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Programme

	08.30	**Registration**	
	08.50	**Welcome**	
1	09.00	Christian Sauermann	Modelling Horse Parasites – 'The Power of Modelling'
2	09.20	Ian Scott	Comparison of the egg reappearance times for ivermectin, moxidectin and abamectin in horses in consecutive egg count reduction tests
3	09.40	Ian Scott	Failure of an abamectin-containing anthelmintic paste to reduce egg counts in horses
4	10.00	David Heath	Interesting results from 4 years of using the Hydatil EG95 vaccine for sheep
	10.20	**Morning tea**	
5	11.00	Ian Scott	Shedding of parasite eggs and other structures in the faeces of feral cats
6	11.20	Ian Scott	Is there a North/South divide in terms of hookworm prevalence in dogs?
7	11.40	Bill Pomroy	Insecticide use on sheep as reported by farmers in a postal survey on flystrike and lice in 2016
8	12.00	Luis Carvalho	Ectoparasite research programme
	12.30	**Lunch**	

9	13.30	Seer Ikurior	What are ewe doing? Monitoring activity in pre-mating adult ewes with high and low FEC
10	13.50	Bill Pomroy	Effect of treating ewes pre-partum with controlled release anthelmintic capsules on ewe and lamb liveweight, wool production and internal parasite populations
11	14.10	Poppy Miller	The faecal egg count reduction test: Uncertainty due to estimating the pre-treatment counts
12	14.30	Tania Waghorn	The Nemabiome in NZ
13	14.50	Arka Gupta	Development of novel anthelmintic to overcome the drug resistance problem in nematode infested ruminants
	15.10	**Afternoon tea**	
14	15.30	Alex Chambers	Unravelling the parasites of deer
15	15.50	Jamie Ward	Increased CarLA IgA decreases lungworm and gastro-intestinal parasite outputs and increases growth rates in young farmed red deer
	16.30	**NZSP AGM**	
	18.30	**Pre-Dinner Drinks**	
	19.30	**Dinner**	

Notes:

Abstracts

1. Modelling Horse Parasites – 'The Power of Modelling'

Christian Sauermann

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A (little) task that started in 2014 became a multiyear project, that by 2020 resulted in the publication of ten peer-reviewed articles, two book chapters and two further publications currently in preparation. The task led to the construction and application of a model of the whole lifecycle for the equine cyathostomins. The model uses climate to simulate the development and survival of the free-living parasite stages with individual horse and treatment data to estimate the dynamics of the parasite populations, including the selection for anthelmintic resistance. It was then used to investigate the development of resistance under various current and future climate projections, and different treatment regimens, including possible benefits of selective treatment or leaving a proportion of the herd untreated. However, what retrospectively became clear is that this process not only created a valuable research tool by combining the available knowledge into a structured and unbiased framework, but also notably influenced scientific thinking of some of the scientists involved and sometimes challenged perceived wisdoms. This Presentation will give a short overview of the project and discuss 'The Power Of Modelling'.

2. Comparison of the egg reappearance times for ivermectin, moxidectin and abamectin in horses in consecutive egg count reduction tests

Ian Scott, Erica Gee, Chris Rogers, Bill Pomroy, Mike Reilly, Barb Adlington, Francis Miller, Andrew Smith, Kylie Legg

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In this study we are investigating egg reappearance periods (ERP) as an early warning of anthelmintic resistance development. Whilst efficacy is generally judged against egg laying adult (cyathostomin) parasites, shortened ERP arise when efficacy has declined against the earlier larval stages. One question that has not been answered is whether there is a seasonal influence on ERP.

So far, 3 Faecal egg count reduction tests have been conducted in Winter (Jun/Jul) 2019, Summer (Jan/Feb) 2020 and Winter 2020. The same group of 24 horses were used in the 3 tests and were divided into two groups based on initial egg counts. In all 3 tests the same horses (Group 1) received ivermectin, whilst the horses in Group 2 received moxidectin (first two tests) and then abamectin. Across the tests, 1, 2 and 1 horses were excluded from analyses due to having zero counts on Day 0 and by the third test one of the Group 2 horses had been removed from the herd. Egg counts were done with a 3-chambered McMaster slide such that each egg counted represented a count of 17 eggs per gram.

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The egg reappearance period was defined by the time taken in weeks for egg counts to increase post-treatment to 10% or greater of what they had been pre-treatment. Both Arithmetic (AM) and geometric mean (GM) counts were used in calculations.

The results for ERP for the three tests are presented as follows, in terms of number of weeks for counts to increase above 10% of the pre-treatment counts.

	Winter 2019	**Summer 2020**	**Winter 2020**
Ivermectin			
AM	6	5	5
GM	7	5	5
Moxidectin			
AM	7	5	
GM	7	6	
Abamectin			
AM			6
GM			6

All tests saw counts reduce by more than 99% in the first 4 weeks after treatment. There was little difference between the ERPs for ivermectin and moxidectin, but in the second test the ERPs for both were 1 to 2 weeks shorter. Test 3 showed no return to a longer ERP for ivermectin and suggested a slight advantage for abamectin, but in fact there were no significant differences between the egg counts of the groups in this or any of the preceding tests.

Since egg counts were essentially zero for the same amount of time (4 weeks) in all tests, any differences in ERP depended principally on how quickly counts rose after treatment in week 5 and onwards. Differences in ERP were thus likely not due to more rapid development of larval stages, but rather by the number of these stages left behind by treatment, or at least how many eggs they ultimately produced.

Shortened ERP almost certainly results from reductions in efficacy against cyathostomin L4, but the exact efficacies of the treatments in this study against these stages are unknown. As efficacy against L4 further declines, and more are left behind after treatment, then counts may rise yet more quickly and ERP may reduce more consistently. Nevertheless, the data suggests that L4 surviving treatment still take at least 4 weeks to finish their maturation and commence egg laying, and this further suggests that ERP may be unlikely to decline much further. An obvious next step in resistance development will of course be the occurrence of resistance in the egg-laying adult stages, but this obviously will manifest not as a shortened ERP, but as a failure to adequately reduce egg counts in the first place.

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3. Failure of an abamectin-containing anthelmintic paste to reduce egg counts in horses

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In recent work also reported at this conference we have shown that products containing ivermectin, moxidectin and abamectin can all reduce egg shedding by horses by 99-100%. The herd of horses this prior work was conducted in was using a different abamectin-containing product as its routine anthelmintic and the opportunity was taken recently to test the efficacy of this product. Twelve horses were weighed, faecal sampled and then dosed such that every horse was dosed to the next highest division on the syringe – horses weighing 501 and 540kg would both be dosed as if they were 550kg - this was done to avoid any issue with underdosing. Faecal samples were collected again 7 (n=9) or 14 (n=3) days after treatment and egg counts were done with a 3-chambered McMaster slide such that each egg counted represented a count of 17 eggs per gram. Larval culture results showed that 100% were cyathostomins. The average (range) of the pre-treatment egg counts was 640epg (51-1122). Only 2 animals had zero egg counts post treatment and the post-treatment average was 207epg (0-646). Efficacy calculated using arithmetic mean counts was 68%, and using geometric means was 82%. That a different abamectin-containing product had recently had 100% efficacy in the same horses may indicate that there has been a rapid development of resistance to abamectin, but it is perhaps likelier that the two products despite being used at the same dose rate, do not achieve the same concentrations in the tissues of the worms themselves. In addition to the shortened ERP observed with abamectin and related products in these horses, the present findings are perhaps further indication that it can only be a matter of time before these drugs are no longer effective against adult cyathostomins.

4. Interesting results from 4 years of using the Hydatil EG95 vaccine for sheep

David D Heath, AgResearch Ltd:(35A Hargood St., Woolston, ChCh 8062): Guido Merino Rubilar, Servicio Agricola y Ganadero,(SAG) Chile: Alejandro Pino Nunez, Tecnovax, Chile/Argentina

In 2016, in Alto BioBio there were 1,358 families of the Pehuenche people. They live in the valleys around two volcanoes, and take animals to the mountain region during the Summer. Animal statistics: 9000 bovines,14000 sheep, 17000 goats, 555 pigs, 1700 horses. After 20 years of SAG trying to remove Echinococcus from dogs with anthelmintics, the decision is made to stop the dog treatments, and to try to use the EG95 vaccine to remove the infections from the grazing animals. This would be carried on for at least 6 years, until the death of the animals that were already infected at the time of starting the vaccine. Because only sheep had been registered for the vaccine in Chile, goats and bovines can come later. This 4 year program is to show how sheep hydatid cysts can be heavily reduced after 4 years, even though most dogs will still be shedding Echinococcus eggs for all that time.

At the end of 4 years animals were necropsied from almost all the areas, and especially from the areas with most echinococcus previously. The Head, liver and lung were provided on the day that

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had been previously arranged with the owner. 200 samples were analysed. All age groups have had several months of grazing infected pasture from birth until receiving the first injection. At necropsy, cysts were divided into 3 classes : 2mm diameter, with a discernable cavity: 5mm diameter, with a cavity: 10mm or more, with a cavity. Sheep with **cysts** in 2020 - about 50% of 1 year, 50% of 2 year, 70% of 3 year, and 86% of 4 and 5 years. Of the 2 year- infected group, all had cysts of 2mm-5mm, with a cavity but fairly thick walls. Of the 3-4 years infected groups, approx 40% had some cysts in the 10mm size, and the remainder in the 2-5mm size. Normally some should be 2cm and with protoscoleces.

Only a few animals had smallish Fasciola hepatica in the bile ducts, and there was no obvious liver damage due to Fasciola.

5. Shedding of parasite eggs and other structures in the faeces of feral cats

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There are an estimated 2.5 million feral cats in New Zealand, almost twice as many as there are owned pet cats. Feral cats are present across most of both of the mainland islands and in a wide variety of habitats within them. Between 2012 and 2014, faecal samples from 119 feral cats trapped across both North and South Islands were examined for the presence of helminth eggs and protozoal stages identified morphologically using a centrifugal floatation test with ZnSO4.

Virtually every sample contained at least one parasite stage or what was likely to be a pseudoparasite (a stage of a parasite present in another animal that the cat had eaten). 78% of the cats were shedding *Toxocara cati* eggs. The next most common finding were *Capillaria*-type eggs (57%), although these eggs were not examined further to distinguish the eggs of true feline parasites from those of other animals. Lungworm larvae were found in 6%. Tapeworm eggs were also found in 6% of samples and the majority were *Taenia* spp., although 2 animals trapped in Northland were positive for *Spirometra* spp. Oocysts consistent with either *Toxoplasma* spp. or *Hammondia* spp. were only found in 2 cats (1.7%). Pseudoparasite stages included pinworm eggs most likely from rodents, *Eimeria* spp. and avian-type oocysts,

The finding of *T. cati* eggs in the faeces of so many of the feral cats is potentially important for the health of humans, and other animals such as Kiwi which are known to be susceptible to infection with this parasite. Feral cats appear a far more likely source of eggs than are owned pets. This may also be important for the diagnosis of infection in dogs since *T. cati* eggs are thought to be a common finding in the faeces of dogs due to coprophagic behaviour.

Although the ZnSO4 centrifugation floatation test is not considered reliable in the diagnosis of lungworm or tapeworm infection (with the exception of *Spirometra* spp.) the presence of a number of positive tests suggests that our general inability to find the same stages in the faeces of pets is more likely to be due to a lower prevalence in these animals.

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Spirometra spp. infection has before now only been recorded in cats (feral and pet) in the lower North Island, but the finding of two infected cats from Northland, suggests that the parasite is more widely dispersed at least in the North Island.

That only two animals had oocysts that could be consistent with *Toxoplasma gondii* infection, is likely because most of the cats had been exposed to the organism at a younger age and had become refractory to further episodes of shedding.

6. Is there a North/South divide in terms of hookworm prevalence in dogs?

Ian Scott, Barbara Adlington

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Last year we presented data from a survey of endoparasite prevalence based on egg shedding, in pound dogs from across New Zealand. Only a small number of samples were submitted from dogs in shelters in the South Island (56 versus 286 from the North Island) but the prevalence of hookworm (*Uncinaria stenocephala*) eggs in those animals was about half that of the dogs in the North (8.9% versus 18.1%). This seemed to lend some support to the notion that hookworms were not a significant issue for dogs in the South Island. To further explore this a further 43 samples were obtained from South Island shelters in late 2019 and early 2020. The additional samples did not affect the overall prevalence of hookworms which was now 8.1%, but closer examination of the data suggests that other reasons may account for the difference. The South Island samples were more likely to be from dogs older than 1 year of age (67% of dogs versus 42%), and across both Islands, hookworm is much less common in these older dogs (10% versus >20% for younger age groups). When prevalence was compared only in the older dog age groups, the figures for the North and South Islands were much more similar, 8.8% (NI) versus 10.6% (SI). From conversations with the staff in shelters, those in the North Island are processing larger numbers of unwanted young dogs whereas the shelters in the South Island are more involved in rehoming (dogs of any age). Thus in addition to differences in the ages of the dogs, there may also be differences in the care afforded to the dogs prior to entry to the shelters with young dogs submitted to shelters in the South perhaps more likely to have been recently treated with anthelmintic.

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7. Insecticide use on sheep as reported by farmers in a postal survey on flystrike and lice in 2016

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2. School of Veterinary Science, Massey University

There has been minimal research on insecticide usage on sheep in New Zealand in recent years. A questionnaire was sent out with the special edition of Country Wide Sheep in October 2016. A previous report at the NZSP 2017 conference detailed the management practices of farmers with regards to flystrike and lice but not details on the actual insecticides used.

This survey was sent to 14000 farmers. It comprised 30 questions on aspects of management of flystrike, louse control, tailing and castration. A total of 1254 questionnaires were returned. For flystrike, it is notable that despite regular chemical use, flystrike control remains a challenge problem for New Zealand sheep farmers

Methods to apply insecticides show that automatic jetting races were the most popular (37%) but even so were used by less than half the respondents. Backline applications were the next most popular (28%). The use of shower dips has declined, and results indicated that only 9% of respondents used this method and only a very small number still used a plunge dip (1%). The following table indicates active ingredients used for the two most popular methods (automatic jetting and backline application). Clearly some are incorrect as some chemicals were not available for the type of application indicated.

	Automatic jetting		Backline application	
	Lambs (n, %)	Ewes	Lambs	Ewes
Dicyclanil	1 (0)	1 (0)	90 (27)	68 (23)
Cyromazine	219 (63)	227 (62)	92 (27)	24 (8)
Triflumuron	4 (1)	8 (2)	49 (14)	66 (22)
Diflubenzuron	42 (12)	65 (18)	67 (20)	70 (23)
Spinosad	118 (34)	121 (33)	8 (2)	6 (2)
Organophosphate	13 (4)	21 (6)	2 (1)	0
Synthetic Pyrethroid	2(1)	0	6 (2)	5 (2)

Lambs treated for flystrike at docking/tailing were North Island 67% (n=601), Top of the South Island 44% (n=247), Bottom of the South Island 16% (n=334) and over all of New Zealand 48% (n=1253)

Notes:

8. Ectoparasite research programme

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Blowflies and the cattle tick *Haemaphysalis longicornis*, are major concerns to New Zealand farmers. Blowflies cause serious and debilitating disease in sheep (Myiasis), which is a significant production and animal welfare problem. *H. longicornis* has an economic impact on livestock due to production-limiting effects in cattle, deer and sheep, and its role as a vector of theileriosis. The AgResearch Animal Health, Parasitology Team is starting a new Ectoparasite research programme focusing on 3 areas: 1) Creating capabilities: laboratory rearing of blowflies and ticks, development of an *in vitro* tick feeding method. 2)Microbiome analysis: studying the presence of symbiotic microbes and tick-borne pathogens. 3) Biological control of the ectoparasites: search for safer alternatives to chemical pesticides, mainly new pathogen-based biopesticides.

9. What are ewe doing? Monitoring activity in pre-mating adult ewes with high and low FEC

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In initial investigations we used GPS and accelerometer technologies to measure the activity of young growing lambs and were able to show that the distance moved by the lambs and time spent grazing were affected by sub-clinical levels of gastrointestinal nematode (GIN) parasitism. This may mean that such technologies could be used to better assign treatment to only those animals most in need. Another option for reducing anthelmintic use on farms is to similarly restrict treatments in adult animals. To this end, the present study sought to investigate activity patterns in a group of, 2.5 year old Romney ewes prior to mating. All the ewes were faecal sampled on the 15 Jan 2020, and high egg counts (mean 442epg, range 0-3650) led to them all being drenched at this time. The start of the study was therefore delayed to the 9 Mar (Day 0). Fifty nine of the ewes were weighed, faecal sampled, body condition scored and each was then given a collar mounting a GPS monitor (a DataCarter® unit using Trimble Lassen® GPS modules) and an accelerometer (Actigraph® wGT3X-BT). The collars were left on until 20 Mar (Day 11), when the ewes were again faecal sampled, weighed and body condition scored. The activity monitors started recording on midnight of the 9 Mar, providing 10 days of data, from which average daily distance travelled and daily activity budgets (time spent grazing, resting (lying or standing) or walking) were calculated. The data were further analysed by categorising the ewes as either high initial (15 Jan) FEC (≥350epg, n = 24) or low (≤300epg, n=35), and low BCS (≤2.5, n=30), intermediate (3, n=15) or high (≥3.5, n=14). Over the 11 day period of the study, the average (SD, range) egg counts rose from 193(383, 0-1950) to 547(749, 0-3800), and initial egg counts were a poor predictor of the counts perfomed later (k=0.07). On average, bodyweights and BCS did not change significantly. None of the parameters measured (FEC, LW, LWG, BCS) significantly predicted how much the ewes moved, but LWG and daily grazing activity were significantly associated (p=0.018) and BCS predicted resting activity (p=0.017) such that thin ewes rested more. The lack of an influence of FEC may be a consequence of the limitations of using egg counts to predict the impact of GIN on adult animals, but may also reflect the similar issues

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observed around long-acting anthelmintic use in lactating animals, and reflect the fact that parasitism is just one contributor to poor performance of ewes.

10. Effect of controlling gastrointestinal nematodes in breeding ewes with controlled release anthelmintic capsules on ewe and lamb liveweights, wool production and internal parasite populations.

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2. School of Agriculture and Environment, Massey University
3. School of Veterinary Science, Massey University

Two experiments were conducted over two years to quantify the effects of treating ewes pre-partum with albendazole controlled release capsules (CRC), relative to a traditional drenching programme, on the internal parasite burden in breeding ewes and lambs.

Year 1: A replicated experimental design comprising 10 paddocks in total with 5 paddocks allocated to each of two ewe drench treatments (n=60/treatment). The trial ran from 9 August 1993 (D0) to 28 February 1994 (D204) at Massey University. The drench treatments for ewes comprised either a single dose of a combination levamisole/ricobendazole anthelmintic ('Leviben®', Novartis NZ Ltd) at docking (27 September, D 49; CONTROL) or a single dose of an albendazole 100-day Controlled Release Capsule ('Proftril®', (now 'Extender 100®'), NuFarm, Auckland, NZ; CRC) at set stocking for lambing (D0; 9 August 1993; 7 days before the first ewe was due to lamb on 16 August). All lambs were dosed at weaning with 'Leviben', and thereafter according to treatment as described below. All doses of 'Leviben' were given at the recommended dose for the heaviest animal in the group. Each paddock was allocated 12 ewes and 18 lambs per hectare (=120% lambing) from 30 August (D21). Treatment groups were balanced for age, live weight and rearing rank.

After weaning (15 November; D98) lambs were retained on the paddocks they were lambed in which were further subdivided at weaning by electric fences to provide 16 paddocks for the lambs post-weaning. Lambs from within each ewe drench treatment were randomly reallocated to their respective prior-treatment paddocks under one of two regimens. The first involved the dosing of lambs once a 'trigger level' (TRIG) of faecal worm counts (mean 500 eggs/g) had been reached in those paddocks. This provided an indication of the time taken for worm burdens to build-up on the pastures associated with each ewe drench treatment. The second lamb drench strategy, applied to lambs on the remaining 4 paddocks arising from each ewe treatment, followed the pattern for the recommended '5 drench' programme for lambs comprising drenches at weaning and thereafter at intervals of 21-28 days.

Faecal samples for estimation of faecal egg count (FEC) were taken from 30 ewes at the commencement of the trial and then from 6 ewes in each paddock, 7 days post-dosing and at approximately 3 weekly intervals thereafter until weaning (i.e. Days 0, 7, 35, 56, 77 and 98). Lambs (n=7 per paddock) were rectal sampled for faeces from about 10 weeks of age (D94), weaning (D98) and on days 119, 133, 149, 155, 164, 176, 186 and 194. Ewe and lamb live weights (fresh off pasture) were recorded at the same intervals as sampling for ewe faecal egg counts up to weaning and on d 119, 133, 155, 164, 176 and 194. A dag score (1 = none to 5 = heavy) was assigned to each ewe and lamb at weaning [13] and for each lamb at the completion of the trial (D204).

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Ewe wool growth was estimated from a 100 cm^2 midside area (n=6 ewes per paddock; 3 single- and twin-bearing ewes respectively) for the period 8 weeks pre-dosing (covariate) and from docking to weaning. Lamb wool growth (n=8 per paddock, balanced for rearing rank and sex) was recorded from docking to weaning (D49 to D98) and from weaning to the completion of the trial (D98 to D204).

Ewe herbage intake was estimated using chromic oxide CRC (Parker *et al*. 1989) with faecal samples from 4 ewes (balanced for rearing rank) from each paddock over 4 days during Weeks 7 and 9 of lactation, respectively. A total of 20 ewes per drench treatment were sampled for the intake measurement.

Year 2: Year 2 was a repeat of Year 1 except that no treatment was applied post weaning. Two groups of 32 ewes were formed 16 days before lambing. One group was dosed with a 100-day albendazole CRC plus 'Leviben' (CRC) treatment on 11 August 2004; the other was dosed at docking with 30 mls of 'Leviben' (CONTROL). The CRC ewes were dosed (D0) with 'Leviben' because Year 1 faecal samples indicated that *Teladorsagia* caused low FEC in the CRC ewes. The ewes, balanced for scanned pregnancy status, were allocated at equivalent stocking rates (14 ewes/ha) to 8 paddocks/treatment and remained on these areas until weaning on 11 November (D92). Measurements were taken of wool growth, ewe live weight and condition, lamb birth weight and live weights, faecal egg counts and pasture mass as described for the Year 1 experiment. Herbage intake was estimated during Weeks 6 and 9 of lactation using a single chromic oxide CRC per ewe. FEC were determined for the ewes on d 0, 47, 70 and 92, and for the lambs on d 70.

Results: In Year 1, FEC for Day 0, docking and weaning respectively in CONTROL ewes were 392, 648 and 10 eggs/g, and for CRC were 355, 126 and 48 eggs/g. In Year 2 CONTROL ewes were 98, 1101, and 40 whereas CRC were 12, 6 and 29 eggs/g respectively. Ewes showed similar weight loss from lambing until docking, after which CRC ewes gained weight more rapidly and were heavier than CONTROL ewes at weaning ($P<0.05$; 2.4 kg in 1993; 4.1 kg in 1994). Ewe herbage intake corrected for differences in ewe live weight (i.e. OMI expressed as g OM/kg $LW^{0.75}$) was greater for CONTROL ewes ($P<0.01$) during Week 9 of lactation otherwise no differences were seen in either year. In Year 2, lower than desired levels of pasture may have affected results. Ewe midside greasy wool growth in Year 1 was faster ($P<0.05$) from capsule dosing until weaning (98 days) in the CRC than the CONTROL ewes (0.68 ± 0.02 vs 0.61 ± 0.02 mg/cm^2/day) but similar in Year 2 (0.80 v. 0.82 mg clean/cm^2/d; P=NS). Mean ewe dag scores at weaning in Year 1 were 3.35 ± 0.20 vs 1.15 ± 0.14 ($P<0.001$) in the CONTROL and CRC groups respectively, with 55% more ewes in the CONTROL group requiring dagging (dag score >2) than in the CRC group.

In both years, lamb live weights (kg) at weaning were heavier ($P<0.01$) for the CRC group (Y1 23.24±0.45; Y2 23.63±0.73,) than the CONTROL group (Y1 20.83±0.44; Y2 20.38±0.67). In Year 1, this weight advantage diminished up to Day 175 and thereafter was not significant ($P>0.05$). Lambs from CRC ewes subjected to a '5 drench' programme, were almost 4 kg heavier by the completion of the trial than their TRIG contemporaries from CONTROL ewes which grew least well (36.8 ± 5.4 vs 32.9 ± 4.5 kg; $P<0.05$). Lambs from the CONTROL ewes on the '5 drench' programme post-weaning reached a similar average live weight to those raised by CAPSULE ewes and then dosed according to FEC (35.4 ± 4.8 vs 34.5 ± 7.2, P=NS). Lamb dag scores were not significantly affected by ewe drench treatment or the post-weaning lamb drenching programme. Wool growth was significantly ($P<0.01$) slower in the lambs raised by the CONTROL ewes up until weaning. After weaning the rate of wool growth remained slowest in TRIG lambs from CONTROL ewes.

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Overall, use of a CRC in ewes had small advantages for ewes over a single mid-lactation treatment with some advantages also evident in their lambs. However, this advantage for lambs largely disappeared in the post-weaning period depending on parasite control options in that period.

11. The faecal egg count reduction test: Uncertainty due to estimating the pre-treatment counts

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The faecal egg count reduction test (FECRT) is the principle method available to farmers and veterinarians for estimating the efficacy of anthelmintics in gastrointestinal nematode parasites of livestock. Simply, the test relies of counting the number of eggs present in faeces collected from a selection of animals prior to and following treatment with anthelmintic. The percentage reduction in the mean number of eggs is then calculated as the treatment efficacy.

The expense involved in data collection has resulted in a popular modification of this process where the egg counts pre-treatment are only collected from a subset of the animals (usually 10 out of 40-60 animals). This process substantially affects the accuracy of the efficacy estimate and therefore, the subsequent diagnosis of resistance. The purpose of this study was to evaluate the potential impact of this approach on a diagnosis of resistance, under what circumstances this might occur and to assess whether any simple modifications could improve the outcome.

101 FECRT were available for the study, each of which included an evaluation of at least 4 anthelmintics. This gave a total data set of > 400 efficacy tests to work with. For each efficacy test the 'true' efficacy was calculated using counts of eggs from every animal in the test group animals both pre- and post-treatment. Random sampling of subsets (n= 10, 20, or 30) of the animals used in the FECRT were then used to estimate the 'sampling' mean FEC for the pre-count – this was repeated 1,000 times for each test. The resulting efficacy calculations (n=1000) were then compared to the 'true' result.

Results indicate that a diagnosis of resistance using a sample of 10 animals to estimate the pre-count is reliable if the estimated efficacy is <90% or >98%. However, there is large uncertainty regarding a diagnosis of resistance if the estimated efficacy falls within this range. Using this method, results from FECRT between 90 and 98% should be considered as only possible resistance. However, the level of uncertainty can be reduced (but not eliminated) if a larger sample of animals is used to estimate the pre-count.

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12. The Nemabiome in NZ

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Morphological identification of parasitic gastrointestinal (GI) nematodes is always tricky and no more so than with the larval stages. You need to have good microscope skills, a keen eye for detail and have had lots of ongoing practise. Even if you have these skills and are well practised you cannot visually tell several species apart due to similar morphological characteristics.

Modern technology has led to the development of molecular tools enabling us to differentiate all the developmental stages of these parasite species. In our lab we use a multiplex PCR method to determine the species of individual larvae, it is however, labour intensive and expensive. The development of newer molecular methods has allowed us to study the nemabiome; "parasite community", rather than individuals. Illumina deep amplicon sequencing has provided a method that can simultaneously identify and quantify strongyle larvae in mixed-species pools. Providing a comparatively, quick and cheap method, to determine what species and how many of each are present in cultures from field collected samples.

It works by amplifying the ITS-2 region of rDNA, and by adding a barcode to each sample we can process hundreds of mixed population samples at one time. These sequences can then be compared with the known sequences for each species and the proportion of each species present determined.

Currently we are validating the technique for New Zealand GI parasite species of sheep cattle and deer against visual and individual PCR identifications of the same populations. The intention is to have it up and running as a research tool for all our projects in the near future.

13. Development of Novel Anthelmintic to Overcome the Drug Resistance Problem in Nematode Infested Ruminants.

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Gastrointestinal nematode (GIN) infections represent a major threat to the health, welfare, and productivity of sheep populations in New Zealand (NZ). Infected lambs have the reduced ability to absorb nutrients from the gastrointestinal tract, resulting in weight reduction and potential mortality. Internal parasites cost the NZ sheep industry approximately NZ$300M annually in lost production and drench use. The excessive use of anthelmintics to cure GIN infections has led to a widespread problem with anthelmintic resistance by parasites. Anthelmintic resistance costs an estimated additional NZ$20M per year and this is predicted to rise to NZ$60M per year by 2022. There is an urgent need to introduce a new class of anthelmintic which will be efficient for killing nematodes. Bioactive plant extracts are reported to have significant potency against nematodes throughout their life cycle. The aim of this PhD project is to find a novel anthelmintic formulation derived from bioactive plant extracts. Preliminary results have shown extracts of quebracho, a plant rich in condensed tannins (CT), have good anthelmintic efficiency against GIN larvae in lab condition.

Notes:

Further isolation of these plant extracts and identification are currently being evaluated. The project has two main challenges: 1. developing an effective anthelmintic formulation against GIN, 2. delivering the agent to the fourth stomach of the ruminant.

14. Unravelling the parasites of deer

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Currently, little is understood about the biology and lifecycle of many of the parasitic species infecting farmed deer in New Zealand. This includes the seasonality of pasture contamination on farm, and the prevalence of gastrointestinal and lungworm species within different age/stock classes (fawns, stags, hinds). Sporadic, and often chronic, lungworm infection in young deer has resulted in many farmers relying on the ad hoc use of anthelmintic treatments to prevent losses. Despite sometimes heavy anthelmintic use, disease outbreaks occur and are largely unpredictable. A better understanding of the parasites infecting managed deer is required to develop efficient, and sustainable, control strategies, in addition to highlighting areas of future research. The project aimed to determine the levels of egg/larval shedding by deer of different age/stock classes throughout the year.

The study monitored monthly strongyle nematode egg and lungworm output from 2-4 different deer mobs, from 6 farms over 2018 – 2020. The 6 farms were located in Te Anau, Mosgiel, Mid-Canterbury, Central Plateau, Hawkes Bay and Matamata. Faecal egg counts were determined by mini-flotac (5 eggs per gram sensitivity), lungworm counts by standard baermanisation (Hendrickson's technique) and L3 were cultured for future speciation by deep-amplicon sequencing by Illumina MiSeq.

All age/stock classes of deer passed strongyle parasite eggs and lungworm larvae onto pasture all year round, with little to no seasonality. However, at any given time many adult animals had very low or zero counts. This work suggests a lungworm infection may potentially persist on farm due to continuous, low-level pasture contamination from all age/stock classes, regardless of age, sex or season, with a small number shedding higher numbers of larvae.

The study has provided an epidemiological snapshot of the seasonal prevalence of parasites on the different farms across New Zealand, with the purpose to better understand the lifecycle of deer parasites, in particular where pasture contamination comes from. This will help farmers to target the sources of infection rather than trying to deal with the unpredictable outbreaks after they occur.

Notes:

15. Increased CarLA IgA decreases lungworm and gastro-intestinal parasite outputs and increases growth rates in young farmed red deer.

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Deer farming in New Zealand is negatively impacted by lungworm (*Dictyocaulus eckerti)* and gastro-intestinal nematode (GIN) parasites notably *Ostertagia* types. Lungworm are the most pathogenic of these and cause the most dramatic productive impacts. The most impacted stock-class are young deer in the first year of life, which are very vulnerable until their immunity develops. A salivary IgA response to the carbohydrate molecule, CarLA located on the surface of ex-sheathed L3s has been shown to be protective in sheep. The salivary CarLA antibody concentration is measured by the CARLA test and this response has been shown to be heritable in young deer. Deer stud farmers are able to get estimated breeding values for CARLA to select for the response.

The latest study investigated the impact of CARLA on the outputs of GIN eggs and lungworm larvae in the faeces of 251 young deer exposed to four continuous eight-week cycles of natural challenge with nematode parasites. These deer were grazing on pasture from weaning at 100 days of age in March until November. In each cycle of parasite challenge faecal samples and live weights were collected at weeks 4, 6 and 8. At week 8 the cycle was terminated, and the next cycle started with anthelmintic treatment with short acting anthelmintic (either Matrix Mini-dose or Oxfen-C).

Mean faecal egg counts (FEC) at 8, 16, 24 and 32-weeks reduced in a linear fashion, while faecal larval counts (FLC) increased from week 8 to 16, then dropped dramatically at week 24 and was essentially zero at week 32. Over the same period the mean natural logarithm (logN) of the CarLA IgA response increased in a linear fashion. Restricted maximum likelihood models (REML) were used to predict the relationships between CARLA, cycle x CARLA and FEC and FLC. Both FEC and FLC changed significantly with cycle ($P<0.001$). The models predicted dramatic reductions in FEC and FLC over the first two cycles March-April and May-June. For Cycle 1, FEC decreased 18% and 30% for Cycle 2, for FLC the decreases were 14% and 50% from Cycles 1 and 2 respectively **for each 2.72-fold increase in CARLA**. Growth response analysed by the same REML method predicted 7% and 4% increased liveweight gain for males and females respectively for each 2.72-fold increase in CARLA measured at Cycle 2.

These results show positive productive benefits of increased CarLA IgA response in young deer between March and June under natural parasite challenge. Both FEC and FLC have been shown to correlate with GIN and lungworm burdens in young deer during these periods. There is a benefit of selecting young deer for increased CarLA-IgA as it provides a productive advantage by reducing their overall level of parasite infection and output and is a measure of developing host resistance to nematode parasites.

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