Non-Pharmaceutical Control of Endoparasitic Infections in Sheep

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Prior to 1960 researchers, advisors and farmers were forced to consider and use several non-pharmaceutical options to control internal parasites, but this changed as a number of highly effective, safe and relatively cheap anthelmintic drug groups came into use over the next 25 years. Worldwide, this resulted in an almost total reliance on anthelmintics to control sheep worms; initially, this was rewarded by dramatic suppression of worm burdens. Systems such as regular, blanket deworming of the flock with immediate movement to fresh (uncontaminated) pasture after treatment, became universally advocated. However, the very success of these drugs carried with them the seeds of their own destruction, since the only worms that could survive this treatment onslaught were those that had genes for anthelmintic resistance (AR) - now a major international problem. Unintended selection for AR has to be stopped, since there will nearly always be a need for treatment with highly effective remedies when circumstances dictate. Non- pharmaceutical control is thus not in opposition to conventional drug therapy, but rather an adjunct and ally. The need for sustainable, holistic and integrated parasite management (SHIPM) is now almost universally recognised (1-5). Veterinary advisors and their clients should accept this paradigm shift. Admittedly, SHIPM is more difficult to implement and manage than purely pharmaceutical methods, but in every country where it has been tried, these holistic measures have proven to be practical and sustainable (2,6,7).

REDUCE THE RATE AND AMOUNT OF CONTAMINATION

This applies firstly to the pastures and secondly to the sheep.

- Internal parasites build up in “worm hotspots”, such as continually wet areas, where sheep are attracted to graze intensively. This causes greater contamination of these areas; moisture then ensures a higher larval survival, while intensive grazing means the sheep are eating very short

grass, heavily contaminated by larvae. Examples are marshes, around leaking water troughs, or overnight pens. Either eliminate these areas or manage them carefully (7).

- Short cropped grass contains more concentrated larvae, so do not use such pastures for susceptible sheep.
- The greater the grazing pressure (number of sheep per area per time), the more the contamination of the pasture there will be. Reduce this where possible.
- By resting a pasture for long enough, fewer larvae will survive. The time needed for this varies with the worm species and climate, but generally a rest of two to three months is helpful in a temperate climate during the hot, summer months (1).
- Alternating pasture use with grazing species that are not susceptible to sheep worms (this excludes goats) will assist in that the pasture can be grazed more intensively or more often, the other grazers actually clean up the pasture by consuming larvae, but not allowing them to survive (7,8).
- The type of pasture influences larval survival and ingestion by sheep: thus alfalfa and shrubs may be less dangerous than grass.

IDENTIFY AND PROTECT THE MOST VULNERABLE SHEEP

This usually applies to nursing and weaned lambs, as well as to lactating ewes and ewes in late-pregnancy. Old or sick animals also need extra attention (7). These sheep should be given the safest grazing by allowing them to graze new or well rested pastures first. They will require extra monitoring and probably also more treatment. Sheep on the farm that do not fit these categories will not require the same treatment protocol. To treat all categories similarly is unnecessary, uneconomical and will lead to AR.

REDUCE THE SELECTION PRESSURE FOR ANTHELMINTIC RESISTANCE

If all the sheep in a group are treated and immediately moved to a “clean” pasture (with very few larvae) the only worms (and thus worm eggs) that survive to contaminate the new pasture are resistant to the anthelmintic drug used (8). This is a potent though unintended way to hasten the onset of AR, since these refractive parasites quickly become the dominant population on a farm. There are several ways to prevent this:

- First, treat only the animals that are likely to benefit from it. This is known as Targeted Selective Treatment or TST (2) and can be done on-farm by the use of a number of techniques that require direct monitoring. By only treating some sheep, it takes much longer for the resistant worms to become dominant.
- Second, the entire flock can be treated, but at times when this is most useful and when there are many worm eggs or larvae in refugia (mainly on the pastures), which escape exposure to the drug and thus escape selection for AR. This is known as Targeted Treatment (TT) (2).

- Thirdly, if the whole flock is to be treated, the sheep should be kept on the pasture where they have been grazing for a few more days to weeks to allow them to ingest unselected larvae and thus slow AR development. This is termed Treat All Then Stay (TATS) (7). With TATS, the time needed to leave sheep on that pasture is related to the action of the anthelmintic used. Drugs that have a prolonged action require the sheep be left longer, since unselected larvae can only establish themselves in the host after the effective residual drug action ends.
- The fourth option is to move the flock onto fresh pasture and delay treatment for a few weeks to contaminate it with unselected eggs - Move First Then Treat (MFTT).
- The final action to be taken to prevent the rapid onset of AR in a flock is to apply strict quarantine on all sheep or goats that enter the property. This prevents the unwitting importation of resistant parasites from other farms. In practice, this requires that no new animals go straight onto pasture. Instead they must be kept in pens without pasture or grass, and subjected to intensive treatment with a range of effective remedies. Prior to release and after a suitable waiting period, they are checked for surviving worms using a quantitative fecal egg count (FEC) to ensure minimal contamination of pastures with imported AR worm eggs. Then, the new sheep must be put onto pastures contaminated with eggs and larvae present on the farm. These will help dilute out any remaining AR worm population that survive in the new animals.

MONITORING OF WORM INFECTIONS

The era of fixed treatment programs, strategic treatment and repeated treatment of entire flocks has passed, since although these work well for some time, they are a sure recipe for creating widespread and severe AR (1,8). Instead, a flock should be monitored and treated according to current circumstances as well as parasite load. There are several practical, economical, simple and reliable ways to achieve this. The FEC is widely used for monitoring worm species but has several serious limitations. Each species has its own egg laying capacity, *Haemonchus contortus* being very prolific, whilst *Nematodirus* species are the opposite. Unless this is taken into account by indentifying the eggs, the numbers in the FEC can be very misleading. Secondly, the count will not accurately reflect the number of worms in the host, except in lambs. This is because adults can become resistant to worms and suppress egg laying. The sample taken must also be representative of the flock and, at least 10 and up to 20 animals should be sampled. If the same volume of feces is taken from each sheep, then the sample can be pooled to save costs. The FEC is a good indicator of pasture contamination rate and gives a warning of approaching danger, if it is done on a flock basis every one to two months depending on the season (7,8). Allied to the FEC is the Reduction Test (FECRT) which measures the efficacy of the drugs tested and is useful in giving early warnings of AR and identifying which drugs to use (9,10).

Identifying animals that can benefit from treatment is a good way to reduce the onset of AR and is economically sound. Most of the tests proposed for this are impractical for on-farm use, but clinical

anaemia caused by hematophagous worms is a well proven exception (6). This system, known as FAMACHA©, only requires the examination of the ocular mucous membrane and comparing the colour seen with a standard, five-category illustration. Paler shades are treated and redder shades are not. This means that only animals compromised by blood-sucking worms (mainly *H. contortus)* are exposed to the drug while the rest retain unselected worms, thus slowing AR. Savings on dewoming are considerable, usually in excess of 50%. Very susceptible sheep can also be identified for culling.

A further extension of the principle of TST was announced in 2009, known as the Five Point Check© (11). In this system, i. the nose is checked for discharge that indicates nasal bots, ii. the eyes are checked for anemia indicating blood-sucking worms, iii. the jaw is checked for submandibular edema that also accompanies anemia and protein-losing enteropathies caused by parasites such as the conical fluke (*Callicophoron* sp.), iv. the back for body condition score (BCS) indicating possible infection by internal parasites like *Teladorsagia* and *Trichostrongylus* species and finally v. the tail for signs of diarrhoea, indicating mainly worms that also cause loss in body condition score. This quick, easy and cheap checking system is readily adopted by farmers, since they can do this in the crush and immediately identify which sheep are likely to benefit from treatment. While there are many other causes of these signs, the most important ones include internal parasites; the sheep least likely to benefit from treatment can be passed over, slowing the onset of severe AR. The BCS system does require some practice and expertise in performing body condition scoring accurately and repeatedly; however, this is a skill every stock farmer should have, as it is also useful to monitor nutrition and the correct condition for each phase in the reproductive cycle. The Five Point Check© needs further testing and refinement to make it useful in a variety of conditions. Apart from the scoring systems, it contains tables of the likely parasites involved as well as which drug groups should be used. The mottos of TST summarise the intentions: "*Leave the best, and treat the rest*" or "*Look before you treat*"!

Another way to apply TST is by measuring changes in body weight, but this will only work where the farm is geared up for regular (twice monthly) weighing (2). Animals showing the slowest growth rates can be identified for treatment, but more importantly those with the fastest growth rates can be left untreated. Obviously, this only applies to young weaned sheep, which are most at risk from helminthosis. If tapeworms are seen to be a problem, then lambs with potbellies and poor growth or condition can be identified for treatment.

A test on feces for occult blood has been developed, but it is unsuitable for TST due to the time and expense of individual testing and, like FAMACHA©, it is only applicable to hematophagous worms (12). Its use lies at a group or flock level, since it gives a quick, easy and cheap warning of a build-up of these parasites and the need for enhanced surveillance and control measures (TTS) (2).

Monitoring the weather and the grazing management applied can also give timely warnings of potential or impending conditions conducive to worm infections so that appropriate measures are taken in good time.

INCREASING RESISTANCE TO WORMS IN SHEEP

In the past, far too much attention was given to making the environment suitable to sheep, rather than the other way around. Deficiencies in the animal were covered up by increasing treatments and this reliance on drugs has led to widespread AR. However, resistance (the capacity of the animal to prevent infection) and resilience (the capacity of the animal to cope with infection) have not been given the attention they deserve. It has been shown that these traits do not compromise key production or reproduction parameters much, if at all (13-15). Furthermore, they are heritable at levels (typically around 25% to 30%) that allow practical selection and culling to have a meaningful impact within five years.

There are practical and economical ways of identifying and selecting rams that show superior resistance or resilience. By using an index of FECs, those rams with the lowest counts in a group of animals exposed to the same parasite challenge can be selected for resistance with confidence (14,16). More recently clinical anemia (FAMACHA© findings) or hematocrit results has also been shown to be a reliable indicator of resistance and resilience to *H. contortus* (17). Since these traits usually apply to other worms too, selection will assist in breeding sheep with a strong ability to withstand internal parasites. The same is true of selection based on changes in body weight, provided in all cases that the animals are subjected to a realistic parasite challenge prior to selection. Ewes in large flocks may be more difficult to select, but at least the poorest group (usually <10%) can be easily identified by the Five Point Check© and culled from the breeding group. The motto should be "*Stop Selecting Sissy Sheep*"!

Animals can only express inherent resistance and resilience if they are adequately fed. This applies especially to protein, although, in addition, insufficient copper, iron, selenium, vitamin A and zinc intakes may inhibit the immune response of the animals (18).

It is often forgotten that sheep will develop effective immunity only if they are exposed to regular low levels of parasite challenge. Aggressive treatment results in negligible larval challenge and thus a loss of immunity. Aim for safe, not worm-free, environments. Unfortunately, although vaccines are a theoretical possibility, no vaccine has thus far proceeded to the commercial implementation stage.

Another factor to consider is that a sick sheep is a susceptible sheep. By controlling other diseases, we enable the animals to mount an effective immune response to worms. Finally, by separating the most susceptible categories of sheep (lambs, lactating and heavily pregnant ewes) we can ensure that animals of approximately equal abilities to mount an immune response are run together and can thus be managed accordingly.

CONTROL MEASURES UNDER DEVELOPMENT OR UNPROVEN

The use of copper oxide wire particles dosed by capsule into the rumen has recently been proven to control *H. contortus* for a prolonged period in goats, but also in sheep (18). In most situations, this extra copper is quite safe, but sheep are peculiarly susceptible to poisoning, hence the level of copper in

grazing and supplements needs to be established beforehand. The legume *Sericia lespedeza* has been shown to suppress *H. contortus* worm burdens and FECs, probably by virtue of its high levels of condensed tannins (18). A number of other tanniniferous plants have also been identified. Collectively, these plants promise to make an important contribution to worm control, although the exact methods of management and implementation remain to be determined.

A range of herbal preparations are claimed to be effective, but in nearly all these cases good scientific evidence is either lacking or extremely limited. Extravagant claims may be found on the Internet, but these have to be treated cautiously until they have been properly evaluated. The same is true of "natural" products like Diatomaceous Earth which has good science behind its use against insects in grain silos, but much less to support its use against worms. In all these cases, it must be remembered that a measurable effect on worms does not necessarily mean a meaningful effect in parasite control. An efficacy of 20% is measurable, but not necessarily meaningful. In most countries that would not entitle such a product to be registered for use as an anthelmintic.

The use of nematophagous fungi has been extensively investigated, but although the theory is good, no practical product has emerged. Since it is known that some fungi are able to immobilise and then consume larvae in dung pats or on the pasture, it was hoped that dosing animals with these fungal spores could lead to effective worm control.

SUMMARY

The need for sustainable, holistic and integrated parasite management against sheep worms is emphasized. Approaches include lowering the rate and amount of contamination of pastures, identifying and protecting the most vulnerable animals, reducing the selection pressure for anthelmintic resistance, monitoring of parasite infections and increasing the resistance and resilience of sheep. Control measures under development are briefly discussed.

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