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WORM CONTROL PROGRAM

Summer rainfall/tablelands and slopes

A regional worm control program from WormBoss

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WORMBOSS WORM CONTROL PROGRAM

Summer rainfall/tablelands and slopes

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Each regional 'WormBoss worm control program' has been developed from local research results and experience proven to be relevant and successful for most farms in the region. ParaBoss acknowledges that this is not the only method of worm control in the region and more refined programs can be developed in consultation with your worm management adviser/veterinarian using information and knowledge specific to your property and sheep.

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Program summary

The WormBoss worm control program for the summer rainfall/tablelands and slopes region has five components that are most effective when used in combination.

A summary of the components is below (see further chapters for details).

1. **Use grazing management to create low worm-risk paddocks**
   - Prepare spring lambing paddocks by preventing contamination with worm larvae in the 6 months prior to lambing:
     - March and April: spell paddocks, graze with cattle or graze with sheep for up to 21 days after the protection period (when it is killing worms) of an effective drench[1].
     - May–August: no grazing restrictions apply when maximum daytime temperatures are consistently below 18°C, if they are not then use the same strategy as for March and April.
   - Prepare summer weaning paddocks by preventing contamination with worm larvae in the 3 months prior to weaning:
     - Spell paddocks, graze with cattle or graze with sheep for up to 21 days after the protection period (when it is killing worms) of an effective drench[1].
2. **Breed and feed for worm-resistant sheep**
   - Use rams with better than average worm egg count (WEC ASBVs[2]); choose the more negative values.
   - Maintain good nutrition to enhance the sheep's immunity to worms.
3. ***WormTest* at recommended times**
   - *WormTest* before these routine opportunities to drench:
     - Pre-shearing.
     - Pre-lamb marking (ewes).
     - Pre-weaning (ewes).
   - Weaning to shearing: *WormTest* at 4–6 week (summer) or 6–8 week (winter) intervals after a short-acting drench. If using a persistent drench then see 'Effective use of long-acting drenches'.
   - ***And at other non-routine times as described in the Drench Decision Guide.***
4. **Drench[3] or use Barbervax® at recommended times**
   - If using Barbervax, follow the prescribed program (see 'When to *WormTest* and when to drench or use Barbervax®')
   - Drench breeding ewes pre-lambing (as they temporarily lose their immunity).
   - Drench lambs at weaning.
   - Drench all introduced sheep with a combination of no less than 4 unrelated drench groups with at least one of these being the newest drench actives: monepantel (Zolvix®) or derquantel (with abamectin—Startect®)[4].
   - Drench individual sheep showing obvious signs of worm-related illness and *WormTest* the mob.
   - At other times, use the *Drench Decision Guide* to make drenching decisions.
5. **Manage drench resistance**
   - Conduct *DrenchTests* every 2–3 years. Use *DrenchCheck-Day10s between DrenchTests*.
   - Avoid unnecessary drenching.
   - Use effective drenches and multi-active[4] combinations where possible.
   - Use short-acting treatments. Reserve long-acting products for specific purposes or high worm-risk times.
   - Rotate among all effective drench groups[4] for each mob (and each paddock where possible).
   - Calibrate your drench guns, dose to the heaviest sheep and follow label instructions.
   - Use of Barbervax® vaccination should slow the rate of development of drench resistance.

[1] *This drench must be tested and shown to be highly effective on your property*
[2] *ASBVs=Australian Sheep Breeding Values.*
[3] *Drench refers to anthelmintics regardless of route of administration.*
[4] *Drench groups are the chemical family to which an 'active' belongs. An 'active' is the chemical in a drench responsible for killing worms. Some drenches contain more than one active and are called 'multi-active' or 'combination' drenches. See Appendix 6: Drench groups and actives.*

This is an up-to-date, integrated regional worm control program for sheep in the summer rainfall/tablelands and slopes region of New South Wales and southern Queensland. It builds upon earlier programs (including from the state departments of primary industries: NSW DPI and Qld DAFF) and accumulated knowledge, as well as new information from the Integrated Parasite Management in Sheep project, funded by Australian Wool Innovation and the Sheep CRC.

The program aims to improve the profitability and welfare of your sheep through:

- fewer deaths and illness from worms
- fewer drenches, particularly long-acting drenches
- improved productivity
- prolonged life of drenches

For more information go to the WormBoss web site: www.wormboss.com.au

Where is the summer rainfall/tablelands and slopes region?

This region has summer-dominant rainfall and cold winters west of the Great Dividing Range, but is warmer in the coastal areas. It covers the Northern Tablelands of NSW extending from Stanthorpe in Queensland to Mudgee in NSW, as well as the NSW coast and hinterland from Sydney to the Queensland border.

The southern edge starts from Sydney and extends north-west through Mudgee and Gulgong to Gilgandra. It then goes west of Coonabarabran, through Narrabri and Texas, then south of Warwick and then along the New South Wales/Queensland border to the coast.

This corresponds with the WormKill (NSW DPI) and Wormbuster (Qld DAFF) regions.

Towns included in this region are Mudgee, Dunedoo, Merriwa, Coolah, Tamworth, Coonabarabran, Narrabri, Gunnedah, Manilla, Barraba, Bingara, Bundarra, Inverell, Warialda, Walcha, Bendemeer, Uralla, Armidale, Guyra, Glen Innes, Tenterfield, Texas and Stanthorpe. Coastal towns included are Murwillumbah, Lismore, Grafton, Coffs Harbour, Port Macquarie, Muswellbrook, Maitland and their hinterland areas.

These boundaries are approximations only as seasonal temperature and rainfall variations affect worms.

A map of the region is shown on the next page.

What worms are covered in this program?

Roundworms

The most important roundworms in this region:

- Barber's pole worm — *Haemonchus contortus*
- Scour worms
  - Black scour worm — *Trichostrongylus colubriformis*
  - Small brown stomach worm — *Teladorsagia* (*Ostertagia*) *circumcincta*
  - Thin-necked intestinal worm — *Nematodirus* species (in young sheep)

Less important or only occasionally seen worms:

- Large bowel worm — *Oesophagostomum venulosum*
- Small intestinal worm — *Cooperia* species
- Black scour worm — *Trichostrongylus vitrinus*

Liver fluke

Liver fluke is an internal parasite that occurs in parts of this region depending on the distribution of the intermediate host snail. It can affect sheep severely, sometimes causing deaths.

The life cycle differs from the simple lifecycle of roundworms, so control strategies are different.

This program relates to roundworms. To control liver fluke, see Appendix 1: Liver fluke control.

Other worms

Gastro-intestinal parasites of minor importance, such as stomach fluke and tapeworm, are not covered.

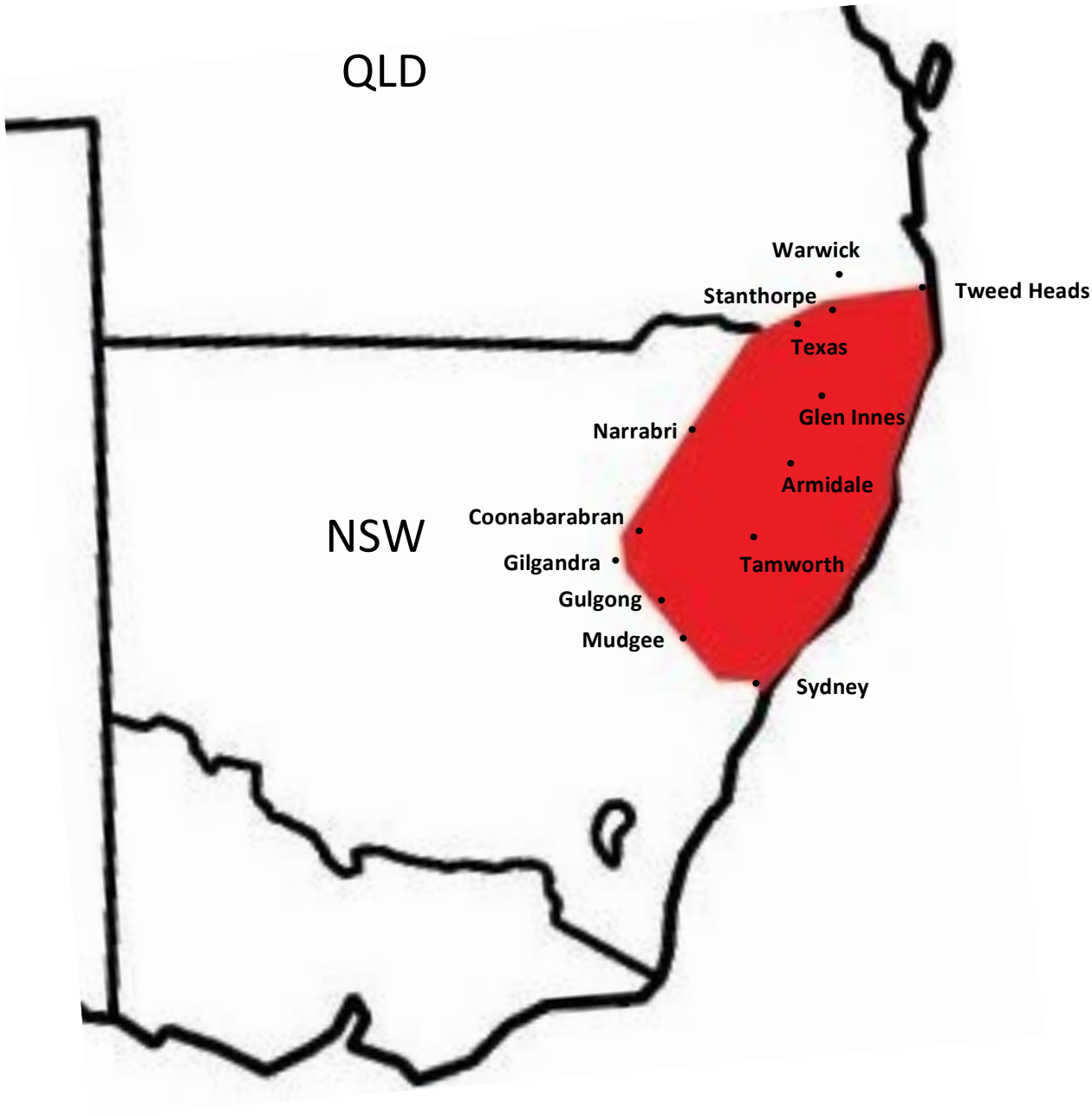


Figure 1. The summer rainfall/tablelands and slopes region.

Grazing management

Effective grazing management reduces the exposure of sheep to worms. There are three methods:

- Avoid paddocks heavily contaminated with worm larvae.
- Reduce contamination of paddocks with worm eggs.
- Allow time for most of the eggs and larvae on the pasture to die.

The last two are used to prepare 'low worm-risk' paddocks for lambing ewes and weaners.

How are low worm-risk lambing and weaning paddocks prepared?

Ewes temporarily lose some of their immunity to worms at and after lambing. As a result, they contribute greatly to the seasonal increase in worm numbers and subsequent infection of lambs.

Weaners are also highly susceptible to worms. Low worm-risk weaning paddocks give weaners a good start so they can build immunity without suffering high initial infections.

To prepare a low worm-risk spring lambing paddock (September/October lambing):

March and April: Prevent contamination with sheep worm eggs by spelling these paddocks, grazing with cattle or grazing with sheep for up to 21 days after the protection period[1] of a drench proven effective on your property.

May, June, July and August: In some areas (e.g. tablelands), any stock including sheep can be grazed because it is consistently cold enough (mean daily maximum temperatures below 18°C) to almost stop the life cycle of the major roundworms (barber's pole worm and black scour worm*). In warmer areas use the 'March–April' strategy in those months where mean daily maximum temperatures are above 18°C.

Where sheep are referred to, include goats and alpacas, as they can carry sheep worms.

*Some development of black scour worms may occur until maximum temperatures fall below 15°C, but in this region barber's pole worm control is the more important consideration.

To find out more see: Appendix 2: Roundworm life cycle and larvae survival, Appendix 3: Factors contributing to paddock contamination with worms and Appendix 4: 'Find your cold period'

An alternative method of lambing paddock preparation is 'Smart-Grazing'. See Appendix 5: Preparing lambing paddocks with 'Smart Grazing—summer rainfall'.

What if lambing is at another time?

Prevent contamination of the lambing paddock in the 6 months before the ewes enter the paddock. (For early autumn lambing, only 3 months preparation is required as larvae die faster in the preceding hotter months). During this 6-month period, sheep can be grazed on the lambing paddocks in months when mean daily maximum temperatures are below 18°C.

For the rest of the 6-month preparation period, the lambing paddock should be grazed by sheep for up to 21 days after the protection period[1] of a drench known to be effective on your property.

To prepare a low worm-risk summer weaning paddock:

In late spring and summer, larvae on pasture die faster than in the cooler months, so preparation of weaning paddocks takes about half the time required for spring lambing paddocks.

In the 3 months prior to weaning: Prevent contamination with sheep worm eggs by spelling these paddocks, grazing with cattle (especially to stop pasture from becoming rank) or grazing with sheep up to 21 days after the protection period[1] of a drench known (from a *DrenchTest*) to be effective on your property.

Other ways to prepare low worm-risk paddocks:

Rotational grazing with short graze periods alternated with rest periods can greatly reduce the number of worm larvae on pasture, especially barber's pole worm. While these systems (e.g. planned grazing, cell grazing, techno-grazing and intensive rotational grazing) are outside the scope of this publication, they use the principles found in Appendix 3: Factors contributing to paddock contamination with worms.

[1]*The protection period of a drench is when it is killing worms: 1–2 days for short-acting drenches, weeks or months for persistent products.*

Breeding worm-resistant sheep

Genetic selection can be used to increase a sheep's resistance and resilience to worms. Resistance can result in fewer drenches being required each year and resilient sheep can better tolerate worms. The best way to increase the genetic resistance of your flock to worms is to use rams with better than average worm resistance. Currently, there are no commercially available tests to select for resilience.

What is the difference between resistance and resilience?

Resistance to worms

Sheep that are resistant to worms can prevent some or all worms from establishing and as a result have lower worm egg counts.

Resilience to worms

Sheep that are resilient to worms can grow and produce with less ill effects from worms. An animal's performance for a particular trait, such as growth, will also be dictated by its genetic merit for that trait. So, when comparing two animals with similar Australian Sheep Breeding Values (ASBVs) for growth, a more resilient animal will perform better than a less resilient animal when both have high worm burdens. It is independent of worm resistance so must be selected separately by choosing better production performance.

Drench resistance

Drench resistance is the ability of a worm to resist the effects of a drench. Note that drench resistance is a characteristic of the worm and differs from a sheep's resilience and resistance to worms.

Dag or Scouring

The propensity to scour has a substantial genetic component that is independent of both resistance and resilience to worms. To reduce dag/scouring select for low dag score and or low moisture levels in faeces independently to selection for low worm egg count.

How can a ram be selected for worm resistance?

1. Choose a stud that provides Australian Sheep Breeding Values for worm egg counts (WEC ASBV) and dag (DAG ASBV). Include selection against dag only where scouring is an issue.
    - Raw WEC values alone are not reliable enough to use in selection as they do not account for environmental differences or pedigree data (which are included in WEC ASBVs).
2. Ensure that selection for worm resistance and dag is balanced with other performance traits.
    - Select better than average WEC and DAG ASBV, i.e. choose the more negative values for both traits.
    - At the same time, select better than average ASBVs for performance traits that are important to you. A compromise regarding the various traits will be required.

    Note: When extra traits are included in a selection program, the progress that can be made with each individual trait will decrease slightly, however progress with your breeding objective can still be high.
3. Choose the WEC ASBV age that corresponds to the time of most worm-challenge on your property, e.g. weaning (WWEC), post-weaning (PWEC), yearling (YWEC).

What are Australian Sheep Breeding Values?

ASBVs are an estimate of an animal's genetic merit rather than its visual or phenotypic merit. The effects of factors such as birth type, dam age, nutrition and management are removed to reveal an animal's genetic breeding value: what can be passed onto its progeny. ASBVs are calculated and reported by Sheep Genetics, the national genetic analysis service for the sheep industry. Ram breeders who are members of MERINOSELECT or LAMBPLAN will have WEC ASBVs available for their sheep if they are measuring WEC.

For more detailed information on using Australian Sheep Breeding Values, go to the Sheep Genetics website: www.sheepgenetics.org.au.

When to *WormTest* and when to drench

Why check worm burdens in sheep?

Checking worm burdens with a *WormTest* is essential for correct and timely drenching decisions. The result is healthy sheep without unnecessary drenching. *WormTests* are the best basis for drenching decisions outside of recommended times. Pale skin and eyes, bottle-jaw, weight loss, a tail in the mob, and deaths may mean that your sheep need drenching. If so, these signs occur well after production losses from worms are already occurring in the mob. *WormTests* give early warning of significant production losses.

How are worm burdens tested?

Checking worm burdens throughout the year using *WormTest*s is a critical part of the WormBoss worm control program.

Most *WormTests* are done through a laboratory. However, worm egg counts (but usually not larval cultures) can be done by producers if they have the equipment and skills.

Which mobs and how many should have a *WormTest*?

WormTest at least one in every three mobs that are similar regarding drenching history, paddock type and class of sheep.

Testing representative mobs saves the cost of testing all mobs. But this assumes the mobs, their paddocks and drenching history are very similar. If in doubt, test additional mobs.

When should *WormTests,* drenches and Barbervax® vaccination be routinely done?

The Barbervax® program is an optional strategy to control barber's pole worm; it will not control other worms. Routine drenching (pre-lambing for breeding ewes and weaning for lambs) and routine *WormTest* times will still apply, however non-routine drenching will be reduced when Barbervax is used correctly. Protection against barber's pole worms requires three initial 'primer' vaccinations at 3–4 week intervals. In the next year of use, one priming vaccination will provide protection from 5 days later. A vaccination schedule can be customised by a professional advisor.

Table 1. Routine Barbervax vaccination times

Lambs or hoggets not previously vaccinated	***Hoggets vaccinated as lambs the previous year***
• V1: lambs at lamb marking; hoggets during October. • V2: 3–4 weeks after V1. • V3: 3–4 weeks after V2. • V4—V6: after V3, give at 6-weekly intervals while protection is required.	• V1: Give in November/December (earlier if spring is wet) • V2–V5: after V1, give at 6-weekly intervals while protection is required.
Breeding ewes not previously vaccinated (assumes a spring lambing)	***Breeding ewes vaccinated the previous year***
• V1: 8–9 weeks pre-lambing. • V2: 4–5 weeks pre-lambing. • V3: 1–2 weeks pre-lambing. • V4: lamb marking. • V5 onwards: after V4, give at 6-weekly intervals while protection is required.	• V1: 1–2 weeks pre-lambing, with an effective pre-lambing drench (for scour worms and early barber's pole worm) and move ewes to a low worm-risk lambing paddock prepared in previous 6 months. • V2: lamb marking. • V3—V6: after V2, give at 6-weekly intervals while protection is required.

Note: V=vaccination, the number (1–6) refers to first, second (and so on) vaccination in the series given in one barber's pole worm season.
It is also important to follow the routine drench and WormTest times shown below.

Ideally, a mob WormTest should be done 4–5 weeks after an effective (i.e. not priming doses) vaccination, from the third vaccination onwards, so that the result is known before the next vaccine muster.

Routine drenching times

In this region there are two situations where sheep should be drenched without a prior *WormTest*, these are:

- Pregnant ewes just prior to lambing when they enter their lambing paddock.
  The worm challenge is typically about to rise at this time of year and lambing ewes, which experience a temporary loss of immunity during lactation, can contribute to a large increase in paddock contamination and a source of ongoing infection for themselves and their lambs.
- Lambs at weaning.
  Weaned lambs are highly susceptible to worms, especially from the stress of weaning. Summer weaning also coincides with high worm-risk weather conditions. Drenching at weaning will help weaners to achieve the growth rates needed for survival.

In both cases, use a drench known to be effective on your property. Preferably, use a short-acting treatment, and where possible, use a multi-active combination. After these drenches, move the sheep into prepared low worm-risk paddocks.

Note: An 'active' is the specific chemical in a drench responsible for killing worms. Some drenches contain more than one active and are called 'multi-active' or 'combination' drenches. See Appendix 6: Drench groups and actives.

Routine *WormTest* times

WormTests can be done at any time; however there are certain routine times to *WormTest* (preferably with a larval culture):

- Pre-shearing.
- Pre-lamb marking for ewes. (Generally, there is no benefit from drenching lambs at lamb-marking, however, if a *WormTest* indicates that the ewes need drenching, the lambs should also be drenched).
- Pre-weaning for ewes. (Not for lambs as they will be drenched at weaning).
- From weaning time, *WormTest* all mobs at 4–6 week (summer) or 6–8 week (winter) intervals after they have been given a short-acting drench. If a persistent drench is given, use the *Drench Decision Guide* to decide when a *WormTest* should be done.

When are other *WormTests* done and drenches given?

The timing of *WormTests* and drenches will vary between farms and seasons. Use the *Drench Decision Guide* (see below) to weigh up important factors when deciding when to drench or *WormTest* on your property. These factors are signs of worms, time since last drench, the persistence of the last drench, *WormTest* results, recent rainfall, and condition of sheep and pastures.

If drenching is done for other reasons (such as an early drench before holidays or harvesting), recommence *WormTests* 4–6 weeks (summer) or 6–8 weeks (winter) after the drench was given. Then use the *Drench Decision Guide* to decide when to drench or *WormTest* again.

What samples should be collected for *WormTests*?

Sheep do not need to be yarded for a *WormTest.* Collect fresh dung from the paddock. Obtain *WormTest* kits or sample collection details from laboratories or resellers in your area. Follow the instructions provided in the kit.

- Avoid delays in transit (when worm eggs can hatch) by collecting and posting early in the week.
- Ensure samples are kept cool, but not refrigerated, before sending.

If you do your own worm egg counts, use the 'bulk' sampling method where all of the dung is collected into one container.

- Collect 3 pellets per pile of dung from at least 20 individual piles of fresh dung.
  - In barber's pole worm areas collect from 40 piles of dung if the mob has over 200 sheep.
  - Choose pellets of equal size so that each sheep is equally represented.
  - If dung consistency is runny, use a plastic spoon. Don't avoid runny or soft dung.
  - Collect lamb and ewe samples separately.

- Dung should be very thoroughly mixed together before preparing your solution for counting.
- Count 5 chambers from the sample.

The following fact sheet is on the WormBoss website: www.wormboss.com.au: 'Checking a mob of sheep for worms with a *WormTest*'.

The WormBoss *Drench Decision Guide*

The *Drench Decision Guide* is reliable and helps to simplify decisions. There is a version of the *Drench Decision Guide* for each WormBoss region.

The guides consider

- whether signs of worms are present
- the class of sheep
- the *WormTest* results
- the condition of the sheep
- the condition of the pasture
- the likely worm contamination of the paddock

The *Drench Decision Guide* will recommend

- whether to drench now
- whether to use a persistent drench
- when to *WormTest* again

Results from the *Drench Decision Guide* can be applied to mobs without a *WormTest* if other mobs (same class, and similar drenching and paddock histories) have been tested. If in doubt, *WormTest* the mob.

How to use the Drench Decision Guide

You can use the *Drench Decision Guide* at any time, whether you are contemplating drenching a mob now or in coming weeks. Not all situations require a *WormTest*: the *Drench Decision Guide* will recommend when these should be done.

1. Firstly, refer to the *Drench Decision Guide*, which is provided separately.
2. Start on the page that shows the '*Drench Decision Guide* Questions'.
3. Read Question 1.
4. Follow the 'go to' information on the right for the answer that applies to your mob.
5. Only go to the question or recommendation to which you are directed by your answer.
6. When you are directed to a letter, this is the final recommendation, and is shown on the next 'Recommendations' page.
7. Also read the important information in the green boxes.

The *Drench Decision Guide* is also available on the WormBoss web site (www.wormboss.com.au) where it is presented differently, so that you only see the questions and a recommendation relevant to your answers.

Managing drench resistance

Why manage drench resistance?

To stay profitable in the long-term, you will need to prolong the effective lives of old and new drench groups by using them well. (Drench groups are the 'chemical families' of drenches. Older groups can often be combined with newer groups to slow development of resistance).

Selection for drench resistance happens when worms in a sheep are exposed to a drench. Some worms can survive certain drench groups as they have genes for drench resistance. This may initially be just one worm in 100,000 or even 1,000,000 worms. Some worms present may be partly drench-resistant: they can survive lower (sub-lethal), but not full doses of the treatment.

Worms that survive treatment continue to produce eggs that give rise to infective larvae on a pasture. These are eaten by sheep and so the worm life cycle continues. In this way, each treatment causes an increase in the proportion of the worm population that is either partly or fully drench-resistant.

If resistance to a drench group is already present, it will likely remain, even if the drench group is not used for years. Drench resistance probably cannot be prevented, but the rate at which it occurs can be greatly reduced.

The first step is to know what drenches are effective on your property.

How can the effectiveness of drenches be tested?

Each property has its own drench-resistance profile based on its own drenching history and that of properties from which sheep are sourced. The profile of neighbouring properties can be quite different.

The extent of resistance is only known by testing. Obvious worm control failures may only occur when resistance is quite advanced.

A *DrenchTest* is needed to accurately test for drench resistance. Do these tests every 2–3 years and test all drench groups.

A *DrenchCheck-Day10* is used to check individual drenches at any time. Regularly do *DrenchCheck-Day10s* between the times that full resistance tests (*DrenchTests*) are performed.

The *DrenchTest* (WECRT)

DrenchTest is the common name for the Worm Egg Count Reduction Test (WECRT). This assesses the drench-resistance status of worms on a property.

WormBoss recommends testing actives from all drench groups; from these results, resistance to the multi-active products can be calculated.

Select a mob for the *DrenchTest.* From this mob, a group of sheep is used for each drench and one group of sheep is left undrenched to act as a 'control' or comparison. Each of the groups is drenched (except the control group) and dung samples are collected from all of the sheep 10–14 days after the drench, for a *WormTest*.

The worm egg counts of each treatment group are compared with those of the undrenched control group. From this, the effectiveness of each drench against each worm type present is calculated.

Discuss the test with your adviser before setting up. For more details, including which drenches to test, see the fact sheet 'Testing drench effectiveness with a *DrenchTest*' on the WormBoss website: (www.wormboss.com.au).

The DrenchCheck-Day10

This simple and inexpensive test gives an indication of drench effectiveness and whether the drench should be properly investigated using a *DrenchTest*.

The *DrenchCheck-Day10* involves two *WormTests*: the first up to 10 days before drenching (usually at a routine *WormTest* time) and the second between 10 and 14 days after the drench.

The results from the two *WormTests* are compared to gauge the extent that worm egg counts have been reduced by the drench. Discuss the results with a worm control advisor.

For more detail see the fact sheet 'Checking for drench resistance with a *DrenchCheck-Day10'* on the WormBoss website (www.wormboss.com.au).

How can drench-resistant worms be kept out of your property?

Keeping drench-resistant worms out of your property is part of sustainable worm control.

Assume that purchased sheep are carrying worms with some degree of drench resistance to one or more drench groups (see Appendix 6: Drench groups and actives).

1. 'Quarantine' drench all sheep new to the property.
    - Use a combination of no less than 4 unrelated drench groups with at least one of these being monepantel (Zolvix®) or derquantel (with abamectin—Startect®). This can be done using multi-active (combination) and/or single-active products concurrently—up the race with one product, then up the race again with the next.
    - Do not mix different drenches unless the label states you can, as different products may be incompatible.
2. Quarantine the sheep after treatment.
    - Hold the sheep in quarantine in yards (small mobs) or a secure paddock (larger mobs) for at least 3 days to allow worm eggs present at the time of drenching to pass out of the gut.
    - Provide adequate feed and water.
    - Keep this paddock free of sheep, goats or alpacas for at least 3 months in summer or 6 months in cooler months.
3. After quarantine, release the sheep onto a paddock that is likely to be contaminated with worm larvae due to grazing by other sheep. This will 'dilute' (lower the proportion of) resistant worms surviving treatment with worm larvae already on your property.
4. *WormTest* the imported sheep 10–14 days after drenching for added confidence that treatment was successful.
5. Get expert advice on up-to-date recommendations for quarantine treatments. These will evolve as the drench resistance picture changes.

How can the development of drench resistance be slowed?

Choosing drenches

Integrate all 4 principles where possible:

1. *Use effective drenches:* these are known to reduce the worm egg count on your property by at least 98% as shown by a *DrenchTest*. The more effective a drench is, the fewer drench-resistant worms will remain in the sheep after treatment.
2. *Use a combination of two or more groups where possible,* as fewer worms are able to resist more than one group at a time.
3. *Use short-acting treatments where possible*, and restrict the use of persistent products for specific purposes and high worm-risk times of year. See page 12, 'How can persistent treatments be used effectively?' There is little need to use mid-length or long-acting treatments if sheep are being moved to low worm-risk paddocks.
4. *Rotate* among all effective drench groups each time a mob is drenched (and for each paddock where possible)*. An effective drench from a different group may kill worms that were resistant to the last treatment. These may be worms that survived treatment in the sheep or were picked up from the paddock.

*When rotating drenches the current drench ideally would include no groups that were used the previous time. However, in practice, ensure it has at least one effective active from a drench group that was not used the previous time.

Using drenches

Follow all 5 principles where possible:

1. *Avoid unnecessary drenching*, especially
    a. adults
    b. during droughts or prolonged dry periods
    c. immediately before or after moving sheep onto very clean, low worm-risk paddocks (such as ungrazed cereal stubbles or paddocks that have been sheep-free for extended periods). See points i) and ii) below for further discussion on this.
2. *Calibrate drench guns* to ensure the correct dose is delivered.
3. *Calculate the dose based on the heaviest animals in the mob.* Split mobs for drenching if there is a large weight range, so sheep are not under-dosed.
4. *Follow the label instructions* to ensure correct dose and use of treatments (including complying with withholding periods).
5. *After sheep have been drenched, graze them initially on paddocks already contaminated with worms likely to be less resistant to drenches* (except in the cases of lambing and weaning paddocks that specifically need to be low worm-risk). Eggs from surviving drench-resistant worms will be diluted by eggs and larvae already on the paddock and therefore not exposed to the drench (i.e. 'in refugia').

If sheep must be drenched onto low worm-risk paddocks do both of the following:

i. When the sheep eventually leave these low worm-risk paddocks, treat them with an effective drench that is from a different group to the drench used when the sheep first went onto the paddock. The aim is to remove any drench-resistant worms surviving in the sheep after the first drench.

ii. Ensure that the next time the paddock is grazed it is with a different mob of sheep. This second mob should have a moderate to high worm burden and their last treatment must be different from the treatment used on the first mob that grazed the low worm-risk paddock. This will dilute drench-resistant worms already on the paddock with more susceptible worms that the second mob is carrying. Note that grazing with cattle will not dilute the proportion of drench-resistant worms, but they will decrease the total number of worm larvae on this paddock.

NOTE: Treating less than 100% of a mob is **not** currently recommended in this region. The practice of leaving some sheep untreated was developed to reduce development of drench resistance. It is successful in some areas where barber's pole worm is not a major threat.

Using Barbervax® vaccine for barber's pole worm

The use of Barbervax should slow the rate of development of drench resistance because fewer drenches will be used. It is unlikely that barber's pole worm will develop resistance to this vaccination.

How can persistent treatments be used effectively?

Effective persistent treatments kill immature and adult worms in the sheep at the time of treatment, as well as infective larvae eaten by sheep (with pasture) during the period of protection of the treatment—about 3 months for long-acting and 1–4 weeks for mid-length treatments (depending on the particular product).

Both may increase selection for resistance to the actives in those treatments for two reasons. Firstly, worms are exposed to the active for longer. This favours surviving resistant worms, which then reproduce. Secondly, persistent treatments have a longer time at the end of their protection period where the active concentration has dropped to a level where partly resistant worms may survive and reproduce.

Use primer and exit drenches with long-acting treatments

Primer drenches clear the sheep of any worms that are resistant to the long-acting treatment. A primer drench is an effective short-acting drench (preferably a combination) that does not include the same group as the long-acting product. Give a primer at the same time that a long-acting product is given.

Exit drenches are used two weeks after the end of the actual protection period. By this time, the persistent treatment has declined to very low levels in the sheep. The exit drench kills larvae that have survived the persistent treatment and developed into breeding adult worms. Another name for the exit drench is a 'tail cutter'.

An exit drench (like the primer drench) is an effective short-acting treatment (preferably a combination) that is from a different group/s to the persistent product.

Mid-length treatments need exit drenches

Resistance can develop to mid-length treatments in the same way as to long-acting treatments. While primer and exit drenches are desirable with mid-length treatments, they are rarely cost-effective because of the relatively short protection period compared to long-acting products. However, the use of an exit drench is highly recommended two weeks after the end of the protection period stated on the label.

Check the persistence of a product

The effectiveness of the persistent product on your property will be shown by the length of the protection period actually achieved (rather than what is claimed on the product label). Persistent products that you plan to use should also be tested in a *DrenchTest* each 2–3 years. However, if you do not have current *DrenchTest* results and you plan to use a persistent product before your next scheduled *DrenchTest*, you should do a *DrenchCheck-Day10* (see page 10) after the next treatment. Also, conduct a *WormTest* at 60 days and 90 days after it is given to see how long it is effective. If it is shown to be ineffective at one of the earlier tests, then the later test/s will be of no value.

When you send the samples, request a larval culture if there is a positive worm egg count because

- resistance may only be present in one worm species
- if moxidectin was used, the protection period against different worm species differs
- if closantel is used, it is a narrow spectrum drench only for barber's pole worm

If the treatment was fully effective, and you used a primer and exit drench, the product will probably have a similar length of effectiveness at the next use. However, it is best to check the effectiveness of long-acting products every year they are used by doing a *WormTest* at 30 and 60 days.

If a *WormTest* shows worm eggs are present before the end of the claimed protection period, drench resistance is likely. You should:

1. Immediately drench the sheep with an exit drench (as described earlier), keep them in their current paddock for a further 3–4 days (while most eggs pass in the dung), then move them to another paddock. This will stop more drench-resistant worm eggs from contaminating the pasture.
2. The next sheep to graze this paddock should have a moderate to high worm burden, with their last treatment not being from the same drench group as the long-acting product. This will help to dilute the resistant-worm eggs already on the pasture.
3. Seek professional advice on further use of products from this drench group and how they should be checked.

At any time that you are concerned that a mid-length or long-acting treatment is not providing protection, *WormTest* immediately and seek professional advice regarding drench resistance.

Appendix 1: Liver fluke control

Liver fluke (*Fasciola hepatica*) only occurs where the intermediate host (lymnaeid snails) are present. These snails are found where there are slow-moving creeks, swamps or springs and they can survive in mud when water flow temporarily stops. However, the snail is not necessarily present in all such areas.

Liver fluke may not be present on all paddocks or properties in a 'flukey' locality.

Roundworms are often specific to one type of animal, but liver fluke can infect many species including cattle, sheep, goats, alpacas and horses, as well as humans and wild animals.

Prevention

Grazing management can help prevent liver fluke infection. Unfortunately, there is currently no effective method to breed for host resistance to liver fluke.

If liver fluke is present on a property, infection can be prevented or minimised by

- isolating the areas that harbour the snail, using fencing
- conducting earthworks to deepen shallow water, or to improve drainage
- repairing broken pipes and troughs that have resulted in permanent wet areas
- avoiding grazing of snail-infested areas by the most susceptible animals (sheep, goats, alpacas and young cattle)

Detection

Testing for liver fluke can be done using the dung samples sent for a *WormTest*. A fluke test, which uses a different method to that used for roundworms, must be specifically requested.

If you don't know whether your sheep are infected with liver fluke, test three times a year (autumn, winter and summer) for at least two years (i.e. 6 tests).

Testing will show whether liver fluke is present and to what extent.

You can also determine which paddocks are affected by testing mobs that have only been run in a particular paddock since the last fluke-treatment.

If fluke egg counts for a particular paddock are frequently high (greater than 25–50 eggs per gram), there may be significant production losses. Reconsider your grazing strategies for the affected paddocks and see if fluke-affected areas can be fenced off.

If results at the three testing times are not always positive, then continue testing at the specified times to decide whether to drench.

If all six tests have been negative and the livers of dead or slaughter sheep have not shown any signs of liver fluke, it is likely that the lymnaeid snails are not present on your property to act as a host for liver fluke. Drenching for fluke will not be required (except to remove fluke from sheep brought onto the property).

A blood test (antibody [ELISA] test) is also available from various laboratories, for example, the NSW Department of Primary Industries State Veterinary Laboratory at Menangle. Also, a faecal antigen test for fluke is available through Charles Sturt University's Veterinary Diagnostic Laboratory.

Response

Any positive fluke egg count is significant and indicates treatment is needed.

If testing for two years confirms that sheep are infected at all test times, then ongoing testing can be stopped. In this case, three routine treatments for liver fluke should be given to sheep that have been grazing the affected paddocks in

- April–May
- August–September
- February

Some treatments for roundworms (scour worms and barber's pole worms) will control various stages of liver fluke. Check the label as some are only effective against mature fluke (see Table 1.).

The most important treatment is carried out in April–May and should be based on the flukicide, triclabendazole, which is effective against all stages of the fluke found in the sheep. If treatments are also required in August–September and/or February, one or both of these treatments should be a flukicide other than triclabendazole (if this was used in April). This treatment rotation will reduce the rate of development of fluke resistant to triclabendazole.

When bringing in sheep from another property, consider including a fluke treatment in the quarantine drench if their fluke status is unknown. Bear in mind that adult liver fluke can live for several years inside host animals.

Table 1. Fluke treatments and the age of fluke from which they are effective

Active	**Age of fluke killed**
Triclabendazole	All stages
Albendazole	From 12 weeks
Closantel	From 8 weeks
Closantel plus oxfendazole	From 6 weeks
Closantel plus albendazole	From 8 weeks
Oxyclozanide plus levamisole	From 12 weeks

Source: from *Liver fluke disease in sheep and cattle*, by J Boray (March 2007) NSW DPI Primefact 446

The following drench actives do not control liver fluke:

- moxidectin, abamectin or ivermectin
- oxfendazole and fenbendazole
- levamisole
- naphthalophos and pyraclofos
- monepantel
- derquantel
- praziquantel

Resistance to flukicides

Resistance has developed to various flukicides. Rotate between flukicides from different chemical groups, beginning with triclabendazole for the April–May treatment.

Resistance of liver flukes to flukicides can be checked, however, fluke egg counts may not be high enough to give a precise estimate of flukicide efficacy, nevertheless, they are still worth doing. You will need a fluke count carried out not long prior to drenching (up to 2 weeks before administering a fluke drench). Follow this up with another fluke count between 21 and 28 days after the fluke drench was given. If your flukicide is effective the fluke egg count will normally go down by at least 90%.

More detailed information on liver fluke can be found at the NSW DPI web site:

http://www.dpi.nsw.gov.au/agriculture/livestock/sheep/health

Appendix 2: Roundworm life cycle and larval survival

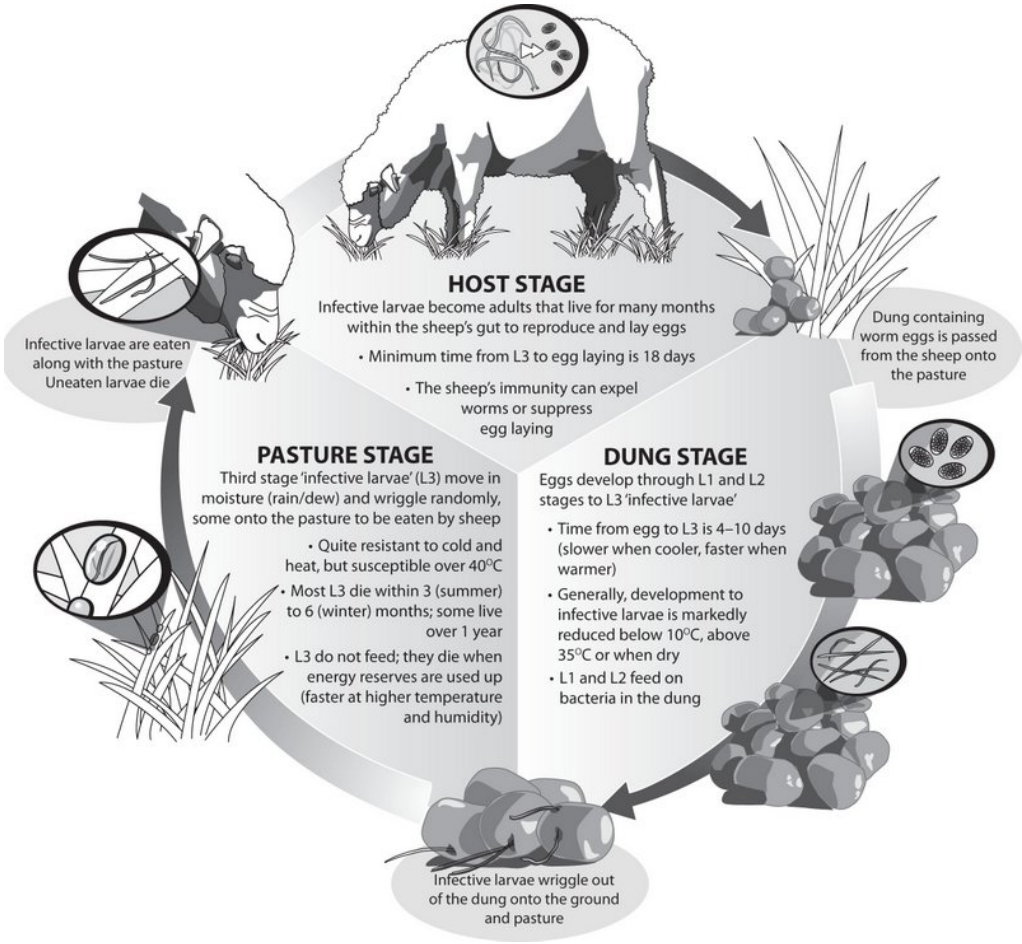
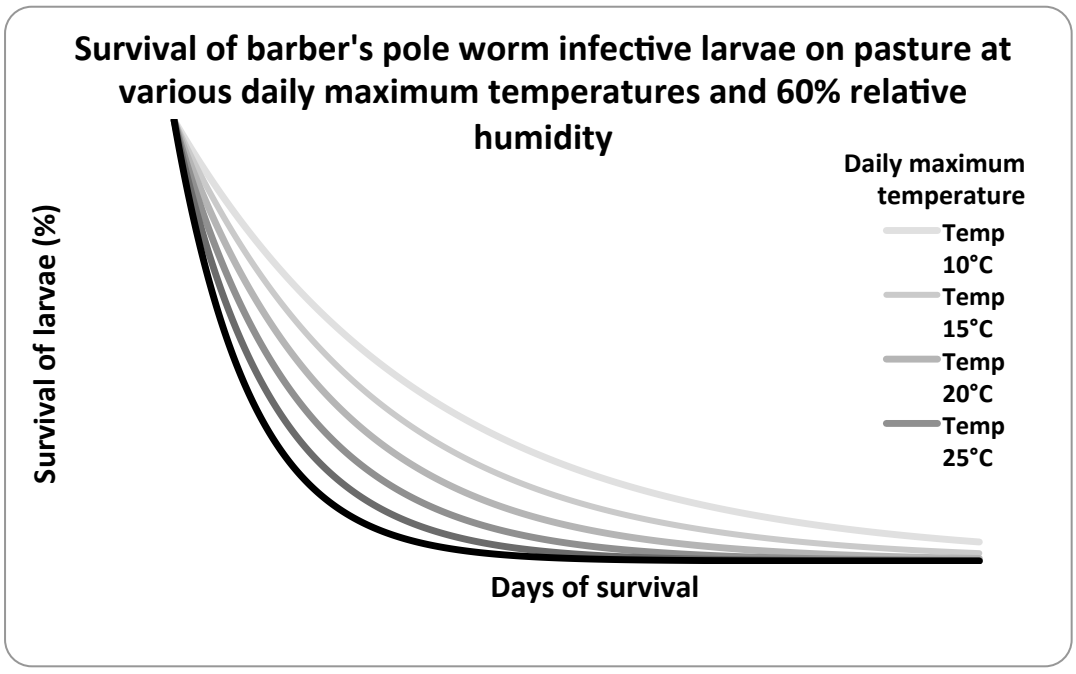


Figure 1. The life cycle of sheep roundworms



Source: Modeled from death rate of the L3 population in 'Simulation of pasture larval populations of *Haemonchus contortus*' by IA Barger, PR Benyon & WH Southcott. Proceedings of the Australian Society of Animal Production (1972) 9: 38

Figure 2. Survival of barber's pole worm infective larvae on pasture

Appendix 3: Factors contributing to paddock contamination with worms

The following table applies mainly to brown stomach worm (*Teladorsagia circumcincta*), black scour worm (*Trichostrongylus* species) and barber's pole worm (*Haemonchus contortus).*

Factor	Time or conditions	Effect
Minimum time before worm eggs can become infective larvae.	4–10 days	Short graze periods (less than 4 days) prevent 'auto-infection' (sheep becoming infected by larvae arising from worm eggs the same mob have recently deposited onto the pasture).
Conditions required for significant numbers of worm eggs to hatch and become infective larvae.	4–10 days of: **Brown stomach worm:** Temperature: daily maximum >8°C[1;] Moisture in this time: >10–15 mm rainfall[2] **Black scour worm:** Temperature: daily maximum >12°C for *T. vitrinus* or >15°C for *T. colubriformis* Moisture in this time: >10–15 mm rainfall[3] **Barber's pole worm:** Temperature: daily maximum >18°C[1;] Moisture in this time: >10–15 mm rainfall[3]	Unsuitable conditions prevent eggs developing into infective larvae. *Note:* The eggs of the small brown stomach worm are much more tolerant of cold and dry conditions, and in general, grazing management has less effect on its control. <<Footnotes for information to the left [1]Some hatching of worm eggs of all species can occur below these daily maximum levels, but this is usually at a small and insignificant rate. [2]Brown stomach worm eggs can develop at low rates without rainfall even in a relatively dry faecal pellet. [3]Development to infective larvae may occur without rainfall if soil moisture profile is high.
Maximum time worm eggs can live awaiting suitable hatching conditions.	**Brown stomach worm**: 21 days Some brown stomach worm eggs may survive for longer periods. Once hatched, infective larvae can remain in the faecal pellet until conditions are more suitable. **Black scour worm**: 16 days Once hatched, infective larvae can remain in the faecal pellet until conditions are more suitable. **Barber's pole worm**: 5 days	Prolonged periods without the right conditions (temperature/moisture) for egg development will result in the eggs dying. This lowers the worm-risk of paddocks.
The time for about 90% of the barber's pole worm infective larvae (L3s) to die (making paddocks low worm-risk). **Note: Larvae of brown stomach worm and black scour worm can survive longer because they can remain in the faecal pellet for extended periods.**	<table><tr><th></th><th>Maximum temperature (°C)</th><th>Time for 90% larvae to die</th></tr><tr><td>Cold</td><td>less than 15</td><td>4 months</td></tr><tr><td>Warm</td><td>about 22</td><td>3 months</td></tr><tr><td>Hot</td><td>about 35</td><td>1.5 months</td></tr><tr><td>Very hot</td><td>more than 40</td><td>1–2 weeks</td></tr></table>	L3 larvae do not feed. While waiting to be eaten by sheep, they wriggle randomly in drops of moisture, more so in warmer conditions. Increased activity in warm weather depletes their energy reserves faster, hastening death. In extremely hot, dry and windy conditions, the larvae dry out and die.
Minimum time for infective larvae eaten by sheep to mature and lay eggs (the 'pre-patent period').	Minimum of 18 days for most sheep roundworms.	Worm larvae eaten by sheep soon after an effective drench will take at least 18 days before they can lay eggs. During this period after administering an effective drench, sheep are not re-infecting the pasture.

Appendix 4: Find your 'cold period'

The following information will show you how to locate climate data on the internet, allowing you to find the period of the year when your average daily maximum temperatures are 18°C or below. At these temperatures *Haemonchus contortus* and *Trichostrongylus colubriformis* will have little or no development to infective larvae.

In average years, the months of May–August meet these temperature conditions in the tablelands districts of Walcha, Uralla, Armidale, Guyra, Glen Innes, Tenterfield and Stanthorpe.

The Bureau of Meteorology (BOM) web site

A BOM temperature map can be used to show where the daily maximum temperature is on average 18°C or below for the month. Unfortunately, this map is small and low resolution, so it may be difficult to pinpoint your location if you are near a temperature gradient line (isotherm).

1. Go to: www.bom.gov.au/jsp/ncc/climate_averages/temperature/index.jsp?maptype=1&period=apr#maps OR go to www.bom.gov.au, then choose: Climate Information, choose: Maps-average conditions, then in the main part of the page choose: Average max, min & mean temperatures.
2. Select: Maximum temperature.
3. Select month as April (then progressively change and view months through to October).
4. Look for the areas coloured pale green to darker green/blue, which have an average maximum of 18°C for the month. Note that the earlier weeks in the first cold month, and the later weeks in the last cold month may not really be 18°C or below, as this is an across-month average.

Weatherzone web site

This site allows you to look up the average monthly maximum temperatures for a particular town.

1. Go to: www.weatherzone.com.au.
2. Type the name of your closest town into the 'site search' box and press enter.
3. When the town's weather information appears, go down to the Almanac (just below the sun and moon times) and select 'Full climatology'.
4. In the top table: 'Long term climatology', look for the months that have temperatures of 18°C or less in the row for Mean Maximum (°C). Note that the earlier weeks in the first cold month, and the later weeks in the last cold month may not really be 18°C or below, as this is an across-month average.
5. Alternatively, look at the graph (below the tables). Look for the months when the solid red line (mean daily maximum temperature °C) is below 18°C.

NOTE: The temperature of a nearby town may be quite different to the temperature on your farm, where there are long distances or considerable differences in the altitude between them.

Appendix 5: Preparing lambing paddocks with 'Smart Grazing—summer rainfall'

'Smart grazing' is a system developed in Victoria by Dr Paul Niven to create low worm-risk autumn weaner paddocks in winter rainfall regions. This was adapted for the Northern Tablelands of NSW by Dr Justin Bailey, and is called 'Smart Grazing—summer rainfall'. Both versions are based on very short periods of intensive grazing at increased stocking rates.

The Northern Tablelands version takes advantage of a four-month cold period in winter (May-August) combined with two bursts of intensive grazing in summer and autumn. This results in an eight-month period where contamination of the paddock with worm eggs is prevented and most of the existing eggs and larvae die.

The process uses a high stocking rate during the grazing period, about four times normal, in order to rapidly reduce the pasture mass, thus increasing exposure of worm larvae to the elements.

Steps for 'Smart grazing—summer rainfall'

1. *January/February:* Graze the lambing paddock with sheep immediately after they have been treated with an effective short-acting drench and graze for no longer than three weeks after that drench. Stock at 3–4 times the normal stocking rate in order to reduce the herbage mass to about 1000 kg DM/ha (or about 3 cm in height).
2. *March/April:* Repeat step 1.
3. *May, June, July and August:* In cold, tableland districts, when the mean daily maximum temperatures are consistently below 18°C, these paddocks can be grazed by any stock as it is too cold for the eggs of the major worm parasites, barber's pole and black scour worms, to hatch to infective larvae.

Note: In warmer areas adjacent to the tablelands, this cold period will be shorter and Step 3 (from above) may be restricted to June and July. Review your local climate history (see Appendix 4: Find your 'cold period') to find when the temperatures over a week will have daily maximums below 18°C.

It is critical that sheep used in 'Smart grazing—summer rainfall' are drenched with a product *known* (as a result of a *DrenchTest* on that farm) to be highly effective.

Appendix 6: Drench groups and actives

Drench groups and actives	Worms	Examples* of brand names/comments
BZ or benzimidazole group ('white')[B] albendazole fenbendazole oxfendazole	barber's pole worm, 'scour worms', adult liver fluke, nodule worm, aids control of intestinal tapeworm (*Moniezia*)	Valbazen (albendazole) WSD Fenbendazole (fenbendazole) Oxfen (oxfendazole)
LV or levamisole group ('clear')[B] levamisole	barber's pole worm, 'scour worms', nodule worm	Nilverm, Levamisole Gold
ML or macrocyclic lactone group[B] (sometimes called 'mectins') Ivermectin abamectin moxidectin	barber's pole worm, 'scour worms', nodule worm	Ivomec, Noromectin (ivermectin) Absolute, Vetmec, Paramectin (abamectin) Cydectin (moxidectin)
AD or amino-acetonitrile derivative group[B] monepantel	barber's pole worm, 'scour worms'	Zolvix
SI or spiroindole group[M] derquantel	barber's pole worm, 'scour worms', nodule worm	Derquantel is only found in a combination: Startect (abamectin + derquantel)[B]
OP or organophosphate group[M] naphthalophos (NAP) (OPs have lower or variable efficacy against 'scour worms' in the upper GIT and immature barber's pole worm)	barber's pole worm, 'scour worms'	Rametin (naphthalophos is commonly used in combinations)
TZ or benzimidazole group (flukicide)[N] triclabendazole	Liver fluke (all stages); not effective against round worms	Tremacide
SA or salicylanilides/phenols group[N] closantel oxyclozanide	Liver fluke (> 9 weeks and adult) and barber's pole worm Liver fluke (adults) and tapeworm	Closicare (closantel) Oxyclozanide is only found in a combination: Nilzan (levamisole + oxyclozanide)[B]
IQ or isoquinolone group[N] praziquantel	Intestinal tapeworm (*Moniezia*)	Praziquantel[N] is only available in combination with broad-spectrum drenches. First Drench[B], Genesis Tape[B]

**ParaBoss does not endorse specific brands, these are presented here as examples only.*

Breadth of activity across different worm species: [B]Broad-spectrum; [M]Mid-spectrum; [N]Narrow-spectrum

Actives: An 'active' is the chemical in a drench responsible for killing worms. Some drenches have more than one active and are called 'multi-active' or 'combination' drenches.

Combination or multi-active treatments: Proprietary treatments containing more than one active. Formulated to be compatible as a mixture. Note: Do not mix your own drenches unless the labels state that you can.

Product formulation: All single actives are available as oral drenches. Moxidectin is also available in injectable products. Intra-ruminal/controlled release capsules are available with BZ and/or ML actives. Abamectin is also in a pour-on formulation for both lice and worm control.

Length of protection: Varies from short-acting ('knock-down' that kills susceptible worms within the animal) to mid-length (1–4 weeks) and long-acting (approx. 3 months), which not only kill susceptible worms already in the animals, but also susceptible infective larvae that the sheep eat during the protection period.

'Scour worms': Mainly black scour worm and (small) brown stomach worm, but also others.

Label: Check product labels for full details. Follow the label.

Other parasites: 'Drenches' in www.wormboss.com.au shows effectiveness of groups against other parasites of minor importance.

wormboss

The WormBoss website is the most complete and current source of information for producers, advisors and students on sheep worms, drenches and worm control in Australia.

On the site you will find information and tools:

Regional worm control plans
A step-by-step guide to controlling worms practically, effectively and profitably on your property all year round.

Regional Drench Decision Guides
A tool to help you decide whether your sheep need drenching now, and if so, what length of protection is required and when to check the sheep again.

Drenches
Lists all of the drench groups and combinations as well as actives and brand names.

Tests and tools
'How to' guides are provided on WormTests, DrenchTests and more.

Worms
Describes the important worm species, their lifecycle and how they affect sheep.

Subscription
Subscribe to the ParaBoss monthly e-newsletter to keep up to date on your regional worm situation and new information.