides are ineffective
  - mites feed on skin exudate without piercing the skin

Forage mites

- only partially parasitic
- climb onto face, legs or flanks of sheep, providing a method of dissemination
- occasionally cause pruritus
- hair or wool loss over affected areas
- control is impossible

Chewing lice

- spread of infection is slow
- transfer between animals requires close contact
- chewing lice don't drop off the host or survive for long in the environment
- chewing lice are host specific
- irritation is caused by biting the host
  - rubbing or biting at the shoulders, flanks and back
  - foot stamping
  - displacement of small tufts of wool

Chewing lice - economic importance

- There is little evidence to show any negative effect of biting louse infestation on liveweight gain or wool yield
- Heavy infestations can reduce wool quality
- Coccle is economically important to the tanning industry
- Louse infestation is an important differential diagnosis for sheep scab

Do heavy chewing louse burdens cause weight loss, or do they exploit sheep which are ill or thrifty for other reasons?
Louse control

- shearing
- organophosphate and pyrethroid plunge dips
- shower dips or hand jetting (only effective in shortwooled sheep and thorough saturation is essential)
- pyrethroid pour-ons
- systemic endectocides are ineffective

Products for louse control listed in the 2004 National Office of Animal Health compendium

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Chemical</th>
<th>Application Method</th>
<th>Treatment Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>COOPERS ECTOFORCE SHEEP DIP</td>
<td>Diazinon 1</td>
<td>Plunge dip</td>
<td>35 days</td>
</tr>
<tr>
<td>OSMONDS GOLD FLEECE SHEEP DIP</td>
<td>Diazinon 1</td>
<td>Plunge dip</td>
<td>35 days</td>
</tr>
<tr>
<td>PARACIDE PLUS</td>
<td>Diazinon 1</td>
<td>Plunge dip</td>
<td>35 days</td>
</tr>
<tr>
<td>ROBUST</td>
<td>High cis cypermethrin</td>
<td>Plunge dip</td>
<td>18 days</td>
</tr>
<tr>
<td>AURIPLAK FLY AND SCAB DIP</td>
<td>High cis cypermethrin</td>
<td>Plunge dip</td>
<td>12 days</td>
</tr>
<tr>
<td>ECOFLEECE SHEEP DIP</td>
<td>High cis cypermethrin</td>
<td>Plunge dip</td>
<td>12 days</td>
</tr>
<tr>
<td>TAKTIC</td>
<td>Amitraz</td>
<td>Pour-on</td>
<td>24 days</td>
</tr>
<tr>
<td>CROVECT</td>
<td>High-cis cypermethrin</td>
<td>Pour-on</td>
<td>3 days</td>
</tr>
<tr>
<td>DYSECT SHEEP POUR-ON</td>
<td>Alphacypermethrin 2</td>
<td>Pour-on</td>
<td>28 days</td>
</tr>
<tr>
<td>VETRAZIN POUR-ON</td>
<td>Cyromazine (IGR 2)</td>
<td>Pour-on</td>
<td>3 days</td>
</tr>
<tr>
<td>CLIK POUR-ON</td>
<td>Dicyclanil (IGR 2)</td>
<td>Pour-on</td>
<td>20 days</td>
</tr>
</tbody>
</table>

1. Organophosphates dips and ganglion blocking anthelmintics should not be used within 14 days of each other.
2. Pyrethroid pour-ons are effective when used off-shears, but long-wool treatments only reduce the louse burden.

Pyrethroid pour-ons

- disperse around the body in wool grease
- the amount of wool grease determines the effective concentration of pyrethroids
  - most effective when applied off-shears
  - high doses are required for long-wool treatments, which are expensive, as they remove all of the lice and present potential wool-residue problems
- require about 6 weeks to disperse around the body and kill lice
  - treatments within 6 weeks of lambing fail to prevent infection of newborn lambs
- a single off-shears application of synthetic pyrethroid pour-on during the summer can provide all-year round protection
- resistance problems
- wool residue problems

Blowfly control - farm management

- despite a good understanding of blowfly biology, the effective prevention of flystrike remains problematic
- blowflies can travel for several miles, so unlike lice and scabies, they can not be eradicated from a farm
- blowfly control requires both application of farm management practices and use of chemicals
- while modern insecticides are extremely effective, in practice correct application of these drugs to achieve satisfactory residual activity is difficult

Blowfly control – predisposing diseases

- baited fly traps can be used to monitor blowfly activity so that chemicals can be applied before problems arise, but delayed until they are required
- the choice of dip chemical is partly governed by the length of protection required
- the choice of application method depends on the product used and facilities available

<table>
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<th>Product Name</th>
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<th>Application Method</th>
<th>Treatment Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>COOPERS ECTOFORCE SHEEP DIP</td>
<td>Diazinon 1</td>
<td>Plunge dip</td>
<td>3 - 6 weeks</td>
</tr>
<tr>
<td>OSMONDS GOLD FLEECE SHEEP DIP</td>
<td>Diazinon 1</td>
<td>Plunge dip</td>
<td>3 - 6 weeks</td>
</tr>
<tr>
<td>PARACIDE PLUS</td>
<td>Diazinon 1</td>
<td>Plunge dip</td>
<td>3 - 6 weeks</td>
</tr>
<tr>
<td>ROBUST</td>
<td>High cis cypermethrin</td>
<td>Plunge dip</td>
<td>8 - 10 weeks</td>
</tr>
<tr>
<td>AURIPLAK FLY AND SCAB DIP</td>
<td>High cis cypermethrin</td>
<td>Plunge dip</td>
<td>Up to 8 weeks</td>
</tr>
<tr>
<td>ECOFLEECE SHEEP DIP</td>
<td>High cis cypermethrin</td>
<td>Plunge dip</td>
<td>Up to 8 weeks</td>
</tr>
<tr>
<td>CROVECT</td>
<td>High-cis cypermethrin</td>
<td>Pour-on</td>
<td>6 – 8 weeks</td>
</tr>
<tr>
<td>DYSECT SHEEP POUR-ON</td>
<td>Alphacypermethrin 2</td>
<td>Pour-on</td>
<td>8-10 weeks</td>
</tr>
<tr>
<td>VETRAZIN POUR-ON</td>
<td>Cyromazine (IGR 2)</td>
<td>Pour-on</td>
<td>10 weeks</td>
</tr>
<tr>
<td>CLIK POUR-ON</td>
<td>Dicyclanil (IGR 2)</td>
<td>Pour-on</td>
<td>16 weeks</td>
</tr>
</tbody>
</table>

1. Organophosphates dips and ganglion blocking anthelmintics should not be used within 14 days of each other.
**Plunge dipping**

- Plunge dipping can afford protection for 3 to 8 weeks, depending on the product used.
- Sheep should have at least 3 weeks fleece growth.
- Avoid excessive faecal contamination of the dip:
  - Remove dags.
  - Yard sheep overnight.
  - Clean feet by running sheep over slats.

Flumethrin plunge dips, which were licensed for the control of sheep scab before 2004 were ineffective for the control of blowfly strike.

**Shower dipping**

- Shower dipping can effectively control flystrike (but is not effective for the control of scab).
- Check machinery beforehand.
- Dip sheep for long enough to ensure that the chemical reaches skin level.
- Requires at least 2 - 4 weeks wool growth for the insecticide to bind.
- Faecal contamination of the dip must be minimised.

None of the plunge dip solutions available in Britain are licensed for use in shower dippers.

**Hand jetting**

- Dip solution is applied using a high pressure pump and specially designed handpiece.
- Advantages:
  - Dip solution is applied only to the sites of potential flystrike.
  - Does not require expensive equipment.
  - Uses less dip solution than saturation dipping.
  - Dip solution is not recycled so problems of stripping and faecal contamination are avoided.
  - No problem of disposal of used dip.
- Disadvantage:
  - None of the plunge dip solutions available in the UK are licensed for jetting use.

**Pour-ons**

- High-cis cypermethrin.
- Insect growth regulators:
  - Cyromazine.
  - Dicyclanil.
- Applied to potential areas of strike over breech and rump.
- Provide effective control of blowfly strike:
  - 6 weeks (HCC).
  - 8 – 10 weeks (alphacypermethrin).
  - 10 weeks (cyromazine).
  - 16 weeks (dicyclanil).
Treatment of fly strike

- Struck areas are sensitive to sunburn, so should not be clipped other than to gain access to the wound.
- Organophosphate or high-cis cypermethrin dressings kill the maggots and protect the surrounding skin from secondary strike.
- If dip solution is used, it should be diluted to normal dip strength.
- Insect growth regulators are ineffective for the treatment of established flystrike.

Headfly

- Farm management
- Topical creams
- Plunge dips
- Pour-ons

Products for headfly control listed in the 2004 National Office of Animal Health compendium

<table>
<thead>
<tr>
<th>Product</th>
<th>Chemical</th>
<th>Application method</th>
<th>Protection</th>
<th>Meat withdrawal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deltamethrin</td>
<td>Pour-on</td>
<td>5 ml to head</td>
<td>2 weeks</td>
<td>7 days</td>
</tr>
<tr>
<td>High-cis cypermethrin</td>
<td>Pour-on</td>
<td>5 ml to head</td>
<td>~3 weeks</td>
<td>3 days</td>
</tr>
<tr>
<td>Alphacypermethrin</td>
<td>Pour-on</td>
<td>5 ml to head</td>
<td>6 weeks</td>
<td>28 days</td>
</tr>
</tbody>
</table>

Keds

- Wingless flies with piercing mouthparts
- Live permanently on their sheep host.
- Adult females produce mature larvae which adhere to wool and pupate immediately.
- Rare in UK.
- Populations build up slowly to peak in autumn/winter.
- Moderate infestation causes annoyance.
- Heavy infestation can result in anaemia and debilitation in addition to severe skin damage.

Tick control

- Fencing and drainage
- Grazing sheep on improved pasture during periods of peak tick activity and treatment before returning to hill pasture.
  - Alternative hosts
- Plunge dips
- Pour-ons

Ectoparasite control

Different ectoparasiticides and different treatment methods are required for the control of sheep scab, blowfly strike, headflies and lice.

Attempts to combine the control of these ectoparasite diseases are often unsuccessful.
The Scottish Sheep Scab Initiative

A 3-Year Awareness Campaign Launched at Kelso 3rd September 2003

Aim of the Sheep Scab Initiative

To reduce the incidence of sheep scab through:
- Promotion and support of best practice (flock biosecurity)
- Minimising the impact of outbreaks (effective and co-ordinated treatment)
- Maximising the effects of preventative action (targeting risk and co-ordinating treatment)

Sheep Scab Initiative

Raise awareness via:
- Provide information on sheep scab
- Provide information on best practice for flock biosecurity
- Promote co-operation at a local level (local veterinary support)
- Promote the initiative

Initiative: Scab Information Line (0131 472 4031)

- Information Pack - technical information from SAC
- Questions & Answers
- Product Information (Commercial Sponsors)
- Free lab scab test (SAC) publicity
- Outbreak situation - co-ordinate local vet support through SAC Vet Services

Initiative: Action periods

1. September - October
   Take time to assess flock health, risk status (incl: local risk factors and local prevention strategy).

2. March - April
   Quarantine and treat away wintered sheep on return.

Initiative: Core messages

1. Prevent disease entering your flock. Isolate and treat any incoming stock.
2. Concerned about your flock’s health? Involve your local vet or phone the ‘Scab Information Line’ direct.
3. Support the Action Periods. Assess your flock status and potential risk, then treat accordingly.
IN THE EVENT OF AN OUTBREAK

- Confirm diagnosis
- Warn Neighbours
- Alert suspect source
- Involve local vet practices
- Select treatment - flock situation
- Treat all contacts with sheep (+fields)
- Remember withdrawal periods

Acknowledgements

SPONSORS
- Fort Dodge
- Norbrook
- Pfizer
- Schering Plough
- Virbac

STAKEHOLDERS
- NFU Scotland
- NSA
- SEERAD
- SAC
- SVS
- QMS
- Moredun
- BVA
- SSPCA
- SEPA
- Auctioneers & Appraisers
- Crofters

Presentation prepared by Brian Hosie, SAC Veterinary Services, Edinburgh 24.02.05

The Scottish Sheep Scab Initiative
Scab Alert Phoneline
0131 472 4031
Research into Alternative methods for the control of sheep scab

Prof Mike Taylor
Central Science Laboratory, York

Sheep Scab Control - Why Alternatives?

- Number of major issues and concerns with current chemical control methods - particularly SAFETY (Human and Environment)
- The main alternatives under consideration are:
  - Immunological control
  - Vaccines
  - Biological control
  - Entomopathogenic fungi

Sheep Scab Lesion

- Caused by the presence and feeding activity of the mite, *Psoroptes ovis*
- The allergic dermatitis caused by the presence of scab mites leads to:
  - Skin exudate or moist 'scab' lesion which can spread all over the body
  - Clinical signs of scratching, wool loss, wounding and fitting
  - Sheep scab is highly contagious and a SEVERE welfare problem

Immunological Research

Two basic approaches:

- Stimulate naturally acquired immunity
  - Requires knowledge of:
    - Protection mechanism
    - How to stimulate it
- Ignore natural immunity, and direct response at vulnerable target on mites
  - E.g. Gut membrane proteins

Immunological control

- Vaccines offer:
  - High safety
  - No residues
  - Low probability of resistance developing
  - Potentially cheap
- Earlier research demonstrated that:
  - Previously infected animals develop a strong natural immunity
  - Immunisation with mite extracts produces a protective response

Sheep Scab pathogenesis

![Graph showing mite numbers and lesion size over days after infection]
**Natural Immunity**

![Graph showing lesion area over days post infection/challenge](image)

**Design of immunisation trials**

- Groups (7-15) of sheep immunised (3x) with different antigens + QuilA
- Control group - QuilA only
- All challenged with *P. ovis* one week later
- Monitor lesion area and mite counts for 6-8 weeks

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**Early Vaccine Studies**

**Lesion Areas**

![Graph showing lesion areas](image)

**Mite Numbers**

![Graph showing mite numbers](image)

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**Fractionation Vaccine Studies**

- Soluble extract of mites gives partial protection
- Membrane extracts ineffective

**Lesion area (>2 fold)**

![Lesion area graph](image)

**No of mites (4-fold)**

![Mite number graph](image)
Conclusions and future work

- The natural immune response is mainly antibody-mediated (T-helper CD4 and CD45 subsets predominate) rather than cytotoxic
- Partial protection can be induced with soluble native antigens in adjuvant
- Protection improves with fractionation
- On-going sheep vaccine trials to identify protective antigens
- These will have to be cloned, sequenced and expressed as recombinants for commercial vaccine

Breed Susceptibilities and Innate Resistance

- Limited studies suggest there are differences in susceptibilities to sheep scab in longwool (hill) and closewool (lowland) breeds
- Highly significant between-breed differences seen in the local eosinophil inflammatory response
- Possible selection for resistance to sheep scab?

Entomopathogenic fungi

- Natural fungal pathogens successfully used in controlling insect (crop) pests
- Astigmatic parasitic mites are unsclerotised and are theoretically ideal targets
- Fungi (Metarhizium and Beauveria) already shown to be pathogenic to mites
- Fleece microclimate conducive to fungal growth

Results from initial entomopathogenic fungal studies

- Fungal stains of Metarhizium and Beauveria are pathogenic to mites in vitro
- “High-temperature” fungal strains isolated
- Demonstrated good mite pathogenicity (in vitro) and can survive on fleece
- Large scale fungal production facilities have been developed
- Formulation studies suggest oil-based carrier vehicle (Silicone oil)
- Fleece constituents e.g. lanolin may inhibit spores
Challenges

- **Temperature** - Few fungi can grow at sheep body temperatures
- **Fleece Fungicidal Properties** - Compounds (e.g. lanolin) present on sheep skin and wool may inhibit spores
- **Application** - Needs to be easy to apply, spread throughout the fleece and be effective and persistent
- **Commercialisation and Licensing** - Novel Veterinary Biological Product

**Sheep Fleece Microclimates**

<table>
<thead>
<tr>
<th>Location</th>
<th>Temp. °C</th>
<th>Range °C</th>
<th>Disease progression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groin</td>
<td>36</td>
<td>34-39</td>
<td>+/-</td>
</tr>
<tr>
<td>Ear</td>
<td>32</td>
<td>27-36</td>
<td>+/-</td>
</tr>
<tr>
<td>Belly</td>
<td>32</td>
<td>23-37</td>
<td>+</td>
</tr>
<tr>
<td>Mid back</td>
<td>28</td>
<td>26-31</td>
<td>++++</td>
</tr>
<tr>
<td>Rump</td>
<td>28</td>
<td>25-30</td>
<td>+++</td>
</tr>
<tr>
<td>Tail</td>
<td>21</td>
<td>19-23</td>
<td>+</td>
</tr>
</tbody>
</table>

**Fungal Growth at 4 temperatures**

Metarhizium anisopliae (French isolate)

<table>
<thead>
<tr>
<th>Temp °C</th>
<th>Days</th>
</tr>
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<tbody>
<tr>
<td>34</td>
<td>40</td>
</tr>
<tr>
<td>32</td>
<td>40</td>
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<tr>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>28</td>
<td>30</td>
</tr>
</tbody>
</table>

**Mycoharvester for mass production**

**First Efficacy Trial**

- Curative trial on “scab” infected sheep
- All sheep pre-inspected for mites and fungi
- 3 groups of 6 sheep
  - Group 1 – infected, untreated control
  - Group 2 – infected, excipient control
  - Group 3 – infected pour-on treatment (35 days p.i.)
- Denmark strain of *Metarhizium anisopliae* (IMI386698) used at 10⁸ concentration in 100ml silicone oil
- Weekly sampling up to 85 days p.i.
**Spray Treated Sheep**

**Efficacy Trial results**

- Statistical analysis of lesion size and mite numbers showed no treatment effect
- Only a few mites recovered from wash samples had *Metarhizium* infection
- No mites recovered from skin samples became infected
- Evaluation of current methodologies ongoing

**Conclusions and Next Steps**

- FORMULATION and ability to deliver spores at the skin surface are key factors to success
- Further high-temperature fungal strains and isolates need to be evaluated
- Planned “fleece” (in vitro) trials to investigate:
  - Spore deposition, migration, persistence and germination
  - Inhibitory fleece factors
  - Improved formulations - excipients and surfactants
- Sheep formulation trials
- Scab protection and efficacy trials

**Product Licensing and Commercialisation**

- Meeting held with VMD – 18th October 2004 with Research, Immunologicals, Pharmaceuticals and Ecotoxicology Groups to discuss potential licensing issues
- Strategic plans for licensing potential vaccine and biological (fungal) control established with VMD and EMEA
- Commercial Interest from Animal Health and Pharmaceutical companies will be sought pending outcome of forthcoming trials

**Acknowledgements**

- Vicky Jackson, Bhushy Thind, Louise Ford, CSL
- University of Leeds (Elwyn Isaac, Josie Thomas)
- University of Bristol (Richard Wall, Stephen Abolins)
- University of Aberdeen (Peter Billingsley, Carol McNair)
- University of Edinburgh (Adri van den Broeck)
- Moredun Research Institute (John Huntley, Dave Smith, Al Nisbet)
- CABI Bioscience, Egham (Dave Moore, Marilena Aquino de Muro, Belinda Luke)
2. Discussion on the Papers

2.1 An Overview of Scab and Lice Control - Peter Bates, VLA, Weybridge

2.1.1 Misdiagnosis

The free VLA ectoparasite survey carried out in 2003/4 identified misdiagnosis, in particular confusion between scab and lice infestations, as an important issue. **Correct diagnosis of the problem is vital to ensuring that the correct products are used.** Vets visit very few sheep flocks on a regular basis and farmers tend not to ask for a professional diagnosis by a qualified expert. This lack of professional advice is a major cause of misdiagnosis which not only leads to failed treatments but also increases the risk that resistance will develop.

2.1.2 Resistance to OPs and SPs

Currently there are no data available on the prevalence of resistance to OPs or SPs in sheep scab mites. However, the group agreed that it was an increasing problem and unless steps are taken to improve dipping practices, resistance could become a significant problem in the short to medium term. Health and safety and environmental concerns regarding the use of these active ingredients (OP and SP) means that future regulatory action may make them unavailable to farmers. If eradication of scab was ever to be considered as an option, the group felt there may only be a relatively short time scale in which to act before SPs and/or OPs either become ineffective or their licenses were revoked.

Furthermore, the mechanism of resistance to synthetic pyrethroids (SPs) and organophosphates is similar, so resistance to one group may confer cross-resistance to another. Resistance of scab to organochlorines before the introduction of SPs may also have accelerated the onset of resistance to SPs.

2.1.3 Cost Benefits

Previous attempts to eradicate sheep scab has cost a considerable amount of taxpayer’s money. Although the exact figures were not immediately available to the group during its discussion, it was agreed that any proposed scab control/eradication programmes should be fully costed and the benefits to the industry as a whole assessed carefully, to see whether or not it was justified.

2.2 An Overview of Blowfly Control- Richard Wall, Bristol University

2.2.1 Modelling

The group recommended that validated computer models should be used as a basis for decision making in the control of blowfly strike. Informed decisions based on spring temperatures and humidity can help optimise control and thus ensure that existing products are used as effectively as possible. This will help reduce the spread of resistance to key active ingredients. The computer model described to the group clearly has the potential to predict the incidence of blowfly strike in particular areas, with some accuracy. Strikewise.com is a website that gives the forecasts and we should be encouraging farmers to use this information.
2.2.2 Fly Trapping

Fly trapping studies have shown that there may be potential for this technique in blowfly control in the UK, although it was noted that in NZ the results have not been so positive. Other techniques have also been shown to have some efficacy in reducing the likelihood and frequency of blowfly strike and these should be encouraged.

2.2.3 Indirect Selection Pressure on MLs

Whilst the macrocyclic lactones are not used for the control of blowfly, there are indirect implications if active ingredients such as synthetic pyrethroids are used which are also used for scab control. This overlap between active ingredients that control different parasites requires an integrated approach to ectoparasite control if the development of resistance is to be slowed.

2.3 Endectocides and Ectoparasite Control – An Industry View, Andy Forbes, Merial

2.3.1 Under-dosing

In discussion, it was agreed that under-dosing with endectocides increased the risk that resistance would develop to the active molecules. In addition, the MLs administered orally were a concern in terms of sub-lethal effects, the group agreeing that this was likely to result in scab mites being exposed to a sub-lethal dose.

2.3.2 Timing of Treatment

The timing of treatments was also discussed in the context of the risk of sub-lethal exposure. The group concluded that it is not clear whether the selection pressure for resistance would be increased or decreased if these products (MLs) are used in the winter compared with the summer. However, consideration must be given to this and further investigation is required.

2.4 Insect Growth Regulators - Lynda Maris, Novartis

Most IGRs are applied to lambs after the farmer has seen the first case of fly strike. However, some flocks do apply both IGRs and SP products prophylactically to both ewe and lambs. Such widespread prophylactic use of SPs could contribute to the spread of resistance in scab and lice. In this context, the value of a predictive warning system was underlined again in this discussion.

2.5 Veterinary Aspects of Ectoparasite Control - Neil Sargison, Royal Dick Vet School and Brian Hosie SAC

The initiative in Scotland had been successful in reducing the incidence of sheep scab in the areas where the farmers and vets had become involved. Farmers are keen to be involved in the scheme and it was agreed that if scab is to be tackled it should be an industry led initiative. However, it would need support from Government and if anything is to be done it must be quickly.
The group felt that with commitment from the industry and vets, eradication in many areas would not take long. However, common grazings remain the main problem areas in terms of total eradication. Securing co-operation from all users of common land and co-ordinating treatment could be logistically difficult.

A breakdown in the programme now would be disheartening for all involved, and biosecurity measures for disease control need to be maintained.

Plunge dipping is still the most robust method available for the treatment and control of sheep scab. There is little evidence to date of resistance to SPs.

### 2.5.1 Cross-Compliance

The question of cross-compliance and sheep scab (and animal health and welfare in general) was raised. Many felt that payments should be made (or withheld) on the basis of the scab status of the flock. However, it was recognised that the EU were moving further away from this in recent announcements. Single Farm Payments are not currently linked to welfare.

### 2.6 Alternatives to Chemical Control - Mike Taylor, CSL York

It was agreed that the development of a scab vaccine and biological control methods are more targeted at control of the disease and its symptoms rather than eradication of the parasite. This means that they need to be viewed in the correct context as part of an integrated control plan. These alternative methods do not support elimination of the disease.

It was noted that the pathogenic fungi do not appear to have any effect on wool quality and the fungal spores stay viable for 3-4 weeks which it is hoped will be extended by mutating the fungi.

#### 2.6.1 Breed variations

It was noted that sheep breed variations have been observed. Current work is using the same breeds, for standardisation purposes. This issue will require further investigation. Virulence of the mites does not appear to vary, but different breeds may have different degrees of tolerance or resistance to the parasite. This is a factor that could be taken into account in future breeding programmes.

### 2.7 General Discussion

#### 2.7.1 Changes in the Sheep Industry

The group agreed that it was important to be aware of fundamental changes taking place in the sheep and wider farming industry. Sheep breeds, stocking densities and grant schemes all need to be considered. The main hot spots for sheep scab are on common grazings. Scab prevalence and control is most likely to be affected by changes in stocking densities, systems, and breeds in these situations.
2.7.2 Cost Benefits

The only way to convince livestock keepers of the need to change attitudes and behaviours is to assess the costs of disease and long-term financial benefits to farmers of tackling problems more proactively.

Eradication of scab and using existing products in a more sustainable way requires careful planning and co-operation, which will have short-term costs. If the future of the sheep industry depends on the availability of existing products, then the long-term costs to the industry of doing nothing could be considerable. Only a well-conducted cost-benefit analysis will provide the case for an eradication programme.

An assessment of the long-term financial benefits may help convince the industry that action is needed sooner rather than later. There will be considerable communication challenges involved in changing attitudes and behaviours and any communication strategies need the full co-operation and involvement of the wider sheep industry.

In considering whether or not SCOPS should propose, support and lobby for the eradication of Sheep Scab, a serious analysis of the costs and benefits to the industry as a whole would need to be undertaken. Roles and responsibilities would also need to be explored – an eradication programme would only be likely to succeed if there was wholehearted support and commitment from all sectors of the farming industry;

2.7.2 Organophosphorus (OP) dips

It was noted that if sheep scab was eradicated in future then the need for OPs as a control agent would be significantly reduced, although their use would be important in the short to medium term. There is a potential issue with animal health companies not wanting to support the OPs in future registration reviews. It was also noted that the Environment Agency would need to be fully involved in any eradication planning as they set disposal charges for OPs. More importantly, there are environmental risks posed by the use of different active ingredients, and these would need to be taken into account in the planning process. An existing model for co-operation of this nature is SEPA support for the current Scottish initiative.

2.7.3 Integrated Approach

It was seen as very important for SCOPs to produce interim recommendations on endoparasite and ectoparasite treatments, with advice and information on how to integrate parasite control in a more sustainable way. A sustainable blowfly control programme should be implemented, including the use of predictive models and information flow to sheep farmers. Blowfly prevention can be achieved without the use of OPs or SPs.

Lice eradication was a lower priority and could be considered at a later stage.
3. Discussion Session Day 2 - Chaired by Bill Parish

3.1 Introduction and Opening Discussion

Bill Parish introduced the objective of the discussion session and described the background to the establishment of the SCOPS initiative. The first workshop (March 2003) had focussed on the sustainable control of endoparasites. The key objective had been to slow the development of anthelmintic resistance, in particular to the Macrocyclic Lactones (MLs). It is vital that the efficacy of this group of chemicals is prolonged for as long as possible, since no new anthelmintics are expected within the short to medium term. The SCOPS endoparasite messages to sheep keepers are complex and SCOPS recognises that there is a significant challenge ahead if old habits are to change. However, significant progress has been made in the two years since the original workshop and this continues to be monitored.

Since it is clear that Macrocyclic Lactones (MLs) are also used widely by sheep farmers to control sheep scab, there are important implications for endoparasite control and the potential for development of resistance to this group of chemicals. SCOPS therefore urgently needs to consider how ecto and endoparasite control should be integrated, to both ensure the messages developed in the previous workshop were upheld and also limit the selection pressure on the MLs.

The primary objective of the discussion was to consider how to preserve the use of the MLs for as long as possible for both endo and ecto parasite control.

3.2 Sheep scab eradication

Eradication of scab had stimulated a lot of discussion the previous day, and proposals had been made that there should be another attempt to eradicate it. The chair commented that Government had tried and failed to eradicate scab before, at enormous cost. If it was to be attempted again it would require 100% commitment from the industry, probably with SVS co-ordination. It would be costly and require detailed, long-term planning and monitoring of progress and the industry and veterinary profession would be expected to play a lead role in implementation.

There was much discussion around the table on the positive and negative aspects that needed to be taken into account in pursuing a proposal for an industry led eradication programme. These are summarised below:
<table>
<thead>
<tr>
<th><strong>PROS</strong></th>
<th><strong>CONS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential-long term benefits to the industry and animal welfare</td>
<td>Potential for cross-transmission as species on other hosts are very similar – rabbits, goats, cattle, and could act as carriers.</td>
</tr>
<tr>
<td>OPs and SPs are running out of time in relation to resistance, environmental and health concerns. These are essential products that would need to be used in an eradication programme.</td>
<td>Problems with treatment of incoming animals from other countries. Will this need industry guidelines or new legislation?</td>
</tr>
<tr>
<td>Preserving the efficacy of MLs will become increasingly difficult as SP and OP use decreases. Eradication will help reduce the selection pressure if they are no longer being used against scab, thus Longer life-span of MLs as endectocides.</td>
<td>Organic units – there are difficulties in treating this population. However, eradication will help protect the organic sector - so there may be scope for developing an organic strategy that complements the approach taken by the rest of the industry.</td>
</tr>
<tr>
<td>An opportunity for the industry to develop closer working partnerships between farmers, the veterinary profession and the SVS in implementing such as programme</td>
<td>Common grazings – will need very close co-ordination and co-operation between all interested parties. Consideration how sanctions can be enforced for those who do not co-operate.</td>
</tr>
<tr>
<td>As routine OP and SP use declines post eradication, the risk of water contamination with consequent effects on aquatic life will be reduced.</td>
<td>Short term risk to human health due to more intensive use of OPs and possible risks to environment if SPS used more widely.</td>
</tr>
<tr>
<td>Reputational benefits if campaign successful, and greater consumer understanding and confidence.</td>
<td>Significant costs involved, and a major PR challenge in order to get all parties’ co-operation.</td>
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</tbody>
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During the discussion the following points were made:

- Even if complete success (eradication) is not achieved, a large reduction in the prevalence of the disease will be highly beneficial. Follow through support is needed and this must be implemented now before the armoury of products available diminishes and OPs and SPs become less and less effective as resistance accelerates.
• Guidance on the use of the various chemicals by farmers for eradication will be difficult. It will also be difficult to get all farmers and common landowners on board. Communication and co-operation between neighbours is essential, particularly on common grazings.

• The policing of the strategy would have to very different to the previous attempt in the 1980s. However, the industry are likely to be more positive towards an eradication programme now than previously, because most sheep farmers have been affected by, or seen sheep scab.

• *Psoroptes* is not a problem in cattle. If outbreaks are reduced in sheep there would be an overall reduction due to lack of intermediate hosts.

• The group were unsure of the resources required to maintain disease-free status for sheep scab. Therapeutic use of medicines would still be necessary, but it was not clear which ones we would need access to.

• The infrastructure is vital. Any strategy must be set up for a 3-year campaign. Traceability has improved (and should improve further) since the last eradication scheme, so a UK-wide strategy should be easier to control and monitor.

• Correct diagnosis is essential, together with accurate treatment advice.

• Prevention and treatment are expensive so medium/long term financial benefits should be identifiable. A full cost-benefit analysis needs to be carried out.

• Eradication is possible, but draconian measures will be needed in the final stages of the programme to mop up any remaining sources of infection – this is likely to be very resource intensive.

• There will always need to be a very strong emphasis on prevention – and this needs to be a key component of flock management plans.

• Geographic and stratification segmentation needs to be considered carefully when putting together a plan along with anticipated changes as the SFP begins to affect the shape of the UK sheep industry.
4. Recommendations and Conclusions

4.1 Sheep Scab

4.1.1 The Group systematically reviewed the existing major ectoparasite issues for the sheep industry and agreed that the key issue with implications for effective endoparasite control was sheep scab, because the macrocyclic lactones are used widely for both scab and endoparasite control. It is imperative that parasite control strategies are integrated, with careful choice of active chemical.

Sheep scab is not being controlled in the UK and the situation will only get worse. Doing nothing is not an option. Even if eradication is a huge challenge, we must aim for it with future proposals.

4.1.2 A Strategic and coordinated approach towards scab eradication is the best way of regaining control and addressing the welfare issues and costs. This also greatly reduces the selection pressure for resistance to an important group of anti-parasitic medicines (MLs) which are not only used for scab control, but are vital for control of endo-parasite in sheep.

4.1.3 A long term management strategy, which includes quarantine measures, and encourages a more sustainable approach to parasite control in sheep is needed. Development of such a strategy should include the organic sector together with Environment Agency, DoH, SVS, and industry support.

4.1.4 OPs and SPs are required to achieve eradication, so there is a need to exploit the opportunity while they are still effective and available – so if an eradication programme is to be considered, it must be NOW.

4.1.5 THE INDUSTRY MUST TAKE OWNERSHIP AND THE LEAD

4.1.6 The group recommended that a cost/benefit analysis is carried out to assess the feasibility of eradication in order to inform a wider discussion on whether eradication should be seriously considered. This should take into account the availability and risks of using existing active ingredients and the knock-on consequences for helminth control in the face of anthelmintic resistance.

4.2 Blowfly

4.2.1 Blowfly strike is considered by farmers to be as important as sheep scab. It is a widespread problem but it is not difficult to control (whereas Scab is less common but more difficult to control). Effective intervention can be based on prediction rather than waiting until the first cases are seen. Good products and supportive science are available.

4.2.2 THERE IS A NEED FOR A FORECASTING SYSTEM, AND THE ENCOURAGEMENT OF FARMERS TO USE IT, TO ENSURE EFFECTIVE AND SUSTAINABLE PREVENTION OF BLOWFLY STRIKE.

4.2.3 It is important to consider the effects of product choice/use on other ectoparasites. Integration of blowfly control into an overall ectoparasite control strategy for a flock is important and through using products specific to blowfly...
control (for example the IGRs), a significant sparing effect on the other products (OPs and SPs) achieved

4.2.4 Education and communication with vets, advisers and farmers is vital. Product use information at point of purchase is important in promoting sustainable use of anti-parasitics. The group recommended that labels should carry essential information on the chemical, parasites and importance of correct timing and dosing. There is a role of the VMD and animal health industry in making this happen.

4.3 Ticks

4.3.1 There is some evidence of resistance to pyrethroids (deltamethrin) on the North York Moors and Cheviots. The NY Moors had a 5 year suppression plan, but overuse of pyrethroids led to an increase in resistance.

4.3.2 The group concluded that there is a general lack of information on changes in grazing patterns, host data, and tick populations. There was concern about the role of ticks as vectors of human diseases and tick-borne encephalitis and Louping Ill incidents are likely to become more prevalent with climate change.

4.3.3 There is a limited (and dwindling) armoury of products to control ticks and in many cases they are being used ineffectively. Effective strategies need to be developed to optimise the use of existing options, particularly to preserve the effectiveness of SPs.

4.3.4 There may be a conflict between animal health and habitat management. Agri-Environment schemes may be encouraging vegetation that harbours significant tick populations. This may be a risk for humans if ticks carry human pathogens, but it could also make the land unusable for sheep grazing if the ticks cannot be controlled with existing products. Research is required to assess implications of current agri-environment schemes that may encourage growth of tick populations.

4.3.5 The Group recommended that there is an urgent need for research into tick prevalence and possible control methods

4.4 Lice

4.4.1 Incorrect treatment for lice is a significant problem and urgently needs to be addressed. **Chewing lice are the key problem in Great Britain, sucking lice are very rare.** MLs are NOT effective against chewing lice and should NOT be used under any circumstances.

4.4.2 If SPs are applied as a pour-on in long wool sheep, there is significant selection pressure for resistance in lice. Label claims for such use should be discussed with the manufacturers with a view to modifications that would discourage this use.

4.4.3 The emphasis for lice control should be on prevention rather than waiting for it to become a problem and then treating. Prevention options are practical and
achievable and guidance should be issued to farmers to encourage a "prevention is better than cure" attitude.

4.4.4 It is possible to take a more flexible approach to lice infestations - both in terms of timing and the number of animals treated. Only affected animals need to be treated and unnecessary treatment should be avoided.

4.4.5 Differential diagnosis, particularly between lice infestation and scab, is essential. Misdiagnosis may not only lead to a failure to cure the problem, but it may also encourage resistance build up in pest populations. It is essential that professional advice is taken on what and if intervention is required.

4.5 Other Recommendations

4.5.1 Chewing lice, blowfly and ticks can be controlled using insecticides and acaricides other than the MLs. However, when OPs and SPs are used for these parasites there is a need to do so very carefully because of the knock-on effect of resistance in scab mites and the consequent reliance in the future on the MLs. This is similar to the endoparasite situation where SCOPS has recommended the use of BZs for example for Nematodirus to spare the selection pressure on the other two anthelmintic groups.

4.5.2 The same basic principles as for anthelmintics should be applied for ectoparasite control. Full therapeutic dosing is essential, including dose rates, technique, handling and storage of products. However, selective treatment (ie leaving some of the flock untreated) to maintain a refugia is not appropriate for the control of some ectoparasite infestations, most notably sheep scab.

4.5.3 Strict quarantine should be implemented for new animals before they join the main flock and treatments integrated into the SCOPS endoparasite recommendations.

4.5.4 Basic, clear advice should be prepared and issued to enable farmers to understand the role of the various products, including the use of MLs as prophylactics v. treatments. Advice must stress the importance of prevention being the key to a good flock health plan. It must also stress the importance of having professional advice in the decision making process.

4.5.5 An integrated approach to parasite control must be adopted by sheep keepers. Guidance needs to include an explanation of the implications of resistance and principles for sustainable control of all parasites. The knock-on effects of using different products for different parasites must be illustrated so the importance of an integrated approach is successfully communicated in order to encourage a more sustainable approach to parasite control for the future benefit of the sheep sector. Sheep keepers must be encouraged to plan with advice from appropriately qualified advisors, and adopt a proactive flock-health planning approach.
Appendix 1 – Attendance List

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
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</thead>
<tbody>
<tr>
<td>Tony Andrews</td>
<td>Vet Consultant</td>
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<tr>
<td>Peter Bates</td>
<td>VLA</td>
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<tr>
<td>Susan Corning</td>
<td>Fort Dodge</td>
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<tr>
<td>Christine Elmer</td>
<td>Defra</td>
</tr>
<tr>
<td>Andy Forbes</td>
<td>Merial/NOAH</td>
</tr>
<tr>
<td>Paul Gayford</td>
<td>Defra</td>
</tr>
<tr>
<td>John Gilleard</td>
<td>Glasgow Vet School</td>
</tr>
<tr>
<td>Margaret Griffiths</td>
<td>Welsh Assembly</td>
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<tr>
<td>Brian Hosie</td>
<td>SAC</td>
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<td>Vicky Jackson</td>
<td>CSL</td>
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<td>Jack Kay</td>
<td>VMD</td>
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<tr>
<td>Nick Leach-Bing</td>
<td>Pfizer</td>
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