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Evaluation of the anthelmintic efficacy situation on member farms of the Tablelands Farming System (TFS)

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Executive Summary

Decreasing susceptibility of parasite population against the currently available anthelmintics is of concern to livestock industries worldwide. Accordingly, the performance of drench efficacy tests remains the cornerstone of successful parasite management on Australian sheep farms. The most commonly used test to evaluate drench efficacy on farms is the faecal egg count reduction test (FECRT). Although this test is recommended by parasitologists as well as on the WormBoss website, adoption of regular implementation of this test into routine farm practices requires continued efforts.

This Project aimed to demonstrate the value of performing the FECRT to members of the Tablelands Farming System (TFS) group by initiating a centrally organised, subsidised FECRT which was designed to complement the recently commenced faecal egg count (FEC) Monitoring Program, a joint TFS-Dawbuts initiative. The project started in March 2020 and the FECRTs were performed using a relatively new protocol which utilises a Day 0 control and therefore dropped the untreated control group. Additionally, the method used for conducting the FECs was the Mini-FLOTAC method, which provides a sensitivity of 10 eggs per gram (epg) compared to the traditionally used McMaster method with a sensitivity of 50 epg. Using this new protocol, the inclusion cut-off FEC was lowered from 350 to 200 epg, aiming at increasing chances for low FEC properties to be included.

The project was introduced using the Annual General Meeting at TFS, along with promotions on the TFS website and on facebook. On 18 farms FECRTs were performed using five single active drenches and one combination drench. Faecal samples were taken on the day of treatment (Day 0 control) from 45 randomly selected animals. On day 14 after treatment individual samples were taken of every sheep enrolled in the FECRT and the mean efficacy of each drench, including the 95% confidence intervals, were calculated. Results were reported back to the farmers along with supporting information.

The results obtained mirror the observations reported in other efficacy investigations in Australia. On every farm, parasite populations with reduced susceptibility to the drenches used were found. This was particularly the case for the single actives. The mean efficacy as well as the number of actives affected varied considerably between different farms, ranging from one farm indicating reduced efficacy for all single actives to another, where only one single active was affected. The combination drench evaluated showed full efficacy against all parasite species involved on all properties included.

A final face to face meeting held on 28 July 2020 for all participating farmers additionally offered the opportunity to receive support for future parasite management and to discuss possible solutions.

Introduction

Gastrointestinal worms are present on every farm without exception. Therefore, all grazing animals have the potential to be exposed to larvae in highly contaminated paddocks. Depending on the individual husbandry systems followed on farm, the prevention of infection and/or treatment of worms using anthelmintics (drenching) is a routine farm procedure. However, this practice has led to the increased development of anthelmintic resistant worm populations, which are hard or sometimes even impossible to control. Even though the clear recommendation is to use drenches only when necessary, strategic or simple routine programmes often do not include pre-testing in order to estimate the worm burden prior to treatment. But most importantly, only few growers actually check if the drenches used are still effective on their properties. This can result in growers unknowingly using expensive, yet ineffective, treatments which do not achieve the anticipated benefit.

One way to evaluate drench efficacy is the Faecal Egg Count Reduction Test (FECRT). This test involves faecal samples taken before and after treatment with an anthelmintic. The amount of parasite eggs present in the samples is determined using an egg count method of choice and expressed in eggs per gram of faeces (EPG), also known as the faecal egg count (FEC). The FEC before and after treatment are then compared and the reduction in eggs present at both time points calculated. In order for an anthelmintic to be classed efficacious, the reduction is supposed to be at least 95%. However, this can be influenced by several factors. One important criterion is the numbers of eggs counted. Ideally this number is supposed to be greater than 10 to allow for individual variation when the statistics are performed. The mean reduction is usually expressed in percentage but should always be complemented with the confidence interval to put the results into perspective.

Despite high number of farms affected by resistant worm populations, the awareness of the problem and the subsequent use of the FECRT is low. A recent AWI funded UNE survey of sheep producers (Benchmarking Australian Sheep Parasite Control Practices) reported that only 37% of respondents carried out a drench test of any kind over the 5- year period from 2014 to 2018, suggesting nearly two thirds do not know their drench resistance status (Colvin, 2019).

Projects sponsored by Australian Wool Innovation (AWI) and Meat & Livestock Australia (MLA), as well as pharmaceutical companies are currently addressing the lack of knowledge regarding the field situation of anthelmintic resistance on Australian sheep farms. This is generally achieved by conducting FECRTs with single active chemicals. Besides this very important approach it is absolutely crucial to not only identify those farms with anthelmintic resistance problems but also come up with fact-based recommendations on how to deal with this problem in the future, or, better, how to avoid the development of anthelmintic resistance on the property. Accordingly, introducing the benefits of drench testing to sheep farmers still remains a key point in extension and adaption orientated work.

Initiating such drench resistance surveys through established grower groups has a number of advantages. Grower groups provide a perfect platform to promote and discuss the purpose, procedures, possible benefits and conditions for participating prior to the start and encourage discussion on potential issues and solutions. Additionally, the final results can be delivered in a more explanatory way and recommendations or possible solutions can be provided in a group as well as on an individual basis.

This survey, involving members of the Tablelands Farming Systems Group (TFS), investigated the efficacy of different single-active drenches against naturally acquired parasite infections in sheep. It provided an opportunity to demonstrate the benefit of regular resistance testing using the FECRT and was designed to complement the recently commenced faecal egg count (FEC) Monitoring Program, which is a joint TFS-Dawbuts initiative.

Drench efficacy tests were performed following the recently established new FECRT protocol evaluated in a previous project (for details see ON-00485). This protocol utilises the relatively new Mini-FLOTAC method which provides a higher sensitivity in combination with pooling the faecal samples, which reduces the overall costs of a more sensitive method. It furthermore replaces the traditional no treatment control group by the Day 0 control, facilitating a more realistic/true efficacy calculation, while enabling the treatment of all animals at the same time without the risk of debilitating health due to untreated progressing worm infections.

Finally, a resistance management orientated presentation of the results will be provided to the project participants to explain the individual farm's situation and offer guidance and support.

Literature Review

Increasing levels of anthelmintic resistant worm populations are jeopardising the sustainability of Australia's sheep industry. The costs of helminth parasite infections to the Australian sheep industry are estimated to be $436m per annum (Lane et al. 2015). Most of those costs are related to the purchase and application of drenches. If such drenches are no longer effective, the money is spent without achieving any benefits and, as well, the risk of resistance to drenches is a major and increasing problem. Apart from the costs involved in the purchase of drenches, a meta-analysis by Mavrot et al. (Parasites & Vectors 2015) has estimated that mixed infections due to poor control of worms in sheep flocks lead, on average, to reduced weight gain (26%), reduced milk yield (25%) and reduced wool growth (22%).

The use of anthelmintics (drenches) for internal parasite control is a routine procedure for Australian wool producers. However, this should be accompanied by both, worm monitoring using FECs and drench testing, using the FECRT. Unfortunately though, due to perceived expense, time and inherent welfare problems associated with the current method of leaving one group of sheep untreated, not many farmers are performing drench tests and are therefore potentially using ineffective drenches as evidenced by national surveys of anthelmintic efficacy as well as several resistance surveys performed by Dawbuts during the past three years. Researchers and extension staff across Australia have long decried the fact that adoption of drench tests is low, despite ongoing investment in publicity campaigns. The major consequence of low adoption is that producers continue to use ineffective drenches. This has several effects relating to animal welfare and productivity, as outlined above. A further effect is that continued use of ineffective drenches speeds the selection of resistant worms resulting in even more rapid onset of anthelmintic resistance, further reducing the efficacy of available treatments.

Despite a large number of farms already affected by resistant worm populations (Playford et al., 2014) the awareness of this problem is still far below its importance and accordingly, only a small proportion of farmers are acting "worm smart". This does not only include the regular testing for worm eggs in the animal's faeces but also other management factors such as the right time of drenching, the appropriate product used for drenching, the correct application & handling of the drenches as well as stocking rates, agronomy programs and lambing & grazing paddock rotation (WormBoss).

The aim of this project was to demonstrate the benefits of performing FECRTs in sheep flocks of the Tablelands Farming System (TFS) group to support their increased adoption. The basic principle of the FECRT is the comparison of FEC numbers of 10-15 individual sheep before and after treatment. Depending on the anthelmintic used, the post-treatment samples can be collected 7 or 14 days after the treatment. To harmonise FECRT procedures, ensure a certain standard and allow meaningful statistical analysis, recommendations by the WAAVP (World Association for the Advancement of Veterinary Parasitology) have been published (Coles et al., 1993).

According to these recommendations an egg counting method with the minimum sensitivity of 50 EPG, combined with 15 individual samples and a group mean before treatment greater than 350 have to be used. Those criteria are necessary to account for individual animal variation and the non-Gaussian distribution of FECs. Secondly, it is important to use a calculation method which also provides 95%- confidence intervals. These intervals flank the calculated mean and allow the obtained value to be put into perspective.

The FERCT protocol used in this study is based on the international recommendations formulated by Coles et al., (1992) with some modifications. Faecal samples were taken from 15 animals per treatment group. The Day 0 (or before treatment) FEC was determined by using 45 randomly collected samples of those animals enrolled in the FECRT. At day 14 after treatment, faecal samples were collected from every individual animal (for further details see Methodology).

Project Objectives

The key aim of this project was to demonstrate the benefits of performing FECRTs in sheep flocks of the Tablelands Farming System (TFS) group to support their increased adoption. Specific Project Objectives were:

1. Organise an information meeting at TFS to introduce FECR testing, explain the new protocol, organise drench supply and recruit interested farms.
2. Perform important screening (pre) tests in order to include a total of 20 farms.
3. Conduct FECRTs on the recruited 20 farms for group A, following a recently established new protocol using the Mini-FLOTAC method and the Day 0 control group (dropping the untreated control group).
4. Perform statistical analysis to determine the efficacy of each tested drug on each individual farm. (as well as an overview of general performance of different drug classes in the TFS farming area)
5. Formulate key messages following important findings regarding the anthelmintic efficacy situation on TFS associated farms and present those findings during a post FECRT meeting at TFS.
6. Promote project outcomes and benefits more broadly to wool growers though industry communication channels.

Methodology

Acquisition and inclusion of participants:

The Annual General Meeting (27th of February 2020) at TFS was utilised to incorporate the kick-off meeting for the project where members received a presentation as well as prepared hand-outs. Test kits as well as the drenches (including drench guns) were delivered to and handled by Pip Frost, the responsible Project Officer at TFS, who delivered them out to interested farmers.

To encourage more members to get involved, the project was also promoted on the TFS website and through their facebook page, and growers were additionally contacted individually by phone. Due to the short time period available for this survey, other farmers, either associated with TFS or within the same region, were also invited to participate, in order to recruit the requested 20 farms. The inclusion criterion was an average FEC above 200 in the pre-test.

FECRTs:

For the FECRTs five single drenches (with only one active ingredient) and one triple combination drench (Tridectin ®) were chosen. Additionally, the farmers could include one additional drench of their choice.

Day 0:
On the day of treatment (Day 0), the sheep were yarded together and a total of 45 samples were randomly collected (or picked up from the ground if freshly deposited) as the Day 0 control. Of those 45 samples, three samples were combined into each well of the provided 15-well test kit.

The sheep were allocated into treatment groups of 15 sheep each and treated with a different drench, all administered using drench guns according to the manufacturer's instruction. Each group was uniquely identified to ensure that post-treatment samples can be firmly allocated to the respective treatment. Depending how many treatment groups were run on the property, between 75 (5 groups) and 105 (7 groups) sheep were enrolled in the test.

Following treatment, sheep were returned to their paddock and grazed for the next 14 days as per usual farm routine.

Day 14:
A second set of samples were taken 14 days later. At this sampling time point, faecal samples were taken from every individual animal (so 15 individual samples were collected per group) of each treatment group. All samples from one treatment group were collected into the same test kit.

Faecal egg counts:

For the faecal analysis the modified Mini-FLOTAC technique and a pooling protocol were used.

For the Day 0 samples, the sample kit contained three samples per well. This was done to increase the number of individual sheep contributing to the Day 0 control value. The content of every well was thoroughly mixed, resulting in 15 "pre-mixed samples". Out of those samples, five pools were done (with each now representing nine animals). The Mini-FLOTAC method involved placing 5g of faeces into a clean 60 ml glass container and macerating it with a small volume of tap water until a soft paste was formed. Saturated saline solution was added and the sample thoroughly mixed. A plastic aeration tube connected to an OTTO Air Pump SA-800 was placed into the container to agitate and homogenise the solution. A loading syringe was used to aspirate some of the solution and fill the chambers of a Mini-FLOTAC chamber were one chamber was filled per sample and eggs counted systematically at 4x magnification using a Prism Optical stereoscopic microscope. This results in a sensitivity of 10 EPG per pooled samples.

For the Day 0 values as well each treatment group, 5 results were obtained, which were entered into an excel spreadsheet for efficacy calculation.

Additionally, a group-based faecal culture was established to determine the genera present before and after treatment. Briefly, the faeces of the 45 individual samples collected prior to treatment were mixed and incubated for 7 days at 28 degrees. This allows the development of the eggs through to third stage larvae, which can be identified using morphological parameters. This provides information what parasites are present in the tested mob before treatment.

A second culture was performed on group level (combining the 15 faecal samples of collected from sheep within one treatment group) on Day 14. The results obtained provide additional information on which parasites have been successfully eliminated or, which parasites are still present after treatment.

Efficacy calculation & Analysis:

For the calculation of the efficacy, data was entered into the an excel spreadsheet. The programmed algorithms of this spreadsheet allow the calculation of the efficacy including 95% confidence intervals for each individual parasite and active combination. As the name suggest, those confidence intervals are necessary to interpret the results with confidence. For example, the mean value can be 80% but the confidence interval ranges from 10-100. That means, that in some animals the efficacy might be good, but in the majority of animals it will be lower than 50%. If the mean efficacy is 80% and the confidence intervals range between 75-85% it means that in almost every animal the average efficacy will be achieved.

Efficacies for active ingredients used were calculated for every individual participant. Additionally, the obtained data was used to gain an overview of the performance of different active ingredients across all participants.

Communication of results:

Results for individual properties were sent to the farmer by email once available – along with supporting information/explanation.

A summary of individual property results, along with the collated analysis was presented at a final project meeting, held at Gunning on the 28th of July, along with an explanation of what the results mean on both an individual and project level. The meeting included a discussion of concerns and offer potential solutions/recommendations.

Success in Achieving Objectives

1-3. It was a challenge to identify flocks with an average 200 or above FEC in the pre-test screening, however, following an introductory meeting, and subsequent promotion, 18 farms were successfully recruited to take part in the project. FECRTs for all 6 treatment groups (five single-active drenches, 1 combination drench) were performed on all properties.

4. Efficacies for each individual substance on the individual properties were calculated using the ResoLoot Spreadsheet and additional statistical analysis providing an overview of the general performance of the different treatment groups in the region was performed.

5. A final meeting was held at TFS to present the results to famers and explain potential problems and offer possible recommendations/solutions.

6. Project outcomes and benefits will be published through industry communications, including an article in Beyond the Bale and information through WormBoss channels, to promote the benefits of regular resistance testing, using the FECRT, to wool growers.

Results

Pre-testing:

For this survey Dawbuts obtained faecal samples for pre-testing from more than 50 flocks. Particularly in the early phase of the survey most samples returned FECs below the threshold and these flocks could not be included. To evaluate if this is a situation unique to TFS farmers or a general observation for sheep flocks in this area, a detailed analysis of the Dawbuts client database was conducted for the time between mid-April and beginning of June. A total of 169 samples were received from the same area. The results revealed that the majority of samples (152 out of the 169) returned negative or very low FECs and only 17 were above the threshold of 200 eggs per gram.

Despite a very large interest within the TFS group, most flocks remained with low FECs and it proved a challenge to recruit the requested 20 farms from TFS members exclusively. Therefore, the invitation to partake was widened to other farmers in the area. As a result, approximately two thirds of the growers included in the study were not TFS members. Interestingly, some farmers have subsequently expressed their interest to or already joined TFS. Finally, even though late in the project time frame, 18 farms were successfully recruited, and on most properties all six treatment groups were included.

FECRT Results:

Larval identification from the larval cultures revealed the following results:

- *H. contortus* was found on 16 out of 18 farms,
- *T. circumcincta* on 15 out of 18 and
- *Tr. colubriformis* on 12 out of 18 farms.

One farm had solely *H. contortus* present, while on 10 farms all three species where found.

The calculated overall efficacies (in percentage) obtained for each farm are presented below in Figure 1 and Table 1.

The combination drench of Moxidectin (MOX), Benzidimazole (BZ) and Levamisole (LEV) was effective (FECR of greater than 95%) against all parasites present on most properties in the study. Only on one farm a decreased efficacy (87%) against *T. circumcincta* was obtained.

However, for single-active drenches mixed results were obtained. In summary:

Abamectin:
Abamectin demonstrated decreased efficacy on almost every farm. This was mostly due to the failure to control *Haemonchus contortus* (all farms) and *Teladorsagia circumcincta* (11 out of 16), while the efficacies against *Trichostrongylus colubriformis* remained above the 95% mark on all farms.

Moxidectin:
Moxidectin showed a similar profile to Abamectin but remained more effective on more farms than Abamectin. As for Abamectin, no decreased efficacy against *T. colubriformis* was detected. Efficacy against *T. circumcincta* was decreased on 4 farms and against *H. contortus* on 9 farms.

Closantel:
Closantel showed good efficacy against *Haemonchus* on most farms. Only on two farms a slightly decreased efficacy (92% and 94%) against *H. contortus* was observed. If no Haemonchus was present on farm in the pre-treatment sample, no efficacy was calculated for this active, since the label claim of the product is only against *Haemonchus* (of the group of gastrointestinal roundworms).

Levamisole:
Levamisole also showed predominantly good overall efficacy, with efficacy against *H. contortus* on most farms (except two) but decreased efficacy against *T circumcincta* on 9 farms and *Tr. colubriformis* on 5 farms.

Benzimidazole:
For the benzimidazoles a very mixed spectrum was obtained. Efficacy against *Tr. colubriformis* remained good on most of the 12 farms where this species was found (only one had no efficacy at all). Efficacy against *H. contortus* was above the 95% mark on only 5 farms, and for *T. circumcincta* on 3 farms.

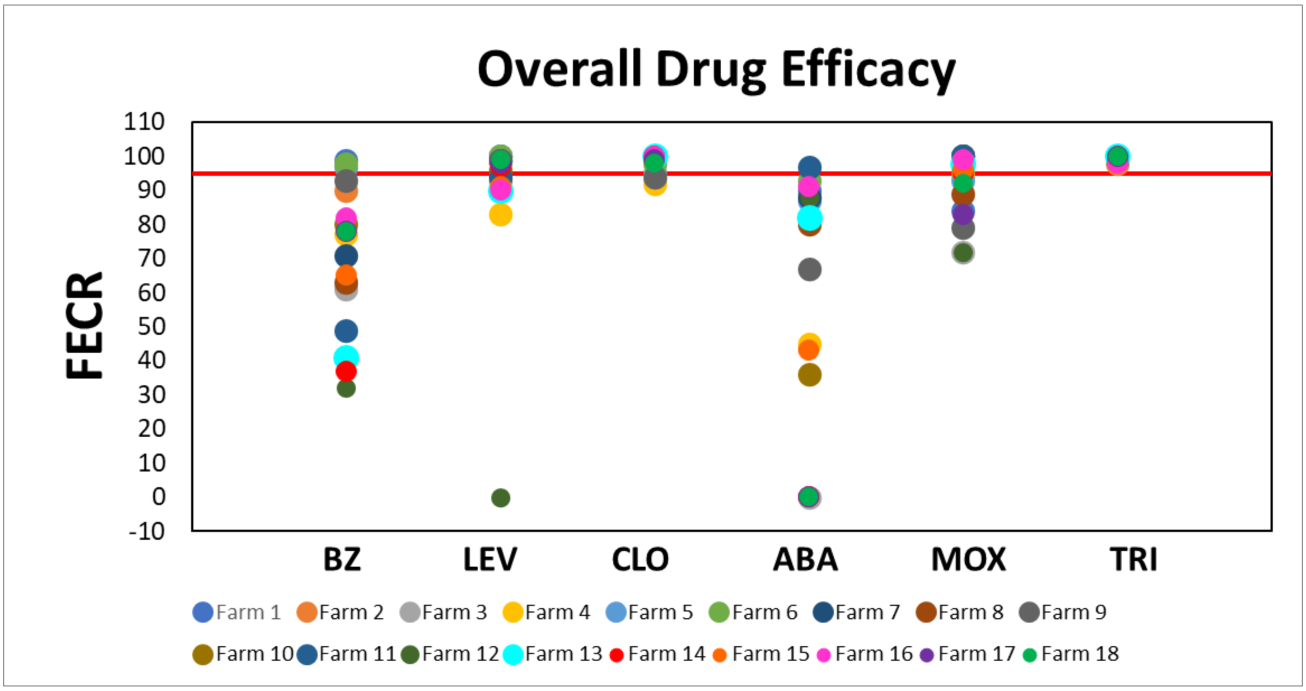

Figure 1: Overall mean drug efficacy on farm level for benzimidazole (BZ), levamisole (LEV), closantel (CLO, abamectin (ABA), moxidectin (MOX) and the combination drench Tridectin® (TRI, containing MOX, BZ & LEV).

Table 1: Overall mean drug efficacy on farm level including the 95% confidence intervals in brackets for Benzimidazole (BZ), Levamisole (LEV), Closantel (CLO), Abamectin (ABA), Moxidectin (MOX) and the combination drench (TRI, containing MOX, BZ & LEV). All mean values below the recommended 95% efficacy cut-off are highlighted in red/bold. If a drug was not tested on a particular farm, the cell is left empty. The grey underlined farms are those with low FECs before treatment. If no *H. contortus* were present before treatment, CLO efficacy was not determined and therefore is indicated NA.

Farm	BZ	LEV	CLO	ABA	MOX	TRI
1	99 (95-100)	100 (97-100)	95 (73-99)	**90 (54-98)**	**84 (73-90)**	99 (89-100)
2	**90 (69-97)**	**93 (69-98)**	99 (94-100)	**88 (41-98)**	96 (80-99)	98 (81-100)
3	**61 (40-75)**	99 (98-100)	95 (91-97)	**0**	**72 (39-87)**	100 (99-100)
4	***77 (59-87)***	***83 (65-92)***	***92 (81-97)***	***45 (0-76)***	***94 (79-98)***	*100 (94-100)*
5	97 (86-99)	100 (97-100)	**94 (75-99)**	**87 (40-97)**	**93 (67-99)**	100 (97-100)
6	98 (93-99)	100 (99-100)	98 (95-99)	**93 (83-97)**	100 (98-100)	99 (95-100)
7	**71 (43-86)**	99 (93-100)	100 (92-100)	**88 (69-92)**	100 (99-100_	100 (99-100)
8	**63 (25-82)**	95 (88-95)	**0**	**80 (52-92)**	**89 (53-97)**	100 (96-100)
9	**93 (86-96)**	99 (96-100)	**94 (89-97)**	**67 (25-85)**	**79 (57-90)**	100 98-100)
10	***80 (0-97)***	*96 (62-100)*	*100 (71-100)*	***36 (0-87)***	*100 (82-100)*	*100 (82-100)*
11	***49 (0-79)***	***94 (46-99)***	***NA***	***97 (73-100)***	*100 (98-1000*	*100 (97-100)*
12	***32 (0-69)***	***0***	***NA***	***88 (0-99)***	***72 (0-95)***	*100 (98-100)*
13	**41 (6-63)**	**90 (78-96)**	100 (94-100)	**82 (67-90)**	98 (90-99)	100 (96-100)
14	**37 (0-77)**	97(89-99)	100 (93-100)	**0**	95 (72-99)	99 (88-100)
15	**65 (29-82)**	**91 (53-98)**	99 (94-100)	**43 (0-82)**	96 (87-99)	100 (96-100)
16	**82 (51-94)**	**90 (73-96)**	100 (90-100)	**91 (71-97)**	99 (95-100)	98 (86-100)
17	**78 (27-94)**	98 (95-99)	99 (99-100)	**0**	**83 (42-95)**	100 (97-100)
18	***78 (28-93)***	*99 (86-100)*	*98 (92-99)*	***0***	***92 (39-99)***	*100 (93-100)*

Three properties elected to also test an additional drench each that were not part of the main study (Zolvix® and Startect®), these were both found to 100% effective against all parasites present. On one property, Napfix® (containing Abamectin, Albendazole and Naphthalophos) was included and demonstrated 100% efficacy (data not shown).

Table 2: Mean drug efficacy at farm level against *Haemonchus* spp. for Benzimidazole (BZ), Levamisole (LEV), Closantel (CLO), Abamectin (ABA), Moxidectin (MOX) and the combination drench (TRI, containing MOX, BZ & LEV).

Farm	BZ	LEV	CLO	ABA	MOX	TRI
1	97	100	94	86	93	100
2	72	95	99	60	87	91
3	63	100	98	0	72	100
4	*97*	*82*	*100*	*40*	*93*	*100*
5	99	100	95	90	84	99
6	98	100	100	93	100	100
7	70	99	100	84	100	100
8	63	100	100	34	100	100
9	94	100	94	67	79	100
10	*69*	*100*	*100*	*0*	*100*	*100*
11	-	-	-	-	-	
12	-	-	-	-	-	
13	73	100	100	77	99	100
14	82	100	100	0	96	100
15	65	91	99	43	96	100
16	62	100	99	0	65	100
17	62	100	99	0	65	100
18	*95*	*100*	*98*	*0*	*95*	*100*
Average	**78.8**	**97.9**	**98.4**	**42.1**	**89.0**	**99.4**

Table 3: Mean drug efficacy at farm level against *Teladorsagia* spp. for Benzimidazole (BZ), Levamisole (LEV), Abamectin (ABA), Moxidectin (MOX) and the combination drench (TRI, containing MOX, BZ & LEV).

Farm	BZ	LEV	ABA	MOX	TRI
1	93	97	95	98	100
2	95	94	93	98	99
3	-	-	-	-	100
4	*0*	*100*	*100*	*100*	*100*
5	100	100	100	100	100
6	100	100	100	99	100
7	71	71	100	99	100
8	55	93	83	85	100
9	72	87	62	79	100
10	*89*	*76*	*96*	*100*	*100*
11	*46*	*94*	*97*	*100*	*100*
12	*0*	*0*	*0*	*0*	*100*
13	0	67	89	93	100
14	-	-	-	-	100
15	-	-	-	-	100
16	66	85	90	99	95
17	78	91	21	96	100
18	*0*	*92*	*86*	*74*	*100*
Average	57.7	83.1	80.8	88.0	99.7

Table 4: Mean drug efficacy at farm level against *Trichostrongylus* spp. for Benzimidazole (BZ), Levamisole (LEV), Abamectin (ABA), Moxidectin (MOX) and the combination drench (TRI, containing MOX, BZ & LEV).

Farm	BZ	LEV	ABA	MOX	TRI
1	-	-	-	-	100
2	63	63	100	100	100
3	-	-	-	-	100
4	*100*	*100*	*100*	*100*	*100*
5	-	-	-	-	99
6	100	100	100	100	100
7	100	100	100	100	100
8	100	100	100	100	100
9	-	-	-	-	100
10	*100*	*100*	*100*	*100*	*100*
11	*100*	*93*	*100*	*100*	*100*
12	*100*	*100*	*100*	*100*	*100*
13	100	50	100	100	100
14	0	74	100	100	100
15	-	-	-	-	100
16	94	88	100	100	100
17	100	91	100	100	100
18	-	-	-	-	-
Average	**88.1**	**88.3**	**100.0**	**100.0**	**99.9**

Table 5: Overall mean drug efficacy on farm level including average across the entire set of 18 farms for Benzimidazole (BZ), Levamisole (LEV), Abamectin (ABA), Moxidectin (MOX) and the combination drench (TRI, containing MOX, BZ & LEV).

Farm	BZ	LEV	ABA	MOX	TRI
1	99	100	90	84	99
2	90	93	88	96	98
3	61	99	0	72	100
4	*77*	*83*	*45*	*94*	*100*
5	97	100	87	93	100
6	98	100	93	100	99
7	71	99	88	100	100
8	63	95	80	89	100
9	93	99	67	79	100
10	*80*	*96*	*36*	*100*	*100*
11	*49*	*94*	*97*	*100*	*100*
12	*32*	*0*	*88*	*72*	*100*
13	41	90	82	98	100
14	37	97	0	95	99
15	65	91	43	96	100
16	82	90	91	99	98
17	78	98	0	83	100
18	*78*	*99*	*0*	*92*	*100*
Average	**71.7**	**90.2**	**59.7**	**91.2**	**99.6**

Discussion

The key objectives of this study were to demonstrate the value of FEC resistance tests as a key decision-making tool on farm, thereby driving improved adoption, whilst establishing benchmark data on the efficacy of commonly used worm drenches for TFS members.

Drench efficacies:

Results obtained during the study revealed a lack of efficacy for several actives on several farms. While the combination drench was effective on all farms, results were different for the five single-active drenches. Worm populations not responding to treatment with at least one single-active drench were present on every farm. Levamisole and Closantel remained amongst the more successful drenches while reduced efficacies were observed for 60% of Benzimidazole treatments, almost 75% of Moxidectin treatments and nearly all Abamectin treatments. This confirms previous findings that single-active drenches have to be used with care but can be a valuable tool on certain farms where good-to excellent efficacy is still reached.

The combination Tridectin® drench was included in this survey alongside the single actives to demonstrate the effect of combining different substances. While reduced efficacies were observed for all three single actives (MOX, BZ and LEV), the combination of the three was highly efficacious. However, it has been observed in other field studies that if reduced efficacy against one active of the combination is present it can relatively quickly lead to a decrease in the combination efficacy. This was predominantly the case for dual combinations. Even though most farms nowadays use combination drenches, the use of single active drenches is preferable in a FECRT in order to obtain the true efficacies of each substance. The results for the single actives still provide an insight into which combinations are likely to be affected, either now or in the future.

The performance of the FECRTs were supervised by Dr Playford to ensure the correct protocol was followed. This professional help was much appreciated by the participants and on none of the properties any problems in following the protocol, animal welfare or any other matter were observed.

Adoption of the FECRT:

Over 35 farmers contributing samples from more than 50 individual mobs for this survey. That indicates that a coordinated and subsidised approach to initiate drench efficacy testing does reach the interest of sheep farmers. It has to be noted that TFS was the main initiator of this project and a parasite monitoring program jointly initiated by Dawbuts and TFS had already resulted in a focus on improved parasite management by TFS members. The interest of the responsible Project Officer and other TFS staff also helped to drive the motivation of members to participate. The already established relationship with Dawbuts additionally provides professional advice as well as assistance in interpreting the results obtained on a farm level. Both are important factors in ensuring that farmers gain a better understanding of parasite management and are more likely to use the tools available to them. This provision of advice and/or possible solutions in combination with the subsidy of a free test kit resulted in its increased use over normal levels for the members.

Although conditions were thought to be favourable for parasite development on pasture at the time, three fifths of the flocks pre-screened did not meet the FEC threshold of 200 eggs per gram, meaning they could not participate. This suggests that the animals were either able to control the worm infections themselves or infection pressure was not as high as presumed. On those properties where animals are systematically treated for worms without pre-testing, drenching would not have delivered any additional benefit, despite its high costs in terms of both drug purchase and time to treat. These pre-screening tests alone highlight the importance and value of monitoring the worm status of flocks before drenching.

On the other side it also highlights the importance of accounting for seasonal as well as on-farm variation if a survey is going to be carried out successfully. This is necessary to ensure that the activities are achievable for farmers and reaching the goal of the project is realistic. Short-term project such as this one might be limited in their outcomes due to the inability to adjust for seasonal conditions as experienced in this study with frequently observed low FEC in pre-screening tests. Although a number of TFS members were unable to contribute, due to failure to meet the pre-screening requirements, they still received project outcomes and are able to participate in project meetings to discuss outcomes and learn of potential solutions to future worm problems.

Due to low pre-screening FECs in combination with an extremely short time frame available for this survey growers outside the TFS group needed to be included in order to meet required numbers. However, in order to reach out to the wider grower community it was also evident that one or two meetings including information material and presentations are not enough of this group. Additional emails, promotion of the survey on the website and through facebook and personal contact with potentially interested growers were also needed to get the required number of participants on board. However, as a result of including non-members, a positive, though unintended, outcome of this project was the demonstration of the value of TFS membership with respect to the ability to be involved in projects such as this.

Conclusions and Recommendations

The project demonstrated that the newly established FECRT protocol combined with the more sensitive Mini-FLOTAC method proved to be reliable and easy to follow. The calculation of efficacies was performed using a program which not only calculates the mean efficacy but also the confidence intervals. The fact that farmers were not just given an average efficacy but also presented with the confidence intervals, in combination with the respective explanation, may increase their understanding of their value as a tool for decision making. The promotion of this new protocol in similar projects is highly recommended.

The fact that efficacies of several of the drenches were below the recommended 95% efficacy cut off mark in many of the flocks tested might not be new to researchers, but it is a very valuable piece of information for the respective farmer. Every farm situation is different and therefore warrants conducting farm specific FECRTs. Since the results will be discussed and recommendations offered at the final meeting, the acceptance as well as the understanding of the problem is expected to increase.

The adoption of techniques such as the FECRT on Australian sheep farms still remains a relatively challenging task for the industry. However, this project demonstrated that when presented with a coordinated supported approach (combined with the benefit of a free drench) farmers are generally very interested. The interest of non-members to join farming groups such as TFS as a result of their participation in the project also suggests that farming groups are perceived positively, particularly when introduced through useful experiences. It underlines the importance of conducting coordinated approaches in order to increase adoption. This could point the way for the increase of adoption through future projects. The positive experiences of this study will be shared with other farmers and hopefully spark the interested to perform FECRTs even outside guided projects. However, in order to facilitate the on-going use of drench efficacy testing, long-term guidance and support is needed. Worm control and resistance management are complex tasks and not easily implemented into different farm management procedures. Farmers need to be provided with support and advice in order to weight up the time and costs involved in FECRTs against the benefits achieved.

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List of Abbreviations and/or Glossary

ABA	Abamectin
AWI	Australian Wool Innovation
BZ	Benzimidazoles
CLO	Closantel
FEC	Faecal Egg Count
FECRT	Faecal Egg Count Reduction Test
LEV	Levamisole
MLA	Meat & Livestock Australia
MOX	Moxidectin
NA	Not applicable
TFS	Tableland Farming System
TRI	Tridectin ®

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