Breeding for resistance to parasites

There are variations in the strength of acquired immunity (resistance) to parasites between individual sheep within a flock. Part of this variation is genetic, and it is therefore theoretically possible to selectively breed for sheep that are more resistant to internal parasites. In flocks that have undergone selection for low FEC, lambs developed stronger acquired resistance, had lower FECs and lower worm burdens than lambs in unselected flocks. Adult ewes in selected flocks had a smaller rise in FEC during the Peri-Parturient Relaxation in Immunity (PPRI) (see Chapter 3. Internal Parasites and Diseases, section 3.3 Host Immunity, 3.3.1 The peri-parturient rise) and their lambs had lower FECs at weaning. However, work is still on-going because there is a cost to the animal in mounting the immune response, which can result in reduced performance.

It is important to note that selection programmes do not confer a significant advantage on lambs compared to lambs in unselected flocks until they are at least 4–5 months of age, when acquired immunity begins to kick-in. This means that as a tool for worm control, genetic resistance is of the greatest benefit when applied to breeds involved in producing breeding stock rather than terminal sires. A flock of ewes that has been sired by rams that are more resistant to worms will cause less pasture contamination with worm eggs at all times of the year, including at lambing. This reduction in contamination will provide substantial benefits to their lambs.

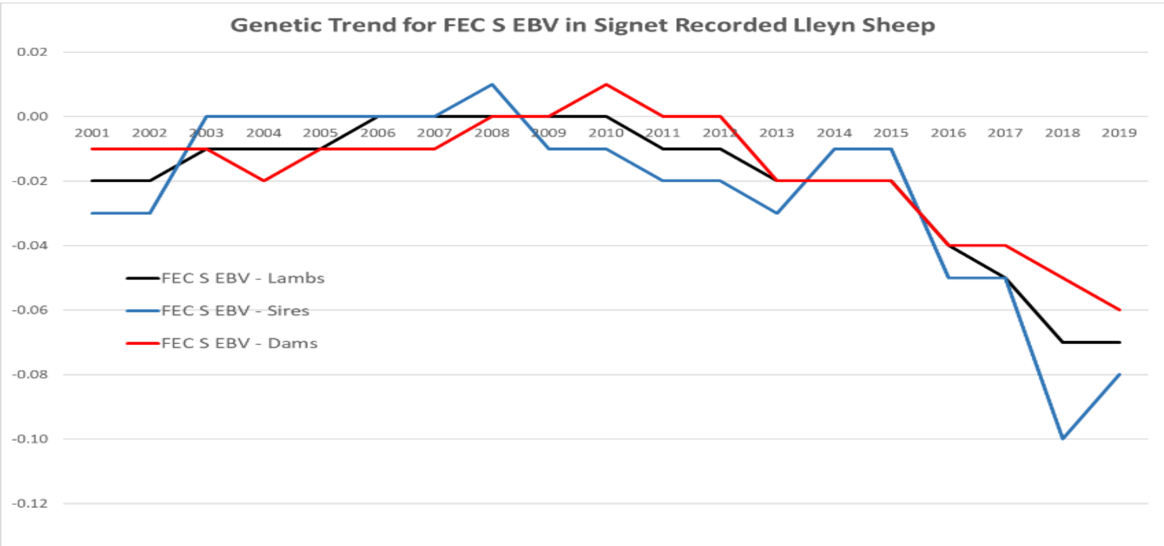
Therefore, selection for parasite resistance can only really be done effectively in flocks breeding and selecting rams. Even those commercial sheep producers who breed their own ewe replacements cannot achieve any significant genetic improvement in their flocks by ewe selection, if the sires they use to breed ewe replacements come from another unselected flock. Producers wishing to improve the genetic resistance of their flocks must either breed rams themselves or buy rams from a breeder who has been selecting for resistance to worms.

Breeding for Worm Resistance in the UK

Selection for low FEC is practiced in some ram-breeding flocks in the UK. Over the last 20 years, nearly 30,000 lambs have been sampled and their data included within Signet's breeding evaluations. Data has been obtained from 13 different breeds over this period, however in the last 5 years over 75% of the samples received have come from Lleyn breeders, with significant numbers of samples also provided by Exlana and Romney flocks.

Progress has been challenging. The collection of FEC samples is time consuming, expensive and comes at a cost to the enterprise in terms of lamb performance. At a breed level, genetic change is slow but heading in the right direction. Within dedicated flocks faster progress is being observed, in part through the culling of poor performing breeding lines – rather than selection for highly resistant stock.

Figure 11. Genetic Trend for FEC S EBV in Lleyn Sheep



Heritability - how much of the variation between sheep is under genetic control?

Heritability is generally thought to be relatively low and this has been confirmed by work carried out since 2000 by AHDB which has supported the collection of FEC phenotypes and data analysis. Disappointingly, while earlier work in experimental flocks suggested that an animal's genes might explain 30-40% of the variation observed between individuals, the current heritability values within the Lleyn dataset are only 0.07 (s.e. 0.02) (Strongyles) and 0.21 (s.e. 0.03) (Nematodirus) respectively; i.e. only 7% and 21% of the variation between animals can be explained by their genes.

The genetic correlation between the two egg counts (Strongyles and Nematodirus) is 0.49, indicating that selection for either species would reduce some of the challenge posed by the other. Genetic correlations with other performance traits are low/negligible.

Why is the heritability of FEC so low?

In any analysis, it is right to question the data quality and analysis models used for assessing heritability. Within the Lleyn dataset, the contemporary groups are large – with lambs believed to be treated the same throughout their life and for the most part lambs are under a significant worm challenge. There are two potential weaknesses of the current approach to consider:

1. The range in lamb age at sampling is wide. Restricting the dataset to lambs sampled at a certain point in the year or age, may yield positive benefits in lifting the heritability of the trait, though the reduction in the size of the dataset may negate the benefit. Obtaining clearer evidence regarding the optimum age (heritability of FEC increases with age) and/or season for sampling may improve the accuracy or sample lambs may help in the future, though this is extremely likely to be season dependant.

2. The trait has a relatively low repeatability, suggesting that multiple measurements would give a more accurate overall prediction of egg output. This is a particular concern where faecal matter is extremely liquid (often in the most challenged individuals) and the obvious dilution of epg that this gives rise to can create bias, unless a protocol is employed that can take this into account.

Newer phenotypes for assessing worm resistance

First developed in Australia, as a biological marker for host response to infection with the larval stage of *Teladorsagia circumcincta,* the University of Glasgow has developed a UK test based on the animal's antibody responses in the form of IgA levels in saliva. This phenotype provides a new way to identify genetic differences in resistance to worms between sheep. High levels of IgA have been shown to be associated with the ability of the host to regulate worm growth and fecundity, leading to a decrease in egg output. However, while it is not possible to directly measure the amount of IgA in the intestine mucosa, it can be detected and measured in saliva and serum. The potential advantages of assessing IgA levels in saliva compared with FECs include possibly higher heritability (Strongyles: Saliva = 0.16: FEC = 0.08), the ease of sampling, sampling cost and the fact that sheep that have been treated with anthelmintic can still be sampled for IgA.

Results to date are variable with relatively low levels of repeatability (see Lleyn breeder projects) because saliva IgA is affected by timing of sampling, saliva flow rate etc. More work is being undertaken, but the Lleyn project is now looking at serum IgA. Preliminary results indicate that this is much more repeatable then either FEC or saliva IgA, though the cost of sampling and invasiveness of blood sampling make it less easy to carry out on farms.

Breeding for Worm Resistance Overseas

Evidence from selection in Romney sheep in New Zealand indicates that substantial and useful improvement can be made over a 10-year period, with selected flocks requiring substantially fewer anthelmintic treatments. Selection for low FEC does not appear to lead to significant correlated responses in resilience to parasites (as opposed to resistance).

Experiments have produced conflicting results about the existence of correlated responses between low FEC and production traits such as growth rate. Research has indicated that lambs with low FEC's do not always perform better than the lambs with high FEC's, and lambs which perform well when left undrenched do not always have low FEC's. What is clear, however, is that if selection for low FEC is pursued as the only or dominant trait, then the opportunity to continue selection for other traits is foregone. Breeders are advised to combine moderate selection pressure for low FEC with continued selection for production traits, such as litter size, maternal ability, growth rate and fat depth.

Lleyn Breeders Projects

In 2013, the Performance Recorded Lleyn Breeders received support from AHDB to collect Saliva IgA measurements and in recent years these measurements have been converted into EBVs (Estimated Breeding Values) to enable breeders to make more informed breeding decisions.

Once again, the heritability value obtained in this commercial dataset is lower than those values obtained in research environments, with a heritability of 0.11 (s.e. 0.02) observed in the latest Lleyn dataset (10,110 lambs with an IgA phenotype, of which 8,754 also had a FEC measurement).

Importantly, a genetic correlation is observed between Saliva IgA and Strongyles (FEC S) of -0.34, showing that selection for an enhanced Saliva IgA response will lead to a reduction in Strongyles egg counts, though this correlation is somewhat weaker than reported in experimental datasets.

Studies at Harper Adams (Barnes and Phillips, 2019) using high and low genetic merit Lleyn sires for FEC & Saliva IgA response have shown that a lamb's sire does have an important influence on these measures, thus demonstrating the value in breeding for these traits. However, their work repeatedly raised questions about the repeatability of both FEC and Saliva IgA measurements for lambs sampled 24 hours apart and at greater intervals – with considerable re-ranking of individuals observed between days. Again, the low repeatability of Saliva IgA may explain – at least in part - the lower than anticipated heritability value observed for this trait.

One extremely promising finding from the Harper Adams study was the much higher repeatability value obtained for blood serum IgA levels. The use of this measurement to predict worm resistance merits further investigation, not least because blood serum IgA levels tend to be the measurements that have yielded the greatest success under experimental conditions. The technical challenge for breeders in measuring this trait is the need for either veterinary assistance to collect blood samples or veterinary training to enable breeders to sample their own sheep.

Are we sampling the right species?

One potential challenge in interpreting FEC counts is getting an accurate picture of the worm species that are creating the challenge, bearing in mind that pathogenicity can vary between strains of worm.

James McGoldrick, Veterinary Diagnostic Services, University of Glasgow very kindly assisted AHDB with a small study in 2017, looking at the worm species hatched from 13 mob samples taken from Signet clients.

This very quick look at worm speciation highlights the variation seen between flocks in the proportion of Teladorsagia circumcincta, one of more challenging Strongyles species, compared to the less pathogenic Cooperia curticei.

Despite these challenges, there have been improvements in FEC measurement technology over time and FEC counts remain the "gold standard" in determining parasitic burden in the live animal.

Table 15. Average FEC S counts and speciation for a number of breeds.

Breed		Average FEC S Count of Group	Average FEC S Count of Group	Speciation provided by University of Glasgow (Funded by AHDB)			
				% T. circumcincta	*% C. curticei*	*% oesophagostomum*	*Other*
LLEYN	Flock 1	213	36	*62*	*30*	*8*	
LLEYN	Flock 2	208	44	*56*	*43*	*1*	
ROMNEY	Flock 3	456	32	*50*	*32*	*18*	
LLEYN	Flock 4	330	60	*50*	*40*	*9*	*1*
LLEYN	Flock 5	191	37	*47*	*42*	*11*	
LLEYN	Flock 6	186	32	*40*	*37*	*23*	
LLEYN	Flock 7	189	1	*39*	*48*	*13*	
LLEYN	Flock 8	795	17	*37*	*59*	*4*	
ROMNEY	Flock 9	621	29	*32*	*40*	*28*	
LLEYN	Flock 10	313	7	*32*	*58*	*6*	*4*
LLEYN	Flock 11	263	51	*25*	*74*	*1*	
ROMNEY	Flock 12	405	85	*21*	*72*	*7*	
ROMNEY	Flock 13	1325	154	*19*	*81*	*0*	

Exlana Composite

Vineer *et al.*, 2019 published results from farmers breeding the Exlana composite for resistance to worms demonstrate a difference in FEC between ewes with low EBVs (more resistant) compared with high EBVs (less resistant). Mean FEC was reduced by 23% and 34% on farms 1 and 2 respectively: peak FEC was reduced by 30% and 37%. There was no correlation between other key performance indicators (estimated milk yield using 8 weeks weight of lambs). Modelling suggest that this would results in a comparable reduction in the level of contamination faced by their lambs.

Reference

Vineera, R.H., Baber, P., White, T. and Morgan, E.R. (2019). Reduced egg shedding in nematode-resistant ewes and projected epidemiological benefits under climate change. *International Journal for Parasitology.* 49(12): 901-910