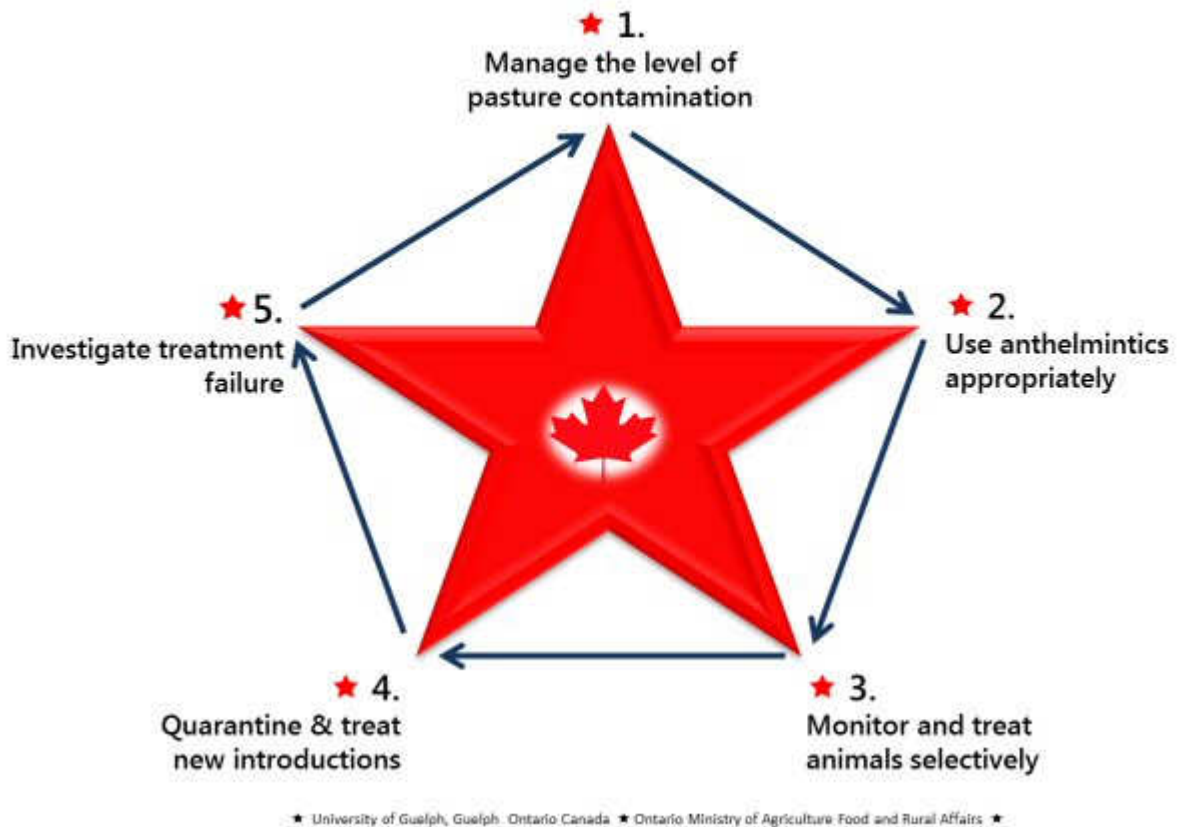


GOAL

The goal of a parasite control program is to control the level of parasites on the farm to a level which has minimal effect on animal health and productivity without allowing the development of anthelmintic resistance.

This is known as sustainable Integrated Parasite Management or sIPM. Gastrointestinal parasites do not need be an issue on a small ruminant farm, if sound principles and an understanding of the epidemiology are used in developing a suitable control program. We present the main points here. The program is called “5 STAR WORM PLAN”. Use this program with your flock veterinarian to develop a flock health management approach which is correct for your farm.

5 STAR WORM PLAN



★ 1. MANAGE THE LEVEL OF PASTURE CONTAMINATION

There are many methods available to reduce the level of parasite contamination of pastures. None in of themselves are 100% effective, but together they are very important in any sustainable integrated parasite management program and will make the difference between success and failure. The goal is to have all pastures as “safe” pastures, and there are many methods to achieve this.

1.1 MANAGE THE BIGGEST SOURCES OF PASTURE CONTAMINATION

The two biggest sources of pasture contamination with parasite eggs are lambs and kids by mid to late grazing season (e.g. late July / August), followed by adult females in late gestation and lactation (the peri-parturient egg rise) – usually in the spring. To manage the contamination by lambs and kids, monitor frequently and treat when needed– particularly from mid-grazing season (e.g. early to mid-July). To manage the contamination from the PPER, if possible, do not graze late gestation or lactating ewes / does, or if not practical to avoid grazing this group, treat selectively (see below).

1.2 USE OUR UNDERSTANDING OF THE BEHAVIOUR OF THE FREE-LIVING STAGES

By understanding where the infective L₃ are in the pasture, we can modify grazing management to try to reduce exposure of the sheep / goats to them.

1.2.1 Break Up the Faecal Pellet

Remember that L₁ and L₂ stages live within the faecal pellet. If the pellet is exposed to moisture or is broken up using a mechanical means (e.g. harrowing), then it breaks down and releases the L₃ to crawl onto the grass but also exposes the L₁ & L₂ to the environment where freezing temperatures or very hot, dry conditions can kill them more rapidly. Soil livestock, e.g. earthworms and dung beetles assist in this breakdown.

1.2.2 Modify Grazing Based on Temperature and Humidity

L₃ dislike dryness so they will go down to the soil during hot days but migrate up when the dew is on the grass. Waiting until the dew is off the grass to graze short pastures is often not practical as a summer shower during the day could bring the L₃ back up the grass. Exposing the ground to sunlight may have some benefits as it gives the L₃ less place to hide and exposes them to heat and drying. This can be done by either de-thatching using a harrow, or routinely planting new pastures and ploughing in old pastures.

1.2.3 Modify Grazing Based on Sward Height

The L₃ are restricted on how high they can climb (usually not higher than 5 cm), so long grass is safer than short grass although must be implemented to in a manner that preserves the optimal nutrition of the pasture. Overgrazing pastures will increase the infection rate by forcing the sheep to graze close to the soil.

1.2.4 Eliminate Areas of the Pasture that Favour L₃ Survival

Areas of the pasture that are wetter, such as marshy areas or around water troughs –may have greener grass and attract sheep and goats to graze but also favour survival of L₃. Eliminate these areas for grazing either by fencing off or gravelling (e.g. around water troughs).

1.3 ROTATE PASTURES WITH OTHER LIVESTOCK SPECIES

While cattle share some parasites with sheep and goats, rotation with this species has been shown to generally lower pasture infectivity to sheep and goats. Horses will also work. Co-grazing (grazing at the same time) with cattle is less effective but may help.

1.4 AVOID GRAZING SHEEP AND GOATS TOGETHER

Sheep and goats share the same parasites. Because adult goats do not develop immunity to parasites they will be a more important source of pasture contamination than adult sheep. Additionally, they metabolize anthelmintics more rapidly than sheep, require higher doses than sheep and because of that are at risk of developing AR more rapidly than sheep.

1.5 REST PASTURES THAT ARE HEAVILY CONTAMINATED

If a pasture was particularly heavily infected at the end of the previous grazing season, select it for ploughing, reseeding, haying and / or grazing with another species.

1.6 BE AWARE OF RISKS OF SPREADING MANURE ONTO PASTURE OR HAY FIELDS

Although it is unlikely that infective larvae will survive in well-composted manure, fresh manure can be a source of parasites. It is possible that hay crops can be contaminated in this way and perhaps may be a source of infection when fed. Thus, it is safer to spread manure onto fields prior to ploughing for crops.

1.7 USE LOW-RISK PASTURES FOR THE MOST SUSCEPTIBLE ANIMALS

Graze weaned lambs/kids on newly seeded pasture or hay fields. Annual pastures (e.g. turnips) that are ploughed in at the end of the season will be beneficial.

1.8 “DOSE AND MOVE” VERSUS “DOSE AND STAY”

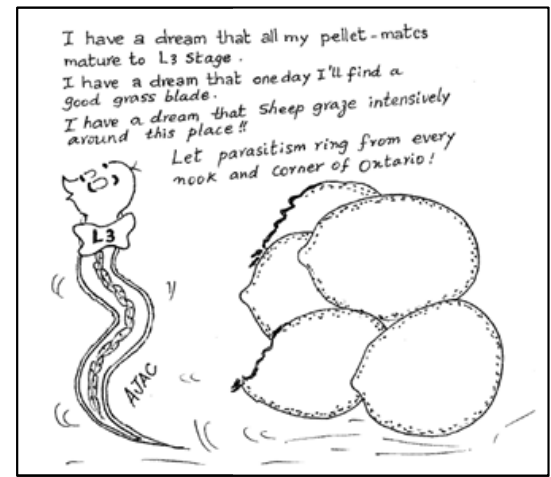
If the entire flock is to be treated, there are techniques explained in Figures 3 a, b, c & d which allow a susceptible refugia to be maintained – ideally, dose and stay for a few days prior to moving is preferred.

1.9 REDUCE THE CONTAMINATION OF A PASTURE BY USING PASTURE ROTATION

Firstly, understand that L3 can survive for weeks or months on pasture if the environment is moist and temperate and that L3 can survive overwinter. This makes it very difficult to accurately predict when a pasture is finally “safe” in a pasture rotation system. Most pasture rotation systems require that the flock return repeatedly to the same pasture in a grazing season. Unless the frequency is < 2 weeks, eggs deposited when grazed previously will likely be hatched and the L3 larvae will be waiting to infect. L3, under the right weather conditions (e.g. temperate and moist), may survive for months. The following are some suggestions that will help with using pasture rotation to control parasites:

1.9.1 Evasive Grazing

This technique of grazing pastures when the risk of parasites is lowest, requires knowledge regarding the speed of larval development given local conditions. Models have been developed that take geography, weather and management practices into account to predict when pastures might becoming dangerous. These are commonly used in countries such as Australia, New Zealand and the UK. It should be remembered that during the summer, pastures can remain very infective for up to 3 months making evasive grazing not practical if used as the sole method for parasite control.



1.9.2 Strip Rotational Grazing

This is a form of evasive grazing and is relatively safe if the following hold true:

- 1) animals are moved from the strip before eggs hatch and the larvae develop to the L₃ stage (variable depending on weather; longer in cool weather but shorter in warm weather); AND
- 2) animals do not return to the strip until the L₃ have died (variable depending on weather and moisture but may be up to several months if temperate and humid).

On average, the worst time period between grazing sessions is 2 to 3 weeks - the most likely time that the eggs have hatched and developed to L₃, although this time may vary depending on weather and parasite species. While short-term grazing will limit pasture contamination, returning to the strip several times in a season will result in the build-up of L₃ - just as if the pasture was set stocked (i.e. animals put to the same pasture for the entire grazing season). While it may be prudent to strip graze in order to make optimal use of the pasture, monitor FEC closely.

1.10 IF HEAVILY CONTAMINATED PASTURES MUST BE GRAZED

Often, the producer has only heavily contaminated pastures available for grazing. The following strategies may help to lower risk in the face of grazing heavily contaminated pastures:

1.10.1 Lower Stocking Densities

By lowering stocking densities, there will be less pasture contamination with faeces. Recommendations vary but keeping set stocking densities < 6 to 8 sheep/goats per acre is often mentioned. With rapid pasture rotation, these densities can be increased. But FEC monitoring must also be done.

1.10.2 Don't Graze Nursing Lambs / Kids

It is more difficult to manage the parasite exposure of lambs / kids when grazing with their dams. If only heavily contaminated pastures are available, try to avoid grazing nursing lambs/kids. If possible, practice early weaning so their exposure can be better managed. If not, increase the frequency of FEC monitoring. Weaned lambs / kids should be pastured on the pasture with the lowest level of contamination.

1.10.3 Rotate Weaned Young-Stock Ahead of Adults

After weaning, lambs or kids should have "first access" to safe pastures. This way there is less risk from exposure to PPER contaminated pastures. Also, adults are better able to tolerate heavily infested pastures.

1.10.4 Use Adults to Graze Heavily Contaminated Pastures

If pastures are heavily contaminated and safe pastures are in short-supply, non-lactating ewes or does not in late pregnancy can be grazed more safely than young-stock on these pastures and may help to lower the infectivity by grazing off L₃. This should be done carefully and not without monitoring FEC.

1.11 RECORD PASTURE USE AND TREATMENTS.

Appendix 3 is an example form that can be used for this purpose

★ 2. USE ANTHELMINTICS APPROPRIATELY

2.1 TO AVOID TREATMENT FAILURE AND DEVELOPMENT OF AR, TREAT APPROPRIATELY.

- ★ Weigh the sheep/goats. Dose for the heaviest in the group
- ★ Use drugs only with a Drug Identification Number (DIN).
- ★ Dose correctly by reading the label.
- ★ If not labelled for sheep or if using in goats, obtain the correct dose from your vet.
- ★ Goats are generally treated at 2X sheep dose (BZ and LV) or 1.5X sheep dose (ML)
- ★ To increase effectiveness of a drug when AR is suspected, do not double the recommended dose but rather give the recommended dose twice 12 hrs apart (BZ and ML only).
- ★ Calibrate your drench gun or automatic syringe frequently.
- ★ Drench correctly by depositing the entire dose over the tongue, at the back of the throat.
- ★ Oral drenches are preferred to injectable products.
- ★ Use the correct route of administration. Do not use a cattle pour-on.
- ★ Holding the sheep/goats off-feed for 12 to 24 hrs before treatment with a BZ, can increase the length of time that the concentration of the anthelmintic is effective.

2.2 Rotate Anthelmintic Classes Slowly

Consensus suggests not to rotate anthelmintic drug classes more frequently than annually. Rapid rotation is thought to lead to multiple class AR.

2.3 Combining Anthelmintic Classes

In many parts of the world, there are commercial deworming products that contain more than one anthelmintic. These were developed for sheep farms with AR and will temporarily improve efficacy of those drugs. However, unless AR has been shown to be present on your farm, and unless prescribed by a veterinarian - do not combine anthelmintic classes as this may lead to multi-class AR.

★ 3. MONITOR AND TREAT ANIMALS SELECTIVELY

3.1 "TARGETED TREATMENTS"

This means to treat sheep or goats **only when they need it**. This is done by monitoring FEC (usually pooled samples) and clinical evidence of disease and then treating the group. Record all FEC results (example form provided in Appendix 4). Increasing the interval between anthelmintic treatments reduces the development of AR. Times to monitor (and possibly treat):

3.1.1 Ewes / Does Prior to Lambing / Kidding

This is to eliminate or reduce the PPER which is considered one of the most important sources of pasture contamination for lambs and kids. For spring or winter lambing ewes and does- this is an obvious time to monitor. Fall lambing ewes (maybe also does) appear not to have a PPER possibly because of seasonal influences.

Ewes / does with a significant PPER will contaminate the spring pasture with eggs starting a few weeks prior to lambing / kidding and continuing through to about 8 weeks into lactation – or until weaning. They will also be more susceptible to infection from any overwintered L₃ on pasture.

Ewes (usually either yearlings lambing for the first time, or ewes carrying multiple lambs and are nutritionally stressed) may suffer disease or decreased productivity if not dewormed in the face of a high FEC. Does may also be more prone to disease as immunity in this species is poor for parasites. However, treatment when treatment is not needed will hasten development of AR on a farm – particularly for *Haemonchus*. Under some management conditions, e.g. if ewes lamb and nurse lambs indoors, it may not be necessary to deworm at this time because they are not contaminating pasture – as long as the females appear healthy.

For these reasons, it is important to make the decision on whether or not to deworm prior to lambing / kidding with your flock/herd veterinarian and to always monitor faecal egg counts in nursing adults.

3.1.2 Lambs/ Kids at Mid-Summer

The exact date to start to take faecal samples will vary depending on the warmth and humidity of the summer and how early summer arrives in our northern climate. Generally early to mid-July is the earliest that we routinely see clinical evidence of disease. Mostly it is slightly later - late July to August, which appears to be the highest risk period in our climate for haemonchosis.

By checking FEC in the young-stock (and adults if grazing together) in early to mid-July, and treating only when high counts are found (or in the case of haemonchosis, evidence of anaemia can also be used), GI parasitism should not become a problem. If the FEC is negative, but animals are showing severe clinical signs of parasitism, consult your flock/herd veterinarian to determine if another disease is present (e.g. coccidiosis).

Occasionally, if the spring pasture is heavily contaminated from the previous grazing season with overwintered L₃ (usually *Teladorsagia* but not *Haemonchus*), parasitism can occur earlier. Lambs / kids on these pastures may encounter such a severe infection with these overwintered L₃ that they become clinically ill (diarrhoea, off-feed, depressed) from the immature parasites before eggs are present in their faeces. Any young stock dying should be necropsied by a veterinarian to determine if this is the cause of death.

3.1.3 Repeat Monitoring in the Grazing Season

Monitor frequently at the times of highest risk, i.e. mid-summer to early fall. If when the lambs/kids are monitored, the FEC is below the cut-point to treat, resample in mid-summer at least every 3 to 4 weeks and perhaps more frequently, particularly if *Haemonchus* has been a problem in the past.

3.1.4 Monitor after Treatment

Faecal egg counts should be done every 4 (BZ and LV) to 6 (ML) weeks after treatment. If the animals appear parasitized after treatment, it is strongly recommended to resample at 14 days to determine if treatment failure occurred (see above).

3.1.5 Monitor According to Farm History

By knowing the farm history, the time of monitoring can be adjusted. For example, if the previous summer, lambs had elevated FEC in the first week of July, then monitoring should be started in mid-June.

3.1.6 Monitor in the Autumn?

By October there is no point in using FEC to determine infection. Although the animals may be parasitized, most of the development is now to the arrested stage (L4 and L5) which do not produce eggs. Performing FEC at this time will not properly estimate the level of infection present in the animal.

3.1.7 Treatment of Breeding Animals in the Autumn or Pre-Breeding?

Treatment in the autumn may reduce the arrested L4 that overwinter in the animal, and are thus available for a PPER the next spring in housed ewes and does. But we need to be assured that the treatment is both necessary and actually works at this time of year. The recommendation to treat pre-breeding should only be done if monitoring or poor condition suggests that the adults are parasitized. Usually adults will not show signs of parasitism unless periparturient or debilitated with another disease or poor nutrition. Treatment when not necessary will contribute to the development of AR.

3.2 "TARGETED SELECTIVE TREATMENTS"

This means treating **only those individual animals that need it when they need it** and is based on the knowledge that in any given population, only a proportion actually requires deworming. The challenge is to correctly identify the animals that need treating and those that don't. The development of AR can be slowed or prevented if about 1/3 (30%) of animals are NOT treated. This approach leaves a susceptible parasite population in refugia – both on the pasture and in the untreated animals and is critical to the success of any sustainable integrated parasite control program. The producer has only a few options to be able to do this effectively and economically.

3.2.1 Using Faecal Egg Counts

Unless the flock size is very small, it is not economical to perform individual FEC on all animals in order to detect the "big shedders", i.e. those 30% of animals that shed 70% of the eggs. There is no method of determining parasite egg load in faeces other than using a laboratory based-test.

3.2.2 Using the FAMACHA® System

The FAMACHA® system can be used very effectively to select individual animals for treatment of haemonchosis - but is not effective at detecting infection of other GIN species. It could be used on farms that know when *Haemonchus* becomes a problem (e.g. starting late July, early August) but should be combined with FEC to rule out other causes of parasitism. Sheep or goats that score 4 or 5 would be drenched (3's too if a large part of the flock is anaemic) and then everybody monitored every 2 to 3 weeks during the high risk period. FAMACHA® cards must be used in good light, i.e. daylight ideally and replaced annually as the colour may fade with time. Because there are other causes of anaemia, it is important to investigate treatment failure. Use the provided record to track FAMACHA © treatment results.

3.2.3 Using Evidence of Diarrhoea

Dag scores indicating diarrhoea may be helpful when the producer can eliminate other reasons for scouring (e.g. coccidiosis or lush pasture) and may work best when combined with monitoring weight gains. However some research suggests that by the time the lambs or kids have diarrhoea, significant clinical disease is occurring - i.e. waiting until they have diarrhoea is too late.

3.2.4 Using Weight Gains

Routine weighing of lambs or kids (e.g. every 2 - 3 weeks) can identify those animals that are not gaining as fast as their cohorts, one reason for which may be GIN parasitism. One method of using this information is to only deworm the lighter animals and leave the heavier ones untreated. More research is needed regarding the appropriate deviation of average daily gain (ADG), e.g. if the normal ADG is 0.35 kg/day, how much less is a “trigger” for treatment? A producer may get a feel for what growth should be expected from the young-stock on a particular type and growth of pasture. That may be more useful than a scientific formula.

Under the new RFID and automated weighing systems, it is possible for producers to select poor gaining animals for treatment on a relatively frequent basis. The same type of system is used frequently for lambs in feedlots. That way, changes in the individual animal’s weight could be tracked and individuals that fail to gain would be treated. Pooled FEC should also be done to verify that parasitism is the cause of the poor growth and not poor nutrition or other disease such as coccidiosis or pneumonia.

Body condition score was not found to be helpful of predicting FEC in a recent Canadian study. It may be that it is not sensitive enough to pick up early parasitism. By the time the animals are thin, parasites have taken a severe toll.

3.2.5 Using Milk Production

Dairy goats in their first lactation may benefit from deworming in terms of improved milk production. While there is evidence that deworming will improve milk production in dairy ewes and dairy does, you must keep in mind that no anthelmintic is approved for use in lactating small ruminants. If deworming is done, it should be an evidence-based decision, e.g. elevated FEC. The producer and veterinarian are responsible for ensuring that chemical residues are not present in milk sold for human consumption.

3.2.6 Using Number of Lambs / Kids Nursing

There is evidence that ewes or does nursing multiples shed more eggs than ewes or does nursing singles. This is likely due to differences in nutritional stresses between the two groups. Deworming only females with multiples - either before parturition based on pregnancy scanning, or after based on number nursing - is one way to target those animals that likely have the highest PPER.

3.3 USING THE “5 POINT CHECK” CRITERIA FOR TREATMENT

This system identifies sheep and goats that may require deworming and was developed in South Africa. It includes infection from a variety of parasites – not just GIN and embraces the concept of targeted selective treatment or “*Leave the best and treat the rest*”.

1. The nose is checked for discharge that indicates nasal bots (*Oestrus ovis*)
2. The eyes are checked for anaemia, indicating blood-sucking worms
3. The jaw is checked for submandibular oedema that also accompanies anaemia and protein-losing infections cause by parasites such as *Haemonchus* and liver fluke (see below)
4. The back is checked for body condition score indicating possible infection by internal parasites like *Teladorsagia* and *Trichostrongylus* species.
5. The tail is checked for signs of diarrhoea, indicating mainly worms that also cause loss in body condition score.

This approach is still being refined and requires FEC monitoring. Remember that by the time an animal shows signs of parasitism such as in points 2, 3, 4 and 5 – it is already very ill. This system requires that you also work hard to reduce exposure to parasites on pasture (under Point 1 of the 5 STAR WORM PLAN)

3.4 ALTERNATIVE METHODS OF CONTROL TO REDUCE RELIANCE ON CHEMICALS

To reduce the use of chemical anthelmintics, some of the following methods have been used to augment targeted selective treatment. Regardless of what methods are employed, make sure they are science-based and can work on your farm. A recent analysis of the published literature in this area found that genetic selection and some nutritional methods were the only scientifically proven means to alternatively control GIN parasitism. The abstract of the publication is presented at the end of this section.

3.4.1 Genetic Selection

The breeding of resistant or resilient sheep or goats can be done by selecting a breed (e.g. some hair breeds such as Barbados Blackbelly, but not Katahdin) or selecting individuals within a breed - usually rams that have lower FEC or other measures when compared to other rams in the group. However, it is important to make sure if “resistant” breeds are selected that one does not sacrifice important economic traits such as prolificacy, milk production, growth and carcass characteristics.

Gene marker tests have been marketed in some countries to help identify sheep that will have lower FEC . Hopefully, within the next decade, better tests for those genes will become be identified. A saliva test (CARLA®) developed in New Zealand measures antibodies to GIN and can help to select sheep that develop immunity more rapidly or to cull animals that do not. This test is currently not marketed in North America and thus is not available at this point.

Remember that immunity is acquired and resistant animals still need to be infected with parasites to develop this immunity. Heritability for this trait is moderate (h^2 is 0.25 to 0.3), so a producer could use FEC in ram lambs or buck kids (comparison within a group) as a criteria for selecting a replacement male. But because heritability is only moderate, genetic progress within a flock may take up to 5 years to see an impact on flock levels of parasitism. To properly select parasite-resistant males, it is important to have a large enough group to accurately find the resistant animals without sacrificing important genetic traits of production.

Also realize that goats in general do not develop immunity as well as sheep. Much less research has been done with goats on selecting for genetic resistance and so the following strategy covered in the next paragraph may work better for this species.

Rather than selecting resistant animals, it may be easier to identify and cull parasitized adults that are slow to develop immunity to parasites. This can be done by culling those with a high FEC , repeatedly have scores 4 or 5 on the FAMACHA © chart or require repeated deworming treatments. These adults should be removed from the breeding flock and ideally, lambs/kids from these animals should be sent to market rather than retained as replacements. Additionally lambs or kids that need repeated treatments should not be retained as replacements as they are also more likely to give birth to offspring with less ability to develop immunity to parasites.

Resilient sheep/goats will be infected and will contaminate a pasture with eggs, but will not have as significant production losses. There is differing opinion about whether these animals should be kept. Regardless, within a population, there will be resilient and susceptible sheep so that selection must be done by using good records, measures of anaemia, FEC and growth monitoring in order to avoid losses and to select the correct animals.

3.4.2 Pasture Plants Containing Condensed Tannins

Grazing pastures seeded with plants that contain high levels of condensed tannins (CT), have variably been shown to reduce shedding of eggs in the faeces. In North America, most research has been published on the legume *Sericae lespedeza* (SL), a warm climate plant. The mechanism may be 2-fold. While there may be a direct effect by CT on the ability of the adult parasite to produce eggs and for those eggs to develop to infective larvae in the faeces, at least some of the effect is from the elevated levels of by-pass protein available to the animal. Animals fed SL also have an improved immune response over animals on a control diet. Low levels of CT in the diet have been shown to increase reproductive performance and wool growth independent of parasite load. However, CT can be toxic to the animal if too high and high levels in the diet decrease feed consumption and have a negative effect on performance.

Two temperate climate plants with some potential benefits are Bird's Foot trefoil (*Lotus corniculatus*) and Sulla (*Hedysarum coronarium*). Experimentally, sainfoin (*Onobrychis coronarium*) has been reported as both beneficial and of no benefit. There are other CT plants and tree extracts (Quebracho extract for example) that are promising and may be a helpful adjunct to other control measures. More research is needed using species that grow well in Canada.

3.4.3 Nematophagus Fungi

A fungus *Duddingtonia flagrans*, grows in faeces - sending out hyphae that will trap and kill the free-living forms of GIN in the faecal pellets. While these fungi occur naturally, in order to get them into the faeces in sufficient quantity to be effective, the spores must be fed to the sheep daily for a minimum of 60 days. The intent is to feed at turn-out for a period of time to disrupt the build-up of L3 on pasture until the season is advanced enough that disease will not occur in that grazing season. Research has focussed on feeding ewes during the PPER - the major source of spring pasture contamination, which should then spare the lambs. This could be viewed as preferable to using anthelmintics which will select for AR. At this point, daily dosing is not practical for grazing sheep and a bolus is being developed that will deliver spores over a longer term.

3.4.4 Copper Oxide

There has been much published on the use of copper oxide wire particles to control GIN. This product was first developed to supplement sheep and goats in areas of the world with copper deficiency. It appears only effective in reducing infections due to *Haemonchus contortus* and only temporarily. It does not appear to improve weight gains (over controls). It does elevate liver copper levels in sheep. Given the copper status of sheep in central Canada where copper toxicosis is already an issue, use of copper oxide wire particles is not advised. It is also critical to realize that copper sulphate(bluestone) should NEVER be fed to sheep or goats. There have been several cases of copper toxicity in both sheep and goats related to producers feeding copper sulphate in the mistaken belief it will control parasites.

3.4.5 Vaccination

A large international research effort is currently underway to develop a vaccine against *Haemonchus*. A particular antigen known as H-gal-GP appears to confer protective immunity against *H. contortus* when lambs are vaccinated. Issues to resolve include purifying and manufacturing sources of this antigen and performing field trials to determine the conditions in which the vaccine best performs. It should be noted, however - that this vaccine will not control other GIN such as *Teladorsagia* or *Trichostrongylus*

3.4.6 Alternative Dewormers

There have been many “alternative” or “natural” deworming products recommended over the years. Some are toxic to sheep and goats as well as the parasites (e.g. nicotine). Some do not work in controlled, peer reviewed studies (garlic, papaya seeds). Diatomaceous earth has been used as an anthelmintic but there is no scientific evidence that it is efficacious. It may be useful for control of external parasites but more research needs to be done to show sufficient efficacy and safety. It is dangerous for humans to inhale. There are other herbal plants that have been hypothesized to be effective parasiticides, (e.g. Neem oil) but at this time there is insufficient supportive scientific evidence for this claim, and safety for both animals and humans has not been demonstrated.

Below is the abstract of a recently published review of the scientific literature on alternative methods of parasite control.

A Systematic Review-Meta-Analysis of Primary Research Investigating the Effect of Selected Alternative Treatments on Gastrointestinal Nematodes in Sheep Under Field Conditions.

Mederos A, Waddell L, Sánchez J, Kelton D, Peregrine AS, Menzies P, Vanleeuwen J, Rajić A. *Prev Vet Med.* 2012.104:1-14

Selected alternative treatments for preventing or controlling gastrointestinal nematodes (GIN) in sheep under field conditions were evaluated using a systematic review-meta-analysis methodology. Forty-three publications reporting 51 studies (21 controlled studies (CS) and 30 challenge studies (ChS)) and 85 unique treatment comparisons were included in the review. The alternative treatment categories were nutraceuticals (28 studies), breeding for genetic resistance (12), nutritional manipulation (6), homeopathies (2), administration of copper oxide wire particles (2), and biological control (1). Random effect meta-analyses (MA) and meta-regression were performed with the natural logarithm of the difference in means (lnMD) between the control and treatment groups, for fecal egg counts per gram of wet feces (FEC), worm counts (WC) or fecal egg counts per gram of dry matter (FECDM) as the outcome. Treatment effect estimates (lnMD) were back-transformed to their count ratios (CR), a relative measure of effect for controlled versus treated groups, for presentation of results.

Significant heterogeneity was observed for both CS and ChS that evaluated nutraceuticals, genetic resistance and nutrition treatments. MA of ChS that investigated nutraceuticals resulted in a significant overall CR of 1.62 ($P<0.01$) and 1.64 ($P<0.01$) for FEC and FECDM, respectively and a marginal significant CR of 1.14 ($P=0.06$) for WC, all favoring the treated groups. MA of CS and ChS that investigated genetic resistance resulted in a significant overall CR of 5.89 and 15.42, respectively ($P<0.01$), again favoring treated groups. MA of CS that investigated homeopathies with FEC as an outcome were homogenous ($I(2)=0.0\%$) and resulted in a non-significant pooled CR of 1.61. ChS investigating copper oxide wire particle treatments and WC as an outcome, were homogenous ($I(2)=0.0\%$) and had a marginally significant pooled CR of 1.68 ($P=0.06$). Publication bias was observed for ChS with WC outcomes, indicating that small size studies reporting non-significant CR, were less likely to be published than similar studies that found a significant CR. In a meta-regression, randomization (6.2%) and study size (29.2%) were the main factors contributing to the total variation when the outcome was FEC, and none of the variables contributed to between study heterogeneity. When the outcome was WC, type of treatment was the only significant covariate, explaining 6% of the heterogeneity and 38.5% of the total variation. The methodological soundness and reporting of primary research in the selected studies were low. Our results indicate that from the studied alternative treatments, nutraceuticals and use of genetically resistant sheep might be more promising for control of GINs in sheep.

★ 4. QUARANTINE AND TREAT NEW INTRODUCTIONS

Purchased sheep or goats may introduce parasites, and possibly AR. While performing a FEC may determine if infection is present, it may be more prudent to effectively treat the animal(s) while in isolation and then expose the animal to the farm parasites prior to mixing. Because these recommendations are very farm specific – you must involve your flock veterinarian in developing this protocol. Below are suggestions as to how this may be done.

4.1 TREAT ALL NEW INTRODUCTIONS WHILE IN ISOLATION

Purchased sheep and goats should not be turned out with your flock or onto pastures grazed by your flock until the possibility of AR parasites has been minimized.

4.1.1 Unknown History of AR in the Farm of Origin

Treat with a full dose of ivermectin (following the rules that you need to weigh the animal and give an effective dose). Goats need a higher dose (1.5 X the sheep dose). Treat by drench, not injection. After the animal has swallowed the anthelmintic, follow-up this treatment with a full dose of a BZ anthelmintic (don't mix together)- either fenbendazole or albendazole (not in ewes or does that may be in their first 30 days of pregnancy). Goats require a higher dose (double the sheep dose). The BZ treatment can be repeated in 12 hours on the advice of your flock veterinarian.

4.1.2 If Resistance to ML & BZ Dewormers is Known to be Present in the Farm of Origin

You need to consult with your flock veterinarian about the possibility of using either levamisole (which your veterinarian must source from a compounding pharmacy) or moxidectin (also not readily available in a form suitable for sheep or goats).

4.2 HOLD TREATED ANIMALS OFF PASTURE

The sheep / goat should be held off pasture and ideally in a drylot for at least 48 hours to allow passage of any parasite eggs. Manure from this holding time needs to be properly composted so that the resistant eggs and larvae are killed.

4.3 TURN ANIMALS ONTO A CONTAMINATED PASTURE

If the new introductions are still infected with GIN, they will be very resistant! This means it is important to dilute any eggs they may still be passing with “farm” parasites, which is accomplished by turning them onto contaminated pasture, ideally one which has a high level of refugia.

4.3.1 If no contaminated pasture is available

Keep the treated animal(s) in isolation. During the grazing season, have a FEC performed on them 14 days after treatment. If more than 10 animals, samples can be pooled from 10 randomly selected animals. If fewer, do individual samples. If still positive, consult your flock veterinarian on other available treatments. If the animals are purchased during the winter months, FEC may not be useful as the parasites are hypobiotic. You must do FEC in the spring prior to turn-out to assess if they are still infected with resistant GIN.

★ 5. INVESTIGATE TREATMENT FAILURE

5.1 IS IT PARASITES THAT ARE MAKING THE ANIMALS SICK?

If your animals appear not to respond to treatment or are showing signs of parasitism despite deworming recently, you must investigate the reason for this. While the signs of parasitism can be very dramatic, other diseases may be the cause of poor growth or diarrhoea, or even sudden death. Poor growth can be nutritional in origin (e.g. poor pasture, selenium deficiency). Diarrhoea can be due to coccidiosis. Pulpy kidney (*Clostridium perfringens* type D) can be the cause of sudden death on lush, green pasture.

Have FEC's performed (if ML's were used, 14 days after treatment; if BZ was used 10 to 14 days post treatment). If animals have died, have your veterinarian or local diagnostic laboratory perform a necropsy and abomasal worm count. Just seeing a few worms in the stomach is not "proof positive" that they killed the animals, they need to be measured and counted as described previously.

5.2 TESTING FOR PRESENCE OF ANTHELMINTIC RESISTANCE

If the FEC is still high, perform a drench response test as described previously. Make sure you are delivering a sufficient dose of the dewormer. If the treatment fails to reduce the FEC, you and your veterinarian need to discuss if you should pursue a faecal egg count reduction test. If AR is confirmed, review this document, and with your flock veterinarian develop a plan for managing parasites.

5.3 RE-ESTABLISHING A SUSCEPTIBLE PARASITE REFUGIA

If AR has been identified on a sheep property, is it possible to re-establish susceptible refugia? The jury is still out on this one. The refugia is reduced through either leaving the pasture fallow for a long period of time, grazing with another species such as cattle or horses (not goats or sheep), or ploughing and reseeded. Lambs or kids that have been purposely infected with susceptible GIN are then introduced to seed the pasture with susceptible L3. Then the flock of that farm is grazed on these pastures and the new infection will dilute the level of resistant parasites carried by those animals. Difficulties with this approach are to first invest in reducing the refugia and then to locate lambs or kids with heavy loads of susceptible GIN.



Sheep and goats raised organically need not suffer from clinical parasitism, but producers must invest heavily in the principles of sustainable Integrated Parasite Management. A recent study performed on conventional and organic sheep farms in Canada found little difference in the level of parasites on these two types of farms, although there was tremendous variation in parasite loads between individual farms. Producers must remember though that reserving treatment only in the face of clinical disease is not appropriate for proper control of GIN parasitism and has welfare implications. Use of unproven, potentially toxic “alternative” compounds should be avoided.

THE ORGANIC PRODUCTION SYSTEMS—GENERAL PRINCIPLES AND MANAGEMENT STANDARDS

(CAN/CGSB 32.310-2006 Amended October 2008)

Section 6.7.4

Medical treatment for sick or injured livestock shall not be withheld to preserve their organic status. All appropriate medications shall be used to restore livestock to health when methods acceptable to organic production fail.

Section 6.7.9:

Organic livestock operations shall have a comprehensive plan to minimize parasite problems in livestock.

- a. The plan will include preventive measures such as pasture management and faecal monitoring, as well as emergency measures in the event of a parasite outbreak.
- b. By way of derogation, when preventive measures fail, the operator may use parasiticides not listed in CAN/CGSB-32.311, *Organic Production Systems - Permitted Substances Lists*, provided that:
 - xii faecal samples or animal examination indicate that an individual or group of animals are infected with parasites;
 - xiii the operator has received written instructions from a veterinarian indicating the product to be used, the individual or group of animals to be treated, the dose and route of administration;
 - xiv withdrawal times are twice the label requirement or 14 days, whichever is longer;
 - xv slaughter animals under one year of age can be treated only once and slaughter animals over a year of age can receive a maximum of two treatments. Slaughter animals that require further treatment will lose organic status; dairy animals needing more than two treatments per year (antibiotics and/or anthelmintics) will lose their organic status and shall go through a 12-month transition. These dairy animals shall never be organic for slaughter purposes;
 - xvi under this derogation, a dam may be treated during gestation;
 - xvii a producer will create a written action plan (including timing), describing how they will adjust/change their parasite control plan to avoid similar emergencies.

CAN/CGSB-32.311, Organic Production Systems - Permitted Substances Lists

This section indicates that parasiticides are allowed but what constitutes a parasiticide is not defined. Producers should always check with their certification body for proper interpretation of the regulations prior to treating animals with products not listed.

