BLOWFLY INSECTICIDE RESISTANCE
RESEARCH RESULTS AND ADVICE FOR WOOLGROWERS

KEY POINTS
- Results from a recently completed collaborative AWI project with the NSW Department of Primary Industries (NSW DPI) demonstrated that the number of samples found to be dicyclanil or cyromazine resistant had increased from the survey last done in 2013.
- If woolgrowers already have resistance on their property, this could result in shorter periods of protection than what they could normally expect, rather than a complete loss of effectiveness.
- With the warm summer months upon us, the risk of flystrike is increased, so it is more critical than ever that all woolgrowers continue to closely monitor their flocks and consider modifying their flystrike management program if they have outbreaks that are difficult to manage and control.

With woolgrowers relying less on mulesing for flystrike control, it is increasingly important for them to achieve good results from chemical treatments. This requires strict adherence to label instructions to ensure the correct dose rate is used, application equipment is working properly, and flystrike control products are carefully applied to all at-risk sheep.

Flystrike control products are carefully tested for efficacy and to justify label claims before they are registered. If treatments are applied strictly according to the label instructions, all products should give the protection periods listed on the label. However, there is one ‘fly in the ointment’: the occurrence of resistance in sheep blowfly populations.

There is a long history of resistance to flystrike control chemicals, including organochlorine compounds, organophosphates, carbamates and to benzoyl phenyl urea growth regulators. Long term use and over reliance on a particular chemical group for any type of pest control almost inevitably results in resistance if good resistance management programs aren’t put in place. In the case of sheep blowflies, resistance results in reduced periods of protection from preventative treatments and, in the case of flystrike treatment products, reduced efficacy in killing maggots.

While there are several different flystrike treatments available, an AWI-funded survey in 2019 of wool grower parasite control practices showed that 64% of respondents nationally used flystrike treatments containing either cyromazine or dicyclanil.

Of Merino producers, 7.2% expressed concerns that some products may not be working as well as previously thought, with the highest concerns in Central NSW where 11.3% suspected the presence of resistance. In addition, a previous study as far back as 2001 indicated the existence of low-level resistance to cyromazine in a number of flocks.

A more recent study of resistance (completed in 2020) has been carried out by AWI in partnership with NSW DPI. Woolgrowers from throughout Australia were asked to send samples of maggots collected from struck sheep to the NSW DPI Elizabeth...
However, the study does seem to confirm the estimate of the prevalence of resistance. The results should not be interpreted as an all-encompassing representation of the resistance status in the region. Therefore, random selection of strains is recommended.

It should be noted that these samples came from properties with a history of either cyromazine or dicyclanil use. Of the submitted samples, 100 yielded live *Lucilia cuprina* flies that provided viable larvae for resistance testing.

The results from the resistance survey (see Table 1) suggested a high prevalence of dicyclanil (and cyromazine) resistance in NSW, with all strains tested resistant to both dicyclanil and cyromazine, and no susceptible strains were found. There was also a relatively high level of resistance in Victoria although one susceptible strain and one strain with resistance to cyromazine, but not to dicyclanil, was found. Dicyclanil-resistant strains were also found in both WA and SA, but at lower percentages than in NSW. Resistance has been maintained in these strains for many years and has stabilised in the population. When organophosphates have been withdrawn from use as preventative treatments, because of occupational health and safety concerns, any impact of resistance is probably minor and only on the efficacy of blowfly dressings in killing blowfly larvae.

**DIAZINON**
With diazinon, resistance in sheep blowflies has been well known for many years and has stabilised in the population. As organophosphates have now been withdrawn from use as preventative treatments, because of occupational health and safety concerns, any impact of resistance is probably minor and only on the efficacy of blowfly dressings in killing blowfly larvae.

**IVERMECTIN AND SPINOSAD**
With ivermectin and spinosad, results suggested that there was no functional fly resistance present to either chemical.

**IMIDACLOPRID**
With imidacloprid, results suggested that there was no functional fly resistance present to either chemical.

These results underline the importance of having a good resistance management plan in place for ALL chemical products and, in particular, where chemicals from the same chemical group are also used to control other parasites.

**EFFECT OF RESISTANCE ON PERIODS OF PROTECTION FROM PREVENTATIVE TREATMENTS**
To assess the effect of resistance on field protection, the researchers used an implant trial to test the length of protection against two field-derived strains, a cyromazine- and dicyclanil-susceptible strain and a dicyclanil- and cyromazine-resistant strain whose resistance level was maintained by laboratory selection with dicyclanil. Groups of six sheep were exposed to blowfly larvae under a “high fly pressure” scenario, after treatment with the following products:

- Three dicyclanil spray products:
  - (a) 12.5 g/L dicyclanil (CLiKZiN™ Spray-On)
  - (b) 50 g/L dicyclanil (CLI™ Spray-On)
  - (c) 65 g/L dicyclanil (CLiKExtra™ Spray-On)

- A cyromazine jetting fluid: 500 g/L cyromazine (Vetrazin™ Liquid); and

- An ivermectin-based jetting fluid: 16.0 g/L ivermectin (Coopers Blowfly and Lice™)

These results (see Table 2) show that with the dicyclanil and cyromazine products, the protection periods against the susceptible strain larvae were at least equal to the label claims in all instances. However, the resistant strain protection periods were less than half the period of the label claims. With the ivermectin-based product, although it appeared that there may have also been some reduction in the protection provided, resistance was not indicated in the resistance assays. As the implant trial represents a preliminary shift towards resistance in some flocks. This was most likely due to exposure of sheep blowflies to lice control treatments as imidacloprid has only relatively recently been registered for flystrike control and is not presently widely used in the industry for this purpose. There is no evidence at this stage that there has been any effect on efficacy for flystrike control.

Macarthur Agricultural Institute for testing.

**INSECTICIDE RESISTANCE SURVEY RESULTS**

**CYROMAZINE AND DICYCLANIL**
Blowfly maggot samples were received from woolgrowers in most states and the majority of these samples came from properties with a history of either cyromazine or dicyclanil use. Of the submitted samples, 100 yielded live *Lucilia cuprina* flies that provided viable larvae for resistance testing.

The results from the resistance survey (see Table 1) suggested a high prevalence of dicyclanil (and cyromazine) resistance in NSW, with all strains tested resistant to both dicyclanil and cyromazine, and no susceptible strains were found. There was also a relatively high level of resistance in Victoria although one susceptible strain and one strain with resistance to cyromazine, but not to dicyclanil, was found. Dicyclanil-resistant strains were also found in both WA and SA, but at lower percentages than in NSW. Resistance has been maintained in these strains for many years and has stabilised in the population. As organophosphates have now been withdrawn from use as preventative treatments, because of occupational health and safety concerns, any impact of resistance is probably minor and only on the efficacy of blowfly dressings in killing blowfly larvae.

**Table 2: Efficacy of protection**

<table>
<thead>
<tr>
<th>CHEMICAL</th>
<th>CONCENTRATION OF ACTIVE</th>
<th>APPLICATION METHOD</th>
<th>LABEL CLAIMED PERIOD OF PROTECTION</th>
<th>PERIOD OF PROTECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dicyclanil</td>
<td>12.5 g/L</td>
<td>Spray-on</td>
<td>Up to 11 weeks</td>
<td>&gt;11 weeks</td>
</tr>
<tr>
<td>-</td>
<td>50 g/L</td>
<td>Spray-on</td>
<td>18-24 weeks</td>
<td>&lt; 3 weeks</td>
</tr>
<tr>
<td>-</td>
<td>65 g/L</td>
<td>Spray-on</td>
<td>Up to 29 weeks</td>
<td>&gt;25 weeks</td>
</tr>
<tr>
<td>Cyromazine</td>
<td>500 g/L</td>
<td>Jetting</td>
<td>Up to 14 weeks</td>
<td>&gt;15 weeks</td>
</tr>
<tr>
<td>Ivermectin</td>
<td>16.0 g/L</td>
<td>Jetting</td>
<td>Up to 12 weeks</td>
<td>&gt;12 weeks</td>
</tr>
<tr>
<td>Control (no treatment)</td>
<td>Nil</td>
<td>N.A.</td>
<td>N.A.</td>
<td>0</td>
</tr>
</tbody>
</table>

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Table 1: Survey samples and results: cyromazine or dicyclanil

<table>
<thead>
<tr>
<th>STATE</th>
<th>SAMPLES TESTED</th>
<th>% SUSCEPTIBLE</th>
<th>% RESISTANT TO CYROMAZINE</th>
<th>% RESISTANT TO BOTH CYROMAZINE &amp; DICYCLANIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSW</td>
<td>55</td>
<td>0</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>WA</td>
<td>21</td>
<td>24</td>
<td>76</td>
<td>28</td>
</tr>
<tr>
<td>SA</td>
<td>12</td>
<td>42</td>
<td>58</td>
<td>25</td>
</tr>
<tr>
<td>Vic</td>
<td>11</td>
<td>9</td>
<td>91</td>
<td>82</td>
</tr>
<tr>
<td>Tas</td>
<td>1</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Overall</td>
<td>100</td>
<td>12</td>
<td>88</td>
<td>73</td>
</tr>
</tbody>
</table>

These results underline the importance of having a good resistance management plan in place for ALL chemical products and, in particular, where chemicals from the same chemical group are also used to control other parasites.
HOW DOES THIS CHANGE MY BLOWFLY CONTROL PROGRAM?

Not very much if you are following the resistance management rules,” said NSW DPI researcher, Narelle Sales. “If you have resistance on your property and you are applying the chemical correctly, this doesn’t mean that the products have totally lost effectiveness, it just means that the period of protection may be less than what you have previously expected – and the degree to which the protection period has been shortened may vary between properties.”

When shortened protection periods are noticed, often this is due to poor application or failure to follow label instructions, so the first thing is to check the label and check your application method.

Resistance is not the end of the road for flystrike control, but it is important to recognise when it is present and manage your flystrike program accordingly.”

Narelle Sales, NSW DPI

However, it is more critical than ever to keep a close eye on your flocks, especially with the current Eastern Australian seasonal conditions and a predicted La Nina likely to produce ideal, warm, wet conditions for flies during the high-risk summer/early autumn period.

Close monitoring will allow you to detect strikes quickly if protection starts to break down earlier than expected. In situations where only a few sheep are becoming struck, it will be enough to treat individual strikes as they occur. In other cases, particularly if it is only part way through the flystrike season, it may be necessary to apply an extra flock treatment.

Even on properties where there is currently no resistance, the resistance management rules are the same. Producers should follow the below eight-step insecticide resistance strategy (outlined in more detail on the opposite page), which was developed by AWI’s Sheep Blowfly Resistance Management Strategy Working Group:

1. Use an integrated approach to reduce reliance on insecticides.
2. Know your chemical groups.
3. Rotate chemical groups where practical.
4. Minimise the number of treatments applied in a season.
5. Consider treatments for other parasites, particularly lice treatments.
6. Apply insecticides carefully and strictly as specified on the label.
7. Monitor for flystrike frequently.
8. Collect and kill all maggots from flystruck sheep.

FLYSTRIKE RESISTANCE TESTING AVAILABLE

NSW DPI is currently offering sheep blowfly insecticide resistance testing to woolgrowers.

For details, contact Narelle Sales via email at narelle.sales@dpi.nsw.gov.au or phone (02) 6640 6446.
## Insecticide Resistance Strategy to Maximise Flystrike Control

1. **Use an Integrated Approach to Reduce Reliance on Insecticides**
   - Breed for resistance to all types of flystrike: poll, pizzle, body and breech (breeding for polled animals; low wrinkle, cover; urine stain, dags; and white wool colour. Cull struck sheep).
   - Shear or crutch at times that maximise protection against flystrike.
   - Dock tails to the correct length.
   - Manage sheep to minimise scouring.
   - Use breech modification if required, until sheep are genetically resistant to flystrike.
   - Use chemicals sparingly.
   - Where the above approaches are insufficient, mules with pain relief.

2. **Know Your Chemical Groups**
   - Insecticides used for flystrike control fall into different groups or chemical families; see Table 3 below.
   - Flies resistant to one insecticide in a particular chemical group are likely to be resistant to other insecticides in the same group.
   - Different flystrike products may contain the same chemical or a related chemical from the same chemical group. When looking for alternatives, change to a different chemical group, don’t just change insecticide brands.
   - Use chemicals sparingly.
   - Where the above approaches are insufficient, mules with pain relief.

3. **Rotate Chemical Groups Where Practical**
   - Insecticide choice should be tailored to your particular location and management.
   - Consider rotating insecticide products from different chemical groups to slow the development of resistance.
   - Use a different chemical group for treating struck sheep to that used for flystrike prevention.
   - Successive treatments within the fly season should generally be different chemical groups.
   - Choose a product with the appropriate protection period and time of application.
   - A product that provides a shorter period of protection may be sufficient in some instances. For example, when sale of sheep or lambs for slaughter is imminent, sheep are soon to be crutched or shorn, or when close monitoring of sheep is not possible for a short period because of other farm tasks or holidays.
   - The FlyBoss Fly and Lice Products Tool can help you select a chemical group that will provide the length of protection that is required.

4. **Minimise the Number of Insecticide Treatments Applied in a Season**
   - Optimise the timing of treatment to provide full protection during high risk periods.
   - Utilise other management strategies, such as shearing and crutching, to minimise the length of time flies may be exposed to inadequate levels of insecticides on the sheep. However, ensure that you abide by wool harvesting intervals so that there are no unacceptable chemical residues in the wool.

5. **Consider Treatments for Other Parasites, Particularly Lice Treatments**
   - Exposure to insecticides used for treatment of other parasites (particularly lice) can contribute to resistance selection in blowflies, and vice versa.
   - Where possible, use a different chemical group to treat flies and lice.
   - Aim to eradicate lice and avoid the need for lice treatments.

6. **Apply Insecticides Carefully and Strictly as Specified on the Label**
   - Shorter protection periods are often due to poor application, not resistance. Be sure to apply insecticides carefully according to the label instructions.
   - Poor application can expose flies to sub-lethal levels of insecticides; this can contribute to an increase in resistance.

7. **Monitor for Flystrike Frequently**
   - Check every 2–3 days during high risk periods to identify struck sheep early.
   - Treat sheep and kill maggots before they become larger and are harder to kill.
   - Record when strike occurs in relation to preventive treatments.
   - Notify the product manufacturer if you suspect resistance.

8. **Collect and Kill All Maggots from Fly Struck Sheep**
   - Place maggots and shorn wool into a sealed plastic bag and leave in the sun so the maggots are killed.
   - If maggots are not collected or destroyed the most resistant ones can burrow into the soil, complete development and contribute to the next generation of flies.

### Table 3. Chemical groups and actives available for flystrike control and their application methods

<table>
<thead>
<tr>
<th>Chemical Group</th>
<th>Chemical Active</th>
<th>Application Method&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insect Growth Regulator (IGR)</td>
<td>Cyromazine &lt;sup&gt;2&lt;/sup&gt;</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Dicyclanil</td>
<td>Yes</td>
</tr>
<tr>
<td>Neonicotinoid</td>
<td>Imidacloprid</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Spinosyn</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Ivermectin</td>
<td>No</td>
</tr>
<tr>
<td>Macrocyclic</td>
<td>Spinosad</td>
<td>No</td>
</tr>
<tr>
<td>Lactone (ML)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synthetic Pyrethroid (SP)</td>
<td>Alpha-cypermethrin&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Yes</td>
</tr>
<tr>
<td>Organophosphate (OP)</td>
<td>Diazinon, Propetamphos &amp; Chlorfenavinphos</td>
<td>No</td>
</tr>
</tbody>
</table>

<sup>1</sup> Always follow label directions  
<sup>2</sup> Registered for prevention of body strike only