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Analysis of 20 Drench Resistance Tests on 19 beef cattle farms in the Agricultural Regions of WA

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Abstract

A series of drench resistance tests in cattle using the macrocyclic lactones, benzimidazole and levamisole groups in southern WA are reported here. The tests have identified:

- Resistance in *Cooperia oncophora* to ivermectin on 63% of farms tested.
- Resistance in *Ostertagia ostertagii* to benzimdizole and levamisole on 50% and 63% respectively of farms tested.
- Resistance in *Cooperia oncophora* to ivermectin using pour on application at Day 14 and Day 28 on 50% and 37.5% of farms respectively.
- Resistance in *Ostertagia ostertagii* to ivermectin pour on at Day 14 and Day 28 on 20% and 37.5 % of farms.

Background

Drench resistance testing was conducted on weaner cattle in their first year of grazing on 19 beef producing farms in the southern region of WA, during 2010 - 2011. The farms represent a diversity of environments, cattle management and drench use history. Treatments were macrocyclic lactone (ivermectin), white (benzimidazole) and clear (levamisole) drench group with comparisons made to a control group. A fourth group included a pour on application of ivermectin following reports of endectocide exchange through oral licking among co-habiting animals in a mob.

Methods

Farm Selection

Farmers were invited to participate in a drench resistance test through various means used to raise awareness that drench resistance may occur in WA. These included media articles, radio chat sessions, speaking at cattle producer group meetings and cold calling of potential participants. The intention was to carry out tests in all areas of the agricultural regions where cattle are raised. Testing was carried out on young cattle, 6 – 18 months of age of either sex in their first season of grazing in the age range of 6-18 months, over a 15 month period with the majority of tests carried out between November 2010 and May, 2011. The timing of tests was influenced by individual farm programs and the weaner cattle's subsequent preparation for sale. Farm selection was based on farmer interest and the capacity to supply a mob of weaned cattle in the appropriate age range that had not received a drench in the 4 months preceding the test. A minimum mob worm egg strongyle count of more than 50 eggs per gram, and preferably higher, was required. Usually between 50 and 75 animals were available and depending on this number and the farmer's management plan and resources, either 4 or 5 groups was used. The factors above determined treatment group size and this varied between 9 and 17 animals per group.

Treatments Used

Treatments used were:

macrocylic lactones:

i) ivermectin by injection, (Ivomec Antiparasitic Injection for Cattle, 10 mg/ ml) dosed at 0.2 mg per kg

ii) or ivermectin pour-on application, (Ivomec Pour –On for Cattle, 5 mg / ml) dosed at 0.5 mg per kg

benzimidazoles:

iv) oral dosing with fenbendazole, (Panacur 100, Coopers Animal Health,100mg / ml) dosed at 7.5 mg per kg

levamisole:

iii) oral dosing with levamisol, (Nilverm LV, Coopers Animal Health, 80 mg per ml) dosed at 6.75mg / kg

A control group remaining untreated at the initial collection were treated at the end of the collection period, ensuring all animals used in the trial received a drench. Cattle were individually tagged, weighed and dosed according to label recommendations, with a modification where individual animals whose measured weight was close to the upper limit of a weight -dosage range. These animals received a volume of drench equivalent to that of an animal weighing 25 kg more than the actual weight. This was to ensure that cattle at the extremes of a weight range received an equivalent dose to those in the centre of that weight range.
Cattle that received a pour on treatment were run as a separate mob for 28 days following treatment.

Sample Collection
Individual rectal samples were collected from all trial cattle on the day of setting up the test, Day 0 and Day 14, with an additional collection at Day 28 for animals in the pour-on group. Samples were stored in marked containers and transported in cool boxes to the laboratory.

Laboratory Analysis
Samples were submitted to DAFWA's Animal Health Laboratory (Albany) where Individual faecal worm egg counts (FWEC) were performed on 4g of faeces from each animal using the modified McMaster technique. Two chambers were counted for each animal, resulting in one egg being equivalent to 12.5 eggs per gram (epg) for all farms (except for farms 15 and 19 where chamber counts were doubled resulting in 1 egg being equivalent to 6.25 epg). Composite faeces were cultured for each treatment group for 7 days at 25ºC, after which larval differentiations were performed.

Data Analysis
Resistance was considered to be present when faecal egg count reduction is lower than 95% and the lower confidence interval limit is lower that 90% (Coles *et al*, 1992). Calculations were based on the 'RESO' FECRT analysis program. Confidence limits were generated by treatment group (Lyndal-Murphy *et al* 2010). The distribution of pre-treatment counts on each farm was examined for fit to the negative binomial distribution with the curves shown in Appendix 1. Only sets of results with appropriate characteristics of fit were included in this analysis. In addition, Dr Robert Dobson of Murdoch University utilised repeated counts on some samples to investigate novel statistical methods for estimating anthelmintic efficacy. (This is reported in the paper: Dobson RJ et al "Preserving new anthelmintics: A simple method for estimating faecal egg count reduction test (FECRT) confidence limits when efficacy and/or nematode aggregation is high". *Veterinary Parasitology* (in press).)

Results

Assessment of 'Fit' to Negative Binomial Distribution
Two tests were carried out on one Narrikup farm and after analysis for fit to the negative binomial distribution only the second test was included in this analysis. The first test was carried out on 2010 weaners in August with the pre test individual FWEC's failing to conform to the negative binomial distribution. (K value =0.4) Distributions with better fit have K values closer to or greater than 1. The test was repeated on the following year's weaners in January 2011. The second set of pre test FWEC's fitted well to the negative binomial distribution with K value = 1.65) and the results of the test are included in this analysis. The reason for the difference in fit

may be explained by a difference in age of the first group of animals in that they were older by a few months relative to the age of their test peers from other farms and it is proposed that a more advanced parasite immunity or 'self cure' may have been progressing in this group evidenced by a higher number of individual animals recording 0 epg.

Average Farm larval differentiation pre- Treatment

Average Farm Larval Differential Pre Treatment

Farm No	Location	Agricultural Region	Ostertagia	Trichostrongylus	Haemonchus	Oesophagostomum	Cooperia oncophora	Cooperia Sp
1	Narrikup	Southern	37	4	6	15	34	4
2	Youngs Siding	Southern	25	1	1	20	53	2
3	Marbellup	Southern	18	10	4	11	56	2
4	Narrikup	Southern	33	2	0	6	60	0
5	New Norcia	Northern	42	3	0	7	49	1
6	Mogumber	Northern	33	4	20	10	29	5
7	Narrikup	Southern	36	11	14	2	36	1
8	Narrikup	Southern	10	0	60	4	26	1
9	Denmark	Southern	41	19	8	1	28	3
10	Manjimup	South West	13	4	8	4	70	2
11	Narrikup	Southern	7	2	33	7	49	2
12	Walpole	Southern	6	3	21	8	60	3
13	Kalgan	Southern	14	5	12	25	44	1
14	Mt Barker	Southern	25	1	8	9	56	1
15	Esperance	Southern	39	2	4	12	43	0
16	Ravensthorpe	Southern	30	3	13	3	52	0
17	Williams	Central	58	2	1	18	22	1
18	Donnybrook	South West	49	1	9	0	40	0
19	Harvey	South West	39	2	8	11	40	0
20	Esperance	Southern	14	0	52	3	31	0
	Average		**28**	**4**	**14**	**9**	**44**	**1**

From here on in this report the following abbreviations refer to the full names of strongyle parasites of interest.
Ostertagia (Ost), Trichostrongylus (Trich), Haemonchus (Haem), Oesophagostomum (Oes), Cooperia oncophora (C.onco), Cooperia species (ie includes species other than *Cooperia oncophora)*

Table 1: Indicates the presence of the parasite species of interest by average larval culture on the farm prior to our drench intervention.

Larval culture figures are an average of cultures from pre- treatment groups at all test sites. Substantial numbers of samples per farm (range 36 and 58) were faecal cultured. Subsequently farm group averages are presented as the overall average of larval species cultured for samples from southern WA. The species average (in orange) is in line with the expected percentage of each of the strongyle parasites of interest. *Species averages in larval cultures across farms were Ostertagia ostertagi* at 28% (range 6 to 58%); *Trichostrongylus axei* at 4% (range 0 to 19%); *Haemonchus* at 14% (range 0 to 60%); *Oesophagostomum* at 9% (range 0 to 25%); *Cooperia oncophora* at 44% (range 22 to 70%); and remaining *Cooperia species* (ie, undifferentiated other than for *C. oncophora*) at 1% (0 to range 5%).

Ivermectin injectable reduction by species

Ivermectin Injectable - %Reduction by species on Farm

Test No.	Farm WEC	Treatment Group WEC	Srongyles	Confidence Limits CL	Ost	Trich	Haem	Oes	C. onco
1	84	140	**95.7**		100	x	x	98	90
2	80	83	**97.8**		100	x	x	94	97
3	70	21	**100.0**		100	100	x	100	100
4	110	65	**100.0**		100	x	x	x	100
5	114	113	**86.9**	**(5, 98)**	100	x	x	x	29
6	63	63	**86.8**	**(21, 98)**	100	x	100	x	72
7	208	225	**97.6**	**(87, 100)**	x	x	100	x	90
8	109	131	**96.0**	**(83, 99)**	100	86	100	x	85
9	108	63	**81.6**	**(53, 93)**	100	x	100	x	70
10	359	415	**95.8**	**(91, 98)**	x	x	100	x	90
11	269	269	**98.0**	**(86, 100)**	x	x	100	x	93
12	115	131	**96.3**	**(87, 99)**	100	x	100	100	91
13	108	120	**100.0**	**(97, 100)**	100	x	x	x	100
14	41	39	**100.0**	**(97, 100)**	100	x	x	x	100
15	49	65	**95.6**	**(77, 99)**	100	x	100	x	90
16	106	91	**100.0**	**(97, 100)**	100	x	x	100	100
17	107	86	**96.3**	**(66, 100)**	100	x	100	x	91
18	44	48	**100.0**	**(97, 100)**	100	x	100	100	100
19	211	193	**89.1**	**(61, 97)**	100	x	89	x	89
Average	124	124.3	**95.4**		100%				63%
N+/N tests					19/19 tests				12/19 tests

x=less than 10epg of this species

Table 2: Indicates the percentage reduction by species on individual farms tested in response to treatment with Ivermectin by injection

i) ivermectin (injectable) was less than fully effective in 63% (12/19) of tests against *Cooperia oncophora*.

ii) ivermectin (injectable) was fully effective in all tests against *Ostertagia ostertagi*.

Benzimidazole Oral Reduction by Species

Benzimidazole Oral - % Reduction by species on farm										
Farm No	**Farm WEC**	**Tx Group WEC**	**Srongyles**	**Confidence Limits CL**	**Ost**	**Trich**	**Haem**	**Oes**	**C. onco**
1	84	93	**100.0**		100	x	x	x	100
2	80	63	**97.1**		95	x	x	80	100
3	70	84	**97.0**		100	x	x	x	100
4	110	108	**97.0**		91	x	x	x	100
5	114	117	**91.7**	**(72, 98)**	85	x	x	100	100
6	63	46	**98.9**	**(88,100**	97	x	100	x	x
7	208	241	**97.9**	**(93, 99)**	97	x	97	x	100
8	109	96	**98.6**	**(86, 100)**	97	99	x	x	99
9	108	173	**94.7**	**(88, 98)**	97	x	x	x	98
10	359	310	**99.8**	**(99, 100)**	x	x	100	x	100
11	269	290	**100.0**	**(99, 100)**	x	x	100	100	100
12	115	145	**98.4**	**94, 100)**	91	x	100	100	100
13	108	74	**96.7**	**(85, 99)**	88	x	100	100	100
14	41	56	**97.2**	**(89, 99)**	96	x	x	100	96
15	49	47	**100.0**	**(93, 100)**	100	x	100	x	100
16	106	90	**85.9**	**(59, 95)**	32	x	x	100	100
17	107	130	**98.4**	**(84, 100)**	93	x	100	x	99
18	211	45	**94.3**	**(73, 99)**	74	x	x	100	100
19	211	196	**98.2**	**(95, 99)**	x	x	98	x	100
Average	132.7	126.5	**96.9**		50%				100%
N+/N tests					8/16 tests				18/18 tests
x=less than 10epg of this species									

Table 3: Indicates the percentage reduction by species in individual tests in response to treatment with oral benzimidazole

i) benzimidazole treatment against *Cooperia oncohpora* was fully effective in all tests where the parasite is present.

ii) benzimidazole treatment against *Ostertagia ostertagi* was less than fully effective in 50% (8/16) of tests.

Levamisole Oral Reduction by Species

Levamisole Oral - % Reduction by species

Farm No	Farm WEC	Tx Group WEC	Srongyles	Confidence Limits CL	Ost	Trich	Haem	Oes	C. onco
1	84	68	**98.5**		97	x	x	x	100
2	80	107	**97.1**		68	x	x	93	96
3	70	74	**-27**		77	x	x	100	-2258
4	110	136	**92.2**		58	x	x	100	100
5	114	91	**91.2**	**(21, 99)**	84	x	x	x	100
6	63	46	**98.8**	**(88,100**	97	x	x	x	100
7	208	163	**98.7**	**(94, 100)**	86	x	100	x	100
8	109	111	**98.7**	**(89, 100)**	98	96	x	x	100
9	108	77	**100**	**(96100**	x	x	x	x	100
10	359	310	**99.8**	**(98, 100)**	x	x	100	x	100
11	269	334	**100**	**(99, 100)**	x	x	100	x	100
12	115	92	**98.6**	**(90, 100)**	92	x	x	100	100
13	108	143	**100**	**(98, 100)**	100	x	x	x	100
14	41	36	**88**	**(67, 96)**	78	x	x	100	100
15	49	35	**100**	**(92, 100)**	100	x	100	x	100
16	106	138	**94.5**	**(84, 98)**	86	x	x	100	100
17	107	124	**98.3**	**(93, 100)**	89	x	100	x	100
18	211	49	**97.6**	**((89, 99)**	96	x	x	x	100
19	211	248	**99.6**	**(97, 100)**	95	x	100	x	100
Average	132.7	90.8	**90.8**		63%				94%
N+/N tests					10/16 tests				18/19 tests

x=less than 10epg of this species

Table 4: Indicates percentage reduction by species in individual tests in response to oral treatment with levamisol.

i) levamisol was fully effective in 94% (18/19) of tests against *Cooperia oncophora.*

ii) levamisol was less than fully effective against *Ostertagia ostertagi in 62.5*% (10/16) of tests.

Ivermectin pour on (Day 14) reduction by Species

Ivermectin Pour on Day 14 - % Reduction by Species

Farm No	Farm WEC	Tx Group WEC	Srongyles	Confidence Limits CL	Ost	Trich	Haem	Oes	C. onco
1	84	51	**96.7**		97	x	100	100	93
2	80	58	**95.2**		98	x	x	100	88
3	70	99	**100.0**		100	100	100	x	100
4	110	150	**99.8**		100	x	x	100	100
6	63	116	**97.8**	**(91,99)**	100	x	x	100	98
8	208	240	**100.0**	**(99, 100)**	x	x	100	x	100
13	108	86	**95.8**	**(74, 99)**	87	x	100	x	100
14	41	34	**86.2**	**(70,94)**	90	x	x	99	39
15	49	40	**96.4**	**(73, 100)**	100	x	100	x	91
16	106	61	**97.9**	**(81, 100)**	96	x	x	100	x
19	211	49	**92.8**	**(69,98)**	100	x	x	x	81
Average	102.7	93.5	**96.2**		20%				50%
N+/N tests					2/10 tests				5/10 tests

x=less than 10epg of this species

- Note Farms 1 & 2 pour on treated cattle were not run separately.

Table 5: Indicates percentage reduction by species in individual tests in response to ivermectin pour on treatment at Day 14.

i) ivermectin pour on treatment was less than fully effective against *Cooperia oncophora* in 50% (5/11) of tests at 14 days post treatment.

ii) ivermectin pour-on treatment was less than fully effective against *Ostertagia ostertagi* in 20% (1/10) of tests.

iii) The effectiveness of the pour on formulation of ivermectin was reduced against both parasites at the 14 day samples (parasite knock down).

Ivermectin pour on (Day 28) Reduction by Species

Ivermectin Pour on Day 28 - % Reduction by Species										
Farm No	**Farm WEC**	**Tx Group WEC**	**Srongyles**	**Confidence Limits CL**	**Ost**	**Trich**	**Haem**	**Oes**	**C. onco**
1	84	51							
2	80	58							
3	70	99	**100**		100	100	100	x	97
4	110	150	**99.8**		100	x	x	100	99
6	63	116	**97.8**	**(91,99)**	100	x	x	100	98
8	208	240	**99.6**	**(97, 100)**	x	x	100	x	98
13	108	86	**94.3**	**(68, 99)**	90	x	x	x	96
14	41	34	**69.6**	**(44, 82)**	89	x	x	86	-61
15	49	40	**67.9**	**(10, 88)**	35	x	100	x	71
16	106	61	**100**	**(96, 100)**	100	x	x	x	x
19	211	49	**85.6**	**(63, 94)**	99	x	x	x	63
Average	102.7	**89.5**	**90.5**		37.5%				37.5%
N+/N tests					3/8 tests				3/8 tests
x=less than 10epg of this species									

Table 6: Indicates percentage reduction by species on individual farms in response to ivermectin pour on treatment at Day 28

i) Ivermectin pour on treatment was less than fully effective against *Cooperia oncophora* on 37.5% (3/8) tests at 28 days post treatment.

ii) Ivermectin pour-on treatment was less than fully effective against *Ostertagia ostertagi* on 37.5% (3/8) tests.

iii) The protective period of the chemical was reduced against both parasites.

Comparison of the reduction of *Cooperia oncophora* by ivermectin injectable Day 14, with ivermectin pour on Day 14 and Day 28

	IVM INJ (day 14)	IVM PO (day 14)	IVM PO (day 28)
Test No.	**C. onco**	**C. onco**	**C. onco**
1	90	93	no test
2	97	88	no test
3	100	100	97
4	100	100	99
5	29	no test	no test
6	72	98	98
7	90	100	98
8	85	no test	no test
9	70	no test	no test
10	90	no test	no test
11	93	no test	no test
12	91	no test	no test
13	100	100	96
14	100	39	-61
15	90	91	71
16	100	x	x
17	91	no test	no test
18	100	81	63
19	89	no test	no test
Prevalence	63% (12/19)	50% (5/10)	37.5% (3/8)
Mean Reduction (Severity)	88%	89%	70%
x=less than 10epg of this species			

Table 7: Indicates a performance comparison between ivermectin injectable (Day 14), with ivermectin pour on (Day 14) and ivermectin pour on (Day 28) treatments against *Cooperia oncophora.*

i) Ivermectin resistance was present in 63% of tests against *Cooperia oncophora* (ivermectin injectable).

ii) Ivermectin resistance was also detected in the pour on formulation at day 14 on 50% of farms and at day 28 on 37.5% of farms that had weaner cattle available for testing.

iii) By day 14, the pour on demonstrated a similar degree of mean reduction in effectiveness (severity of resistance) as the injectable application. Mean reduction in effectiveness was further reduced to 70% (severity of resistance) by day 28 following application.

Comparison of the reduction of *Ostertagia ostertagi* on farms by ivermectin injectable (day 14) with ivermectin pour on day 14 and day 28

	IVM INJ (day 14)	IVM PO (day 14)	IVM PO (day 28)
Test No.	**Ost**	**Ost**	**Ost**
1	100	97	no test
2	100	98	no test
3	100	100	100
4	100	100	100
5	100	no test	no test
6	100	100	100
7	x		no test
8	100	x	x
9	100	no test	no test
10	x	no test	no test
11	x	no test	no test
12	100	no test	no test
13	100	87	90
14	100	90	89
15	100	100	35
16	100	96	100
17	100	no test	no test
18	100	no test	no test
19	100	100	99
Prevalence	100% (19/19)	20% (2/10)	37.5%(3/8)
Mean Reduction (severity)	100%	96.80%	88%
x=less than 10epg of this species			

Table 8: Indicates a performance comparison between ivermectin injectable (Day 14), with ivermectin pour on (Day 14) and (Day 28) treatments against *Ostertagia ostertagi*

i) Ivermectin injectable formulation was fully effective on all farms against *Ostertagia ostertagi*

ii) Ivermectin as the pour on formulation exhibited resistance in *Ostertagia ostertagi* at day 14 on 20% of farms, and at Day 28 on 37.5% of farms that had weaner cattle available for testing.

iii) There was progressive mean reduction in chemical performance with the pour on application against *Ostertagia ostertagii* at day 14 (96.8 % and then 88% by day 28

Summary of major findings

Larval Differentiation

The larval differentiation studies for these farms were in line with expectation. Percentages of species composing weaner cattle worm burdens in these tests were similar to those reported in the south west of WA in 1882 (de Chaneet *et al*). Recent laboratory determinations from saleyard survey samples confirmed similar populations (Cattle Faecal Sampling in the Agricultural Regions of WA, Report to MLA, Oct 2010).

Possible presence *of Haemonchus placei*

An interesting finding is the report from the DAFWA laboratory that the *Haemonchus* species collected from cattle throughout this drench resistance testing was consistently identified as *Haemonchus placei* rather than *Haemonchus contortus*. The parasites grown in larval culture were identified by measurement of larval body and shaft length. Recovered larvae were measured as having larval body and sheath length dimensions equivalent to those of *H. placei*. Further identification studies were undertaken by dosing collected stored larvae into a parasite free sheep. One sheep received a dose of 5000 larvae of a mixed infection and was housed for 57 days. Following slaughter, gut contents were collected for microscopy. Examination of adult *Haemonchus* spicule and vulval flap morphology for length measurement were found to be consistent with known measurements for *H. placei*. This is of interest as it was presumed winter temperatures would prevent the development of *H. placei* in southern WA. PCR testing is planned to confirm this finding. It is conceivable that *H. placei* are brought into southern WA with the transport of northern cattle, but this does not fully explain their presence on particular farms that do not import cattle from northern areas and others that manage completely closed herds. Despite this new information (based on measurement and identification), it is still possible that many *Haemonchus* larvae seen in larval cultures are *H. contortus* picked up from pastures co- grazed with sheep. No clinical signs were observed relating to this parasite in any cattle that were sampled and treated. Currently there are drenches treatments available to which the parasites are susceptible. It remains possible that *H. placei* is residing in cattle in southern WA and this parasite may become importance as a disease potential should any marked climatic change occur (eg a change to more tropical rather than drier conditions).

Drench Resistance Findings

Nineteen Drench Resistance Tests is a relatively small number of tests when compared to other studies from around the world but these results indicate clear trends that are consistent with the findings of others. The major findings are summarized into the table below.

Treatment Group	Summary of % Reduction by species	
	C. oncophora	*Ostertagia*
Ivermectin	63% (12/19 tests)	100% (19/19 tests)
Benzimidazole -albendazole	100% (18/18 tests)	50%(8/16 tests)
Levamisole	94% (18/19 tests)	62.5% (10/16 tests)
Ivermectin pour on (Day 14)	50% (5/10 tests)	20% (2/10 tests)
Ivermectin pour on (Day 28)	37.5% (3/10 tests)	37.5% (3/10 tests)

i) The finding that ivermectin was less than fully effective against Cooperia oncophora on 63% of farms is in agreement with findings of other studies from around the world (New Zealand, Belgium, Germany, Brazil Argentina) and the Australian state of Victoria. (Waghorn et al, El-Abdellati et al, Soutello et al Suarez et al and Rendell).

ii) Resistance in *Cooperia oncophora* to ivermectin was also present with the pour on application. These results recorded a reduction in knockdown capacity (14 days) on 50% of farms and a reduction in the protective period (28 days) on more than a third of farms tested. On the surface, pour on formulation ivermectin appears to be working slightly better than the ivermectin injectable formulation against *Cooperia oncophora* but an overall comparison is difficult. However the greater effect may represent the larger amount of ivermectin in the pour on.

iii) Comparison of the WA situation with the Victorian is also difficult given that different formulations and dose rates are reported in the Victorian study to those used in this study. Rendell used ½ dose oral ivermectin and reported that 100% of properties tested with resistance to *Cooperia sp*. and full dose oral ivermectin showed 62% resistance to *Cooperia sp.* Rendell talks about *Cooperia* species without definition of which ones these are or whether *Cooperia oncophora* is included amongst these. Rendell also reports results following a pour on applications on 3 farms but failed to separate these animals from peers treated with other chemical applications. If chemical availability via oral dosing is considered comparable to delivery by injection then comparison of the level of resistance in *Cooperia oncophora* to ivermectin in WA and Victoria is probably similar or marginally better in WA. An explanation for this might be that management factors known to produce drench resistance have been employed to a lesser extent by WA cattle managers. There remain a proportion of WA producers who do not drench cattle, presumably accepting a production penalty as a result and this may partially account for an apparent lower level of resistance than elsewhere. (Cotter J, Cattle Parasite Current Practices Questionnaire in the Agricultural Regions of WA report to MLA, 2010).

iv) While ivermectin was fully effective against *Ostertagia* on all properties where the injectable formulation was used when the pour on formulation was applied it tested less than fully effective on 20% of farms at 14 Days and progressed to 37.5% at 28 Days. This result is in contrast to the difference between formulations for *Cooperia.* Comparison of these results with the Victorian results suggests ivermectin as the injectable formulation is functioning better than the pour on formulation against *Ostertagia* on West Australian farms. On Victorian farms resistance against Ostertagia was reported occurring on 5/11farms tested (Rendell 2010). Despite these findings it is unlikely that WA farmers using the ML drenches experience any effect of resistance in terms of worm disease or production loss. This is because the bulk of resistance noted is in *Cooperia*, which comprises the greater proportion of worms present in young cattle and considered relatively less pathogenic while the injectable MLs are still fully effective against *Ostertagia*, the more pathogenic of the species. However given that the pour on formulation is most widely used in WA, the 'stage is set' for a rise in resistant *Ostertagia* in the future.

v) Benzimidazoles and levamisole remain fully effective on 100% and 94% of farms respectively against *Cooperia oncohora* but against *Ostertagia ostertagii* both groups are less than fully effective on 50% (8/16) farms and

62.5% (10/16) farms respectively. The presence of a converse resistance between parasite genera and drench groups detected in these test results indicate opportunities for chemical companies to develop useful combination formulations. Possible useful combinations would be ivermectin and benzimidazole, as an injectable if possible or ivermectin and levamisole, as an injectable if possible. Combination products could be used as a means of providing fully effective worm control for the major parasite species of concern on most WA farms or may delay a reduction in worm control effectiveness until new actives for treatment of cattle arrive. The authors are aware that a combination of ivermectin and levamisole as a pour on will be available in Australia early in 2012 and this will be a welcome addition to the available groups. A reduction from 50 kg to 25 kg on product dose weight ranges on labelling would encourage more accurate dosing of animals, although this would require that a farmer has access to scales in order to carry this out.

vi) Information from this series of tests indicates that WA may be at an earlier point along relative drench resistance timeline (eg, a lower prevalence of resistance in *Ostertagia* to ivermectin) than Victoria appears to be, and provides advanced warning about the WA situation. .The awareness of WA farmers needs to be raised regarding best practice in drench management, with the aim of preserving drenches for as long as possible. Practices linked to resistance such as excessively frequent treatment and unnecessary whole herd treatments should be the subject of an active extension campaign for change. Drench resistance minimisation techniques developed over many years of research for sheep should be considered to assist cattle managers maintain the activity of current effective drench groups.

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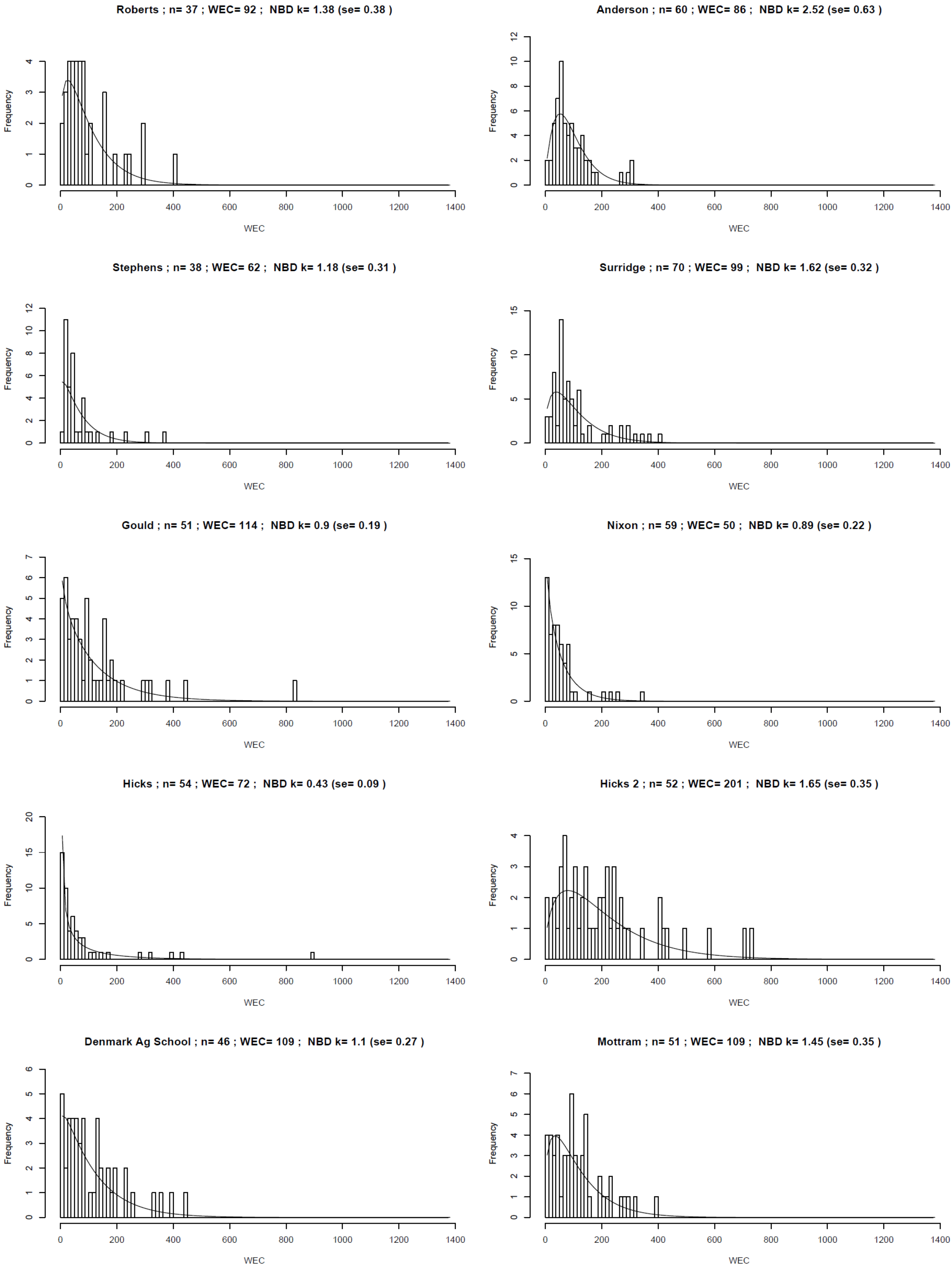
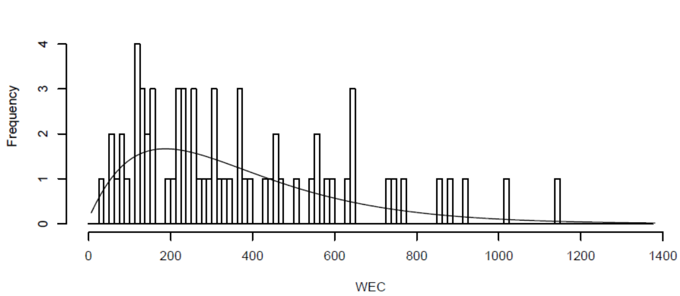
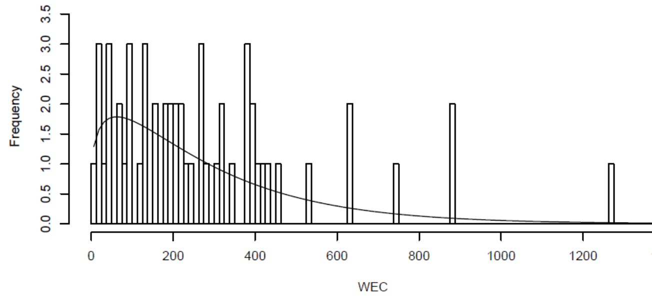
Appendix 1 Farm WEC fit to negative binomial distribution



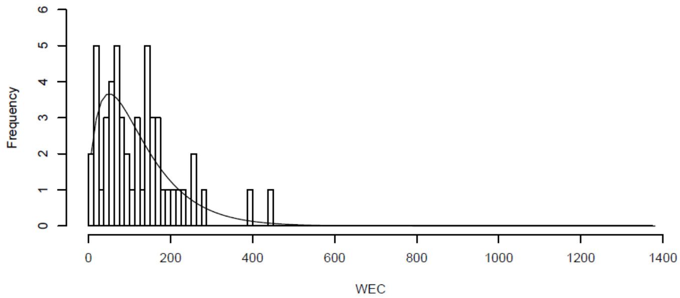
Fisher ; n= 67 ; WEC= 359 ; NBD k= 2.09 (se= 0.37)



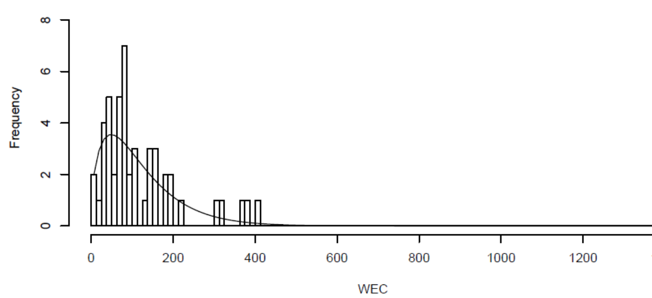
Richardson ; n= 54 ; WEC= 275 ; NBD k= 1.29 (se= 0.25)



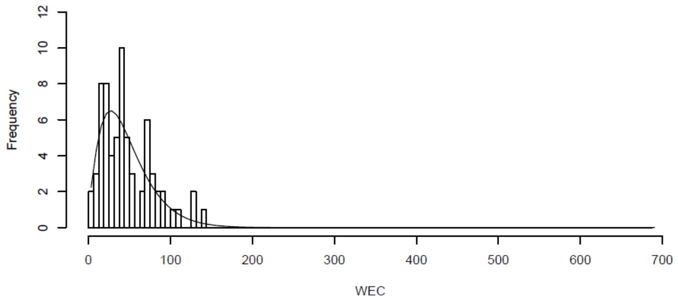
Evans ; n= 51 ; WEC= 116 ; NBD k= 1.77 (se= 0.43)



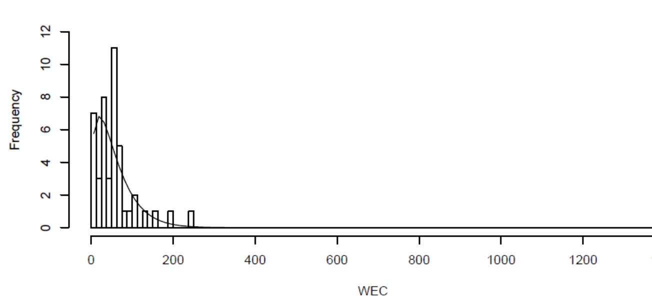
Rodgers ; n= 48 ; WEC= 112 ; NBD k= 1.77 (se= 0.43)



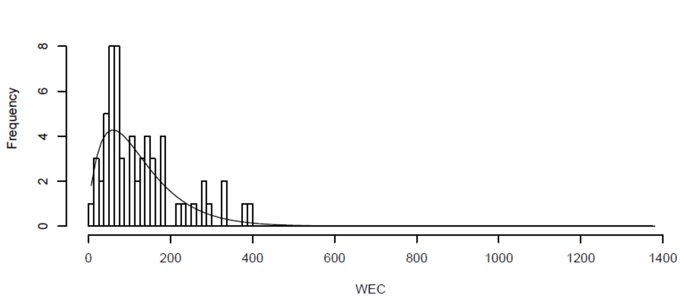
Chalmer ; n= 68 ; WEC= 44 ; NBD k= 2.64 (se= 0.64)



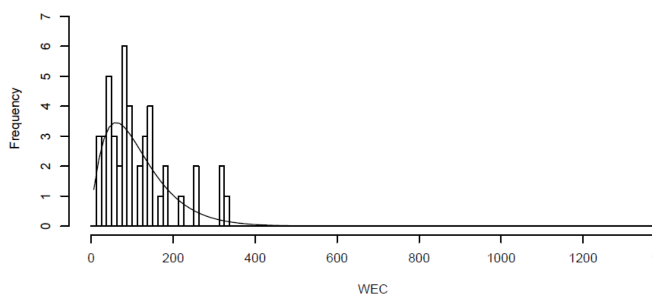
Palmer ; n= 45 ; WEC= 51 ; NBD k= 1.67 (se= 0.54)



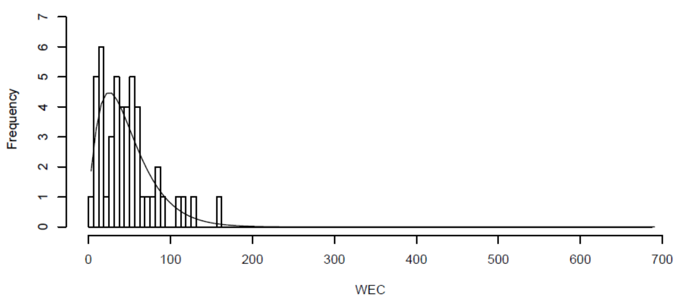
Cowcher ; n= 60 ; WEC= 117 ; NBD k= 2.03 (se= 0.44)



Fry ; n= 44 ; WEC= 107 ; NBD k= 2.32 (se= 0.62)



Harvey Ag ; n= 48 ; WEC= 44 ; NBD k= 2.34 (se= 0.65)



Young River – Witt ; n= 60 ; WEC= 213 ; NBD k= 4.08 (se= 0.93)