Preserve Susceptible Worms on the Farm (*Refugia*)

It is important to preserve susceptible worms within an '*in refugia'* population (see section in 'What is AR') so they can compete with those that have been selected for resistance by treatment. Increasing the size of the *in refugia* population so resistant alleles can be diluted in the population is a key concept in delaying the development of AR. This means that we need to take particular care with treatments where there are pastures which have a low level of contamination, if we wish to take advantage of the benefits of the grazing, while minimising the selection pressure for resistance on the worm population.

There are two main ways to preserve susceptible worms on the farm:

- **Managing the pasture**
- **Managing which animals to treat**

1. Managing the pasture

The 'dose and move' strategy was widely recommended in the past because dosing sheep with anthelmintics before placing them on a low contamination pasture (a "clean" pasture)was considered to be a cost-effective method of achieving good worm control. Unfortunately, this strategy also selects heavily for AR, because any worms surviving treatment (and therefore more likely resistant) will enjoy an extended period of reproductive advantage over unselected parasites, during which time they contaminate the pastures with their eggs. The benefit of the low contamination pasture in terms of challenge may persist for weeks or months, but the levels of contamination will gradually build and ultimately this will be a highly resistant population of parasites.

There are two alternatives to the traditional 'dose and move' strategy –

'Move and then dose'
Untreated sheep are moved onto the low contamination (cleaner) pasture for a few days before treatment, so they contaminate the pasture with an unselected population of worms before being treated themselves. However, more recent evidence, where lambs were moved and then left for one week before treatment suggests that this may give rise to high levels of contamination. If this strategy is used, then FECs should be monitor the egg output of sheep before the move. If it is high, then a short period should be considered.

'Dose, delay and then move'
An alternative is to allow the treated flock to become 'lightly' re-infected before allowing them access to the low contamination pasture. This will ensure that soon after the move, contamination of the 'clean' pasture with eggs from unselected parasites will recommence. The reproductive advantage offered to the selected (resistant) parasites will be short (the pre-patent period minus the number of days the sheep were withheld after dosing) and then will depend on the degree to which the sheep became re-infected after dosing.

The number of days for which dosed sheep should be allowed to graze contaminated pasture before being given access to the 'clean' grazing will depend on variations in pasture infectivity (number of infective larvae available on pasture) and climatic factors. If the pastures are of high infectivity and the sheep reasonably susceptible to parasites (less than one year old, for example) then 4–7 days of grazing may be a satisfactory compromise between making best use of the 'clean' pasture resource and reducing the selection pressure for AR.

NB. Sheep treated with moxidectin will not become re-infected with Teladorsagia or Haemonchus for five weeks after dosing (longer for the long acting 2% LA product), so 'dose, delay and then move' and moving treated sheep onto dirty pastures are both strategies that do not usefully reduce selection pressure on 3-MLs in those worm species. Selective treatments as below are the only option in this case.

2. Managing which animals to treat

Part flock treatment
Some animals in the flock can be left untreated, allowing a pool of unexposed parasites to produce eggs that are passed out on to the low-contamination pasture.

It has been suggested that, as a rule of thumb, leaving about 10% of the flock untreated can delay AR. However, to correctly estimate the proportion of animals to be left untreated to have a significant effect on AR, a farm specific model would probably be needed to take into account parasite population (composition and size), level of AR and the farm conditions (climate and pasture management) and the frequency of resistant alleles in the worm population.

Targeted selective treatment (TST)
In practice, the SCOPS principles are now moving towards minimising the number of animals treated at any one time through the use of TST. Selection of animals to be left untreated is aimed at recognising those which exhibit greater resilience. This means the ability to thrive despite parasitic challenge, or those animals with the lowest worm burdens (resistance) that can be left untreated safely because these animals should be able to cope with worms without needing anthelmintic treatment. Selection can also be done randomly, but this has been shown to have a negative effect on animal performances and could potentially impact on animal health and welfare. Markers/indicators to select animals include production indices, diarrhoea (dag or breech soiling) score, faecal egg counts (FECs), FAMACHA©

- Production indices include milk yield in dairy goats, body condition score (BCS) or live weight gain. BCS and live weight gain are both based on individual assessment and comparison of previous production records so that treatment is targeted to those animals that are not achieving the predicted performances (increasing/maintaining BCS or reaching predicted weight gain). Changes in BCS and weight are useful but one-off measures of BCS, or weight, are not suitable markers. A specific marker that has received particular attention and has shown good result is the Happy Factor™, an indicator of the need for treatment based on the prediction of liveweight gain from nutrient availability (McBean et al., 2016).
- The presence of diarrhoea (dag or breech soiling) has been widely used by farmers as an indication for the need to administer anthelmintic treatment, due to its practicality and perceived association with gastrointestinal parasite. It has been shown that scores 3 or higher (on a scale 1- no visible faecal soiling, to 5- severe, watery diarrhoea) are associated with lower weight gain, suggesting a possible use of this indicator as a marker for impaired growth rate (Busin et al., 2014).
- FECs are used mainly as an indicator of group treatment, by selecting to treat those groups with the highest worm egg count, rather than individual animals.
- The FAMACHA© is based on the evaluation of the mucous membranes of the conjunctivae using a 5 colour chart score (1 – normal to 5 – severe anaemia), with animals showing a score at 3 or higher selected for treatment. It is, however, only applicable for *Haemonchus contortus* infection and not the other trichostrongyles. FAMACHA colour charts are only available to certified individuals. Online certification is available from the University of Rhode Island (https://web.uri.edu/sheepngoat/famacha/).

Farmers may have reservations on the TST approach for different reasons. The first is the time and labour cost involved in applying this strategy, especially when compared to the availability of comparatively cheap products. There is the perception that leaving some animals untreated could negatively affect production and, finally, the perceived lost opportunity to keep a field 'clean'. However, all of these concerns should be seen in the long-term strategy of maintaining effective anthelmintics through their sustainable use versus the development of AR to all of the available drugs, eventually compromising worm control all together. It should be emphasized to farmers that there are many well-documented examples of successful application of TSTs (Charlier, J., et al. (2014))

Work is still ongoing in this area, looking at the most reliable, “pen-side” and cost-effective marker, exploiting the concept of precision farming medicine to automatically identify and draft out animals that could be left untreated. Farmers looking to exploit the concepts of *in refugia* using the TST approach should seek advice. Click here to see a paper on the validation of the “Happy Factor’ for lambs, a weight based TST algorithm.

TST for Ewes

The treatment of ewes around lambing in response to the PPRI is discussed in the ‘Use only when necessary’ section. However, it is important to note that there is a need to avoid treating all ewes at this time to preserve the in-refugia population, which may be relatively small in the spring, particularly following a winter where over-wintered larvae are in lower numbers. If the long acting preparation of moxidectin is to be used this is essential. Poor body condition is a key indicator of those ewes which are likely to shed the most eggs around lambing. Litter size can also be used, but it is important that farmers do not simply leave single bearing ewes untreated since they are most likely to remain in one group, leaving multiples in another with all ewes treated. The aim is to leave at least 10% of ewes untreated, but where ewes are well fed and in good body condition this % can be increased, reducing any selection pressure imposed.

Where *haemonchus contortus* is known to be a problem in a flock, the FAMACHA test can be used to identify which animals require treatment. Body condition is also an indicator and with modern weighing equipment some farmers are now also using weight change which is more sensitive as a possible indictor of those ewes that require drenching.

References - Targeted selected treatments

Rizzon Cintra, M. C., et al. (2019). "Is the Famacha© system always the best criterion for targeted selective treatment for the control of haemonchosis in growing lambs?" Vet Parasitology 266: 67-72.

McBean, D., et al. (2016). "Viability of the Happy Factor™ targeted selective treatment approach on several sheep farms in Scotland." Veterinary Parasitology 218: 22-30.

Busin, V., et al. (2014). "Production impact of a targeted selective treatment system based on liveweight gain in a commercial flock." Veterinary Journal 200(2): 248-252.

Charlier, J., et al. (2014). "Practices to optimise gastrointestinal nematode control on sheep, goat and cattle farms in Europe using targeted (selective) treatments." Veterinary Record 175(10): 250-255.