

***A comparative study on the
impact of the Breeching Process,
on Merino lambs***

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Study design

The study examined the effect of different procedures (treatments) and combinations of procedures comprising a suite of lamb marking interventions on subsequent lamb growth and fleece production. Lambs were allocated to procedure groups and processed accordingly at recruitment. Sex and starting weights were recorded. Regular revisits occurred. Lambs were weighed at most of these visits. Completion of lamb-marking interventions occurred at a subsequent revisit for some procedures and some sexes (ram lambs). This intervention occurred after the third reweighing visit.

The events that variously occurred and combined to make an individual procedure group included:

1. Lamb marking procedure with SAV cautery docking apparatus.
2. Ram lamb marking (with elastrator rings)
3. Mulesing using traditional surgical technique & Standard cautery docking apparatus.
4. Breeching Process with liquid nitrogen with SAV cautery docking apparatus.

Combinations of these interventions were used to define procedure groups. Sex was included as a variable of interest. The presence of multiple perfectly (collinear) interventions within each procedure group will make it difficult to confirm that any individual intervention component of the procedure was the cause of differences in performance between groups. Sheep were shorn at reweigh visit 3.

There were three procedure groups (Table 1). The statistician was blinded to the nature of the lamb marking interventions that comprise each procedure group.

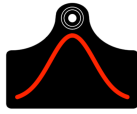


Table 1: Procedure groups

Tag Colour	Procedure group
Black	X
Red	Y
Yellow	Z

The following activities occurred (Table 2):

Table 2: Study activities

Time point	Visit No.	Date	Activity
1	Wt1	2016-11-10	Initial visit & weigh
2	Wt2	2016-12-16	Revisit & weigh
3	Wt3	2017-01-30	Revisit & weigh
4	Wt4	2017-04-18	Revisit & weigh
5	V5	2017-05-30	Breeching process - mechanical issues (non-start)
6	Wt5	2017-06-21	Breeching process - procedure completed
7	Wt6	2017-08-04	Revisit & weigh

Descriptive statistics

The number of lambs per group is presented in Table 3.

Table 3: Total lambs per group

Procedure	No. Lambs
Black	183
Red	177
Yellow	171

The number of lambs by sex status per group is presented in Table 4.

Table 4: Lamb sex status by group

Procedure	Sex	No. Lambs
Black	Female	94
Black	Male	89
Red	Female	86
Red	Male	91
Yellow	Female	76
Yellow	Male	95

The number of observations per lamb per group is presented in Table 5.

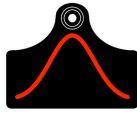


Table 5: Total measurements per lamb per group

Procedure Group	No. Measurements	No. Lambs
Black	1	1
Black	2	3
Black	3	2
Black	4	3
Black	5	174
Red	1	1
Red	2	2
Red	4	2
Red	5	172
Yellow	4	6
Yellow	5	165

The number of lambs per group providing 6 revisit observations per group is presented in Table 6.

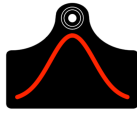


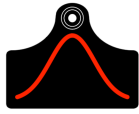
Table 6: Number of valid trial lambs (5 revisits) per procedure group

Procedure Group	No. Lambs
Black	174
Red	172
Yellow	165

The number of lambs per group and sex class providing 6 revisit observations per group is presented in Table 7.

Table 7: Number of valid trial lambs (5 revisits) by sex category per procedure group

Procedure Group	Sex	No. Lambs
Black	Female	90
Black	Male	84
Red	Female	84
Red	Male	88
Yellow	Female	72
Yellow	Male	93



Weight data was normally distributed. See Figure 1 and Figure 2. No transformations were required prior to statistical analysis.

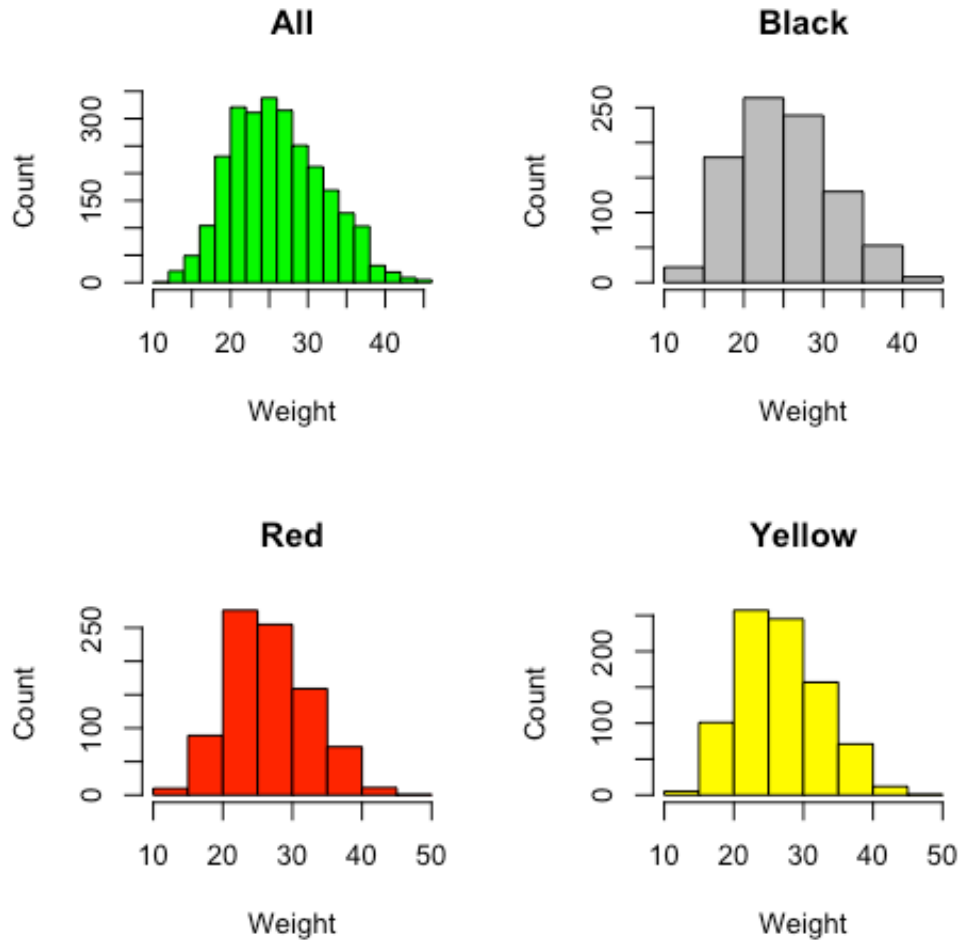
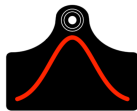


Figure 1: Histogram of weights for all lambs and by individual procedure group (all weighing time points)



The boxplots of weights at the initial visit (day 0) is presented in Figure 2 below. Note that the average starting weight of the black tag group appears to be slightly lighter than the red and yellow tag groups.

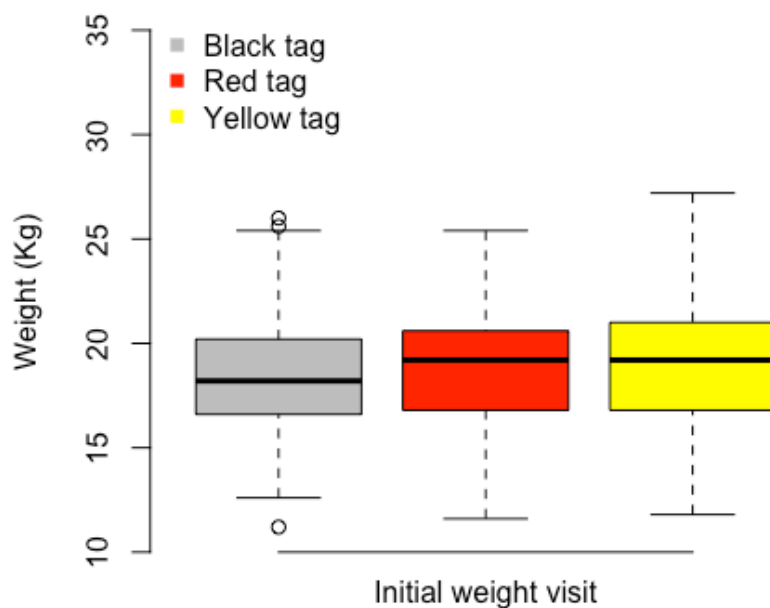


Figure 2: Lamb weight boxplots by procedure group at recruitment

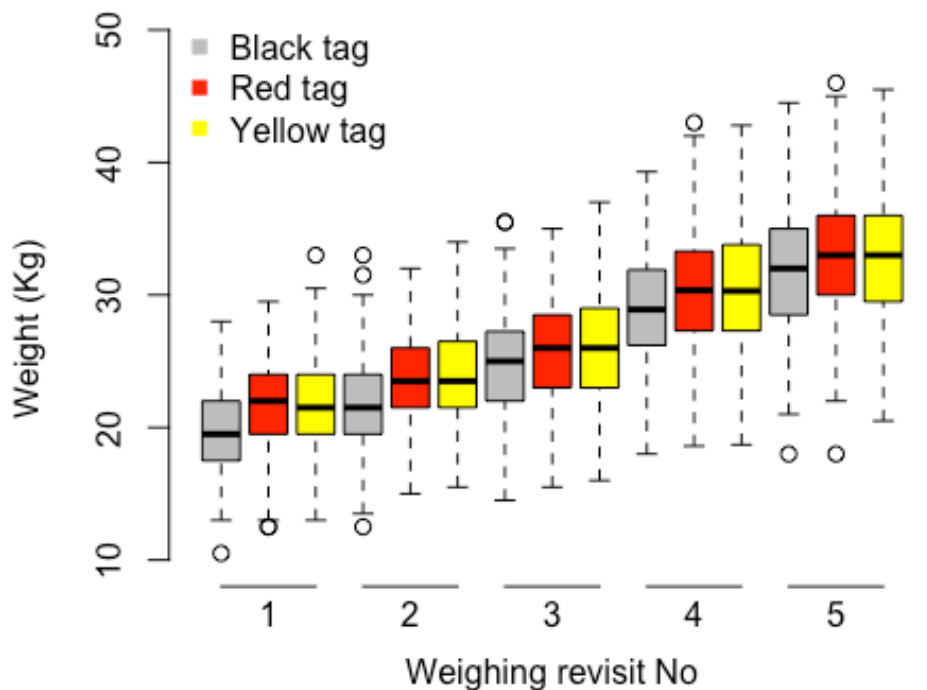
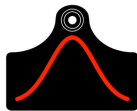


Figure 3: Boxplots of lamb weights by procedure group and reweigh visit number

The histogram of weights at each revisit time by sex class is presented in Figures 4 to 5 below.

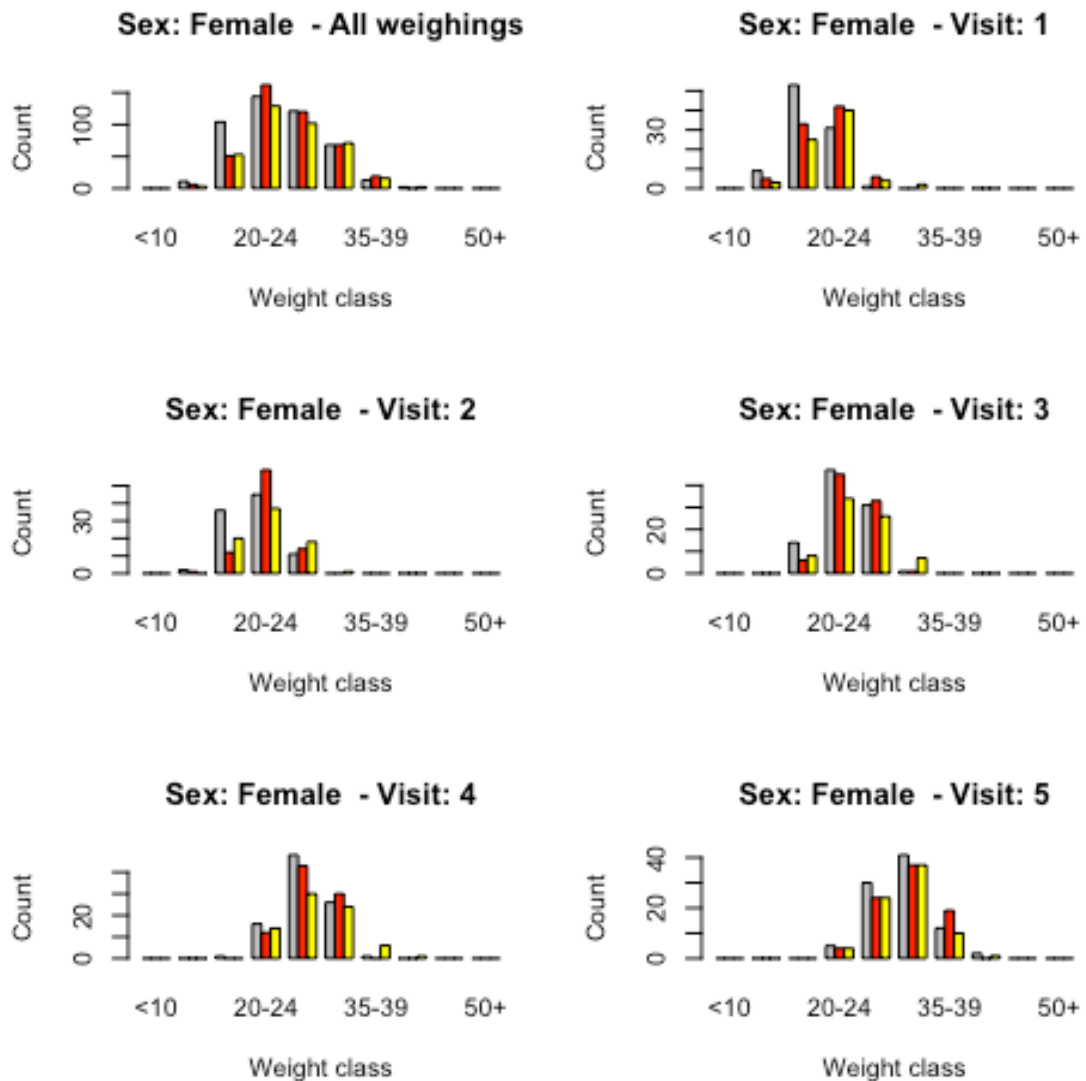
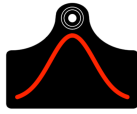


Figure 4: Histogram of lamb weight class by procedure group at each reweigh visit for ewe lambs

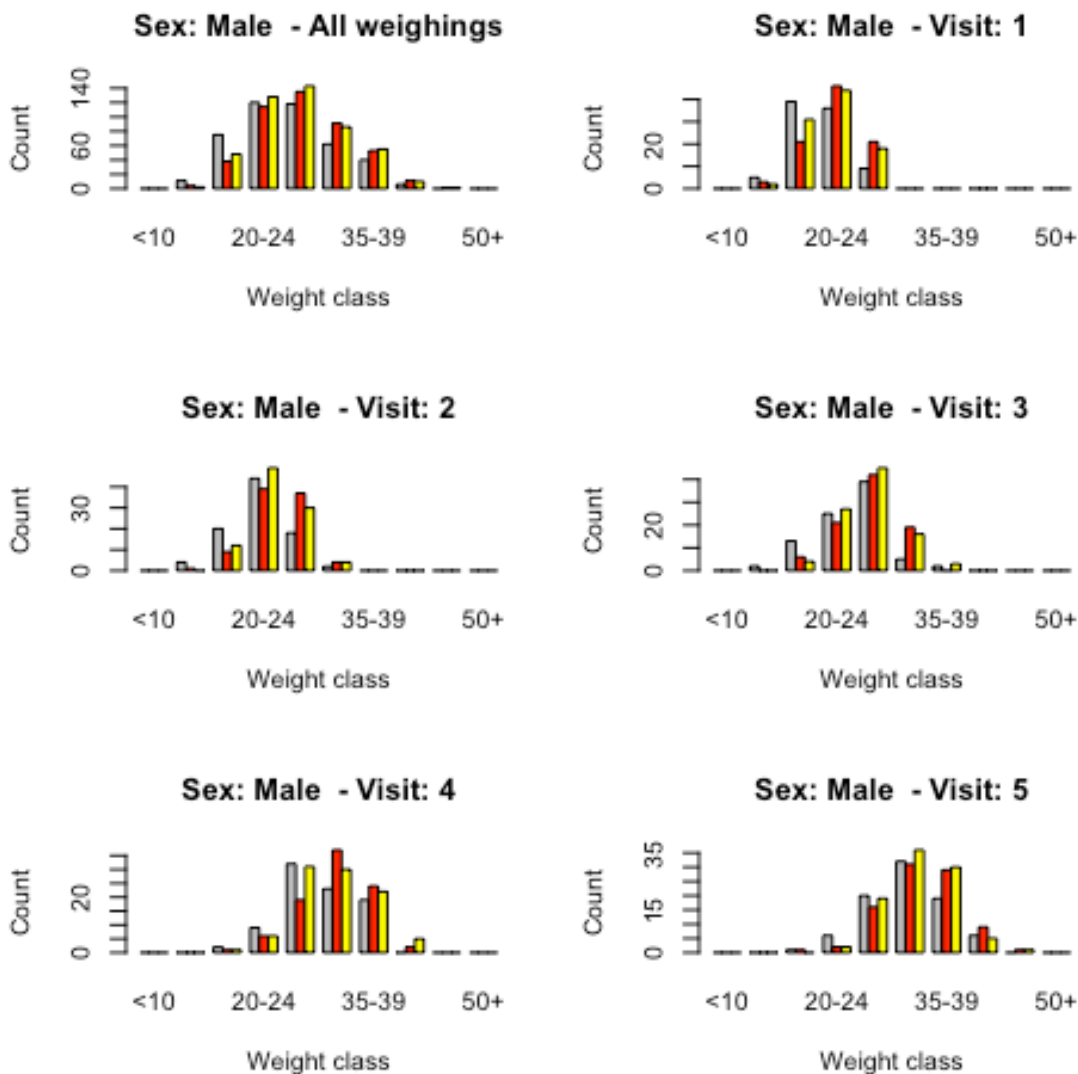
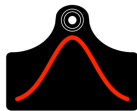


Figure 5: Histogram of lamb weight class by procedure group at each reweigh visit for ram lambs

Statistical analysis

Weight data was normally distributed so linear methods were applied using non-transformed (raw) weight data. A generalized linear model (GLM) to predict weight at each visit time. Predictor variables were sex and procedure group.

Weight ~ Sex + Procedure

For reweigh data, the initial weight of the lamb was also included into the model as an offset variable. This adjustment helps to control for differences in revisit weight that were due to differences in starting weight.

Revisit Weight ~ Sex + Procedure + Initial Weight (Wt1)

Results are presented in Tables 8 to 13 below

Initial weights

Table 8: GLM of initial lamb body weights by procedure group and sex

	Estimate	Std. Error	T stat.	P value
(Intercept)	17.913	0.236	75.85	0.000
Procedure - Red	0.516	0.292	1.76	0.078
Procedure - Yellow	0.559	0.295	1.89	0.059
Sex - Male	1.190	0.241	4.94	0.000

Individual procedure group comparisons for starting weights of lambs is presented in Table 9 below.

Table 9: Pairwise comparison of initial lamb weights by procedure group and sex

	Comps	Coeffts	Sigma	T stat.	P value
Red - Black	Red-Blue	0.516	0.292	1.765	0.183
Yellow - Black	Yellow-Blue	0.559	0.295	1.892	0.142
Yellow - Red	Yellow-Red	0.043	0.297	0.145	0.988

Individual reweighing time points

Revisit 1

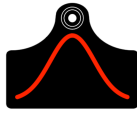
Table 10: GLM of reweigh visit 1 lamb body weights by procedure group, sex and starting body weight (Wt1)

	Estimate	Std. Error	T stat.	P value
(Intercept)	3.981	0.690	5.77	0.000
Procedure - Red	1.388	0.247	5.63	0.000
Procedure - Yellow	1.364	0.250	5.45	0.000
Sex - Male	0.221	0.208	1.06	0.287
Wt1	0.845	0.037	22.92	0.000

Individual procedure group comparisons for weight at reweigh 1 is presented in Table 11 below.

Table 11: Pairwise comparison of reweigh visit 1 lamb weights by procedure group, sex and starting body weight

	Comps	Coeffts	Sigma	T stat.	P value
Red - Black	Red-Blue	1.388	0.247	5.628	0.000
Yellow - Black	Yellow-Blue	1.364	0.250	5.450	0.000
Yellow - Red	Yellow-Red	-0.025	0.250	-0.099	0.995



Revisit 2

Table 12: GLM of reweigh visit 2 lamb body weights by procedure group, sex and starting body weight (Wt1)

	Estimate	Std. Error	T stat.	P value
(Intercept)	5.498	0.712	7.72	0.000
Procedure - Red	1.589	0.255	6.22	0.000
Procedure - Yellow	1.539	0.258	5.97	0.000
Sex - Male	0.385	0.215	1.79	0.074
Wt1	0.858	0.038	22.55	0.000

Individual procedure group comparisons for weight at reweigh 2 is presented in Table 13 below.

Table 13: Pairwise comparison of reweigh visit 2 lamb weights by procedure group, sex and starting body weight

	Comps	Coeffts	Sigma	T stat.	P value
Red - Black	Red-Blue	1.59	0.255	6.222	0.00
Yellow - Black	Yellow-Blue	1.54	0.258	5.970	0.00
Yellow - Red	Yellow-Red	-0.05	0.258	-0.192	0.98

Revisit 3

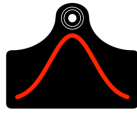
Table 14:GLM of reweigh visit 3 lamb body weights by procedure group, sex and starting body weight (Wt1)

	Estimate	Std. Error	T stat.	P value
(Intercept)	8.405	0.901	9.32	0.000
Procedure - Red	1.009	0.324	3.12	0.002
Procedure - Yellow	0.991	0.326	3.04	0.003
Sex - Male	1.078	0.272	3.96	0.000
Wt1	0.835	0.048	17.34	0.000

Individual procedure group comparisons for weight at reweigh 3 is presented in Table 15 below.

Table 15:Pairwise comparison of reweigh visit 3 lamb weights by procedure group, sex and starting body weight

	Comps	Coeffts	Sigma	T stat.	P value
Red - Black	Red-Blue	1.009	0.324	3.116	0.006
Yellow - Black	Yellow-Blue	0.991	0.326	3.037	0.007
Yellow - Red	Yellow-Red	-0.019	0.327	-0.057	0.998



Revisit 4

Table 16: GLM of reweigh visit 4 lamb body weights by procedure group, sex and starting body weight (Wt1)

	Estimate	Std. Error	T stat.	P value
(Intercept)	12.429	1.048	11.86	0.000
Procedure - Red	1.026	0.377	2.72	0.007
Procedure - Yellow	0.970	0.381	2.55	0.011
Sex - Male	1.778	0.317	5.61	0.000
Wt1	0.846	0.056	15.10	0.000

Individual procedure group comparisons for weight at reweigh 4 is presented in Table 17 below.

Table 17: Pairwise comparison of reweigh visit 4 lamb weights by procedure group, sex and starting body weight

	Comps	Coeffts	Sigma	T stat.	P value
Red - Black	Red-Blue	1.026	0.377	2.719	0.019
Yellow - Black	Yellow-Blue	0.970	0.381	2.549	0.030
Yellow - Red	Yellow-Red	-0.056	0.379	-0.148	0.988

Revist 5

Table 18: GLM of reweigh visit 5 lamb body weights by procedure group, sex and starting body weight (Wt1)

	Estimate	Std. Error	T stat.	P value
(Intercept)	15.332	1.171	13.093	0.000
Procedure - Red	0.637	0.421	1.512	0.131
Procedure - Yellow	0.342	0.424	0.805	0.421
Sex - Male	0.623	0.354	1.762	0.079
Wt1	0.872	0.063	13.923	0.000

Individual procedure group comparisons for weight at reweigh 5 is presented in Table 19 below.

Table 19: Pairwise comparison of reweigh visit 5 lamb weights by procedure group, sex and starting body weight

	Comps	Coeffts	Sigma	T stat.	P value
Red - Black	Red-Blue	0.637	0.421	1.512	0.286
Yellow - Black	Yellow-Blue	0.342	0.424	0.805	0.700
Yellow - Red	Yellow-Red	-0.295	0.422	-0.700	0.764

Total weight gain

Results for total weight gain is presented in Table 20 below. Because there may be growth rate differences between ram and ewe lambs over time there is potential for a procedure time by sex interaction, so this was included the the total weight gain analysis

Table 20: GLM of total weight gains by procedure group, sex and starting weight (Wt1)

	Estimate	Std. Error	T stat.	P value
(Intercept)	15.131	1.361	11.119	0.000
Procedure - Red	0.371	0.674	0.551	0.582
Procedure - Yellow	0.359	0.699	0.513	0.608
Sex - Male	-0.520	0.675	-0.770	0.442
Wt1	-0.115	0.071	-1.610	0.108
Procedure – Red : Sex - Male	1.108	0.953	1.163	0.246
Procedure – Yellow : Sex - Male	1.111	0.965	1.151	0.250

Individual procedure group comparisons for total weight gain is presented in Table 21 below.

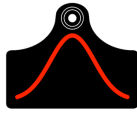


Table 21: Pairwise comparison of total weight gains by procedure group, sex and starting weight

	Comps	Coeffts	Sigma	T stat.	P value
Red - Black	Red-Blue	0.371	0.674	0.551	0.846
Yellow - Black	Yellow-Blue	0.359	0.699	0.513	0.865
Yellow - Red	Yellow-Red	-0.013	0.712	-0.018	1.000

Repeated measures — body weight

Repeated-measures model results are presented in Table 22 below.

Table 22: Repeated measures model of weight by procedure group, sex, starting weight (Wt1) and visit number

	T stat.	Std.Error	DF	T stat.	P value
(Intercept)	-1.090	0.769	2065	-1.417	0.157
Procedure - Red	1.180	0.274	521	4.309	0.00002
Procedure - Yellow	1.095	0.277	521	3.959	0.00009
Sex - Male	0.770	0.230	521	3.344	0.0009
Wt1	0.855	0.041	521	20.929	0.000000
Visit No.	2.303	0.021	2065	111.117	0.000000

The pairwise comparison are presented in Table 23

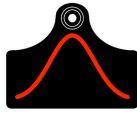


Table 23: Pairwise comparison of lamb body weight change by procedure group, , sex, starting weight and visit number

	Comps	Coeffts	Sigma	T stat.	P value
Red - Black	Red-Blue	1.180	0.274	4.309	0.00
Yellow - Black	Yellow-Blue	1.095	0.277	3.959	0.00
Yellow - Red	Yellow-Red	-0.085	0.277	-0.306	0.95

Fleece weight

Results for fleece weight is presented in Tables 24 below. Initial body weight was used as an offset variable in analysis to control for differences in fleece weight due to different body weights at first visit.

Table 24: GLM model of fleece weight by procedure group, sex and starting body weight (Wt1)

	Estimate	Std. Error	T stat.	P value
(Intercept)	0.836	0.078	10.67	0.000
Procedure - Red	0.070	0.028	2.50	0.013
Procedure - Yellow	0.056	0.028	1.99	0.048
Sex - Male	-0.040	0.024	-1.70	0.091
Wt1	0.050	0.004	11.87	0.000

Individual procedure group comparisons for fleece weight is presented in Table 25 below.

Table 25: Pairwise comparison of fleece weights by procedure group, sex and starting body weight

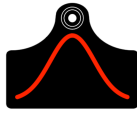
	Comps	Coeffts	Sigma	T stat.	P value
Red - Black	Red-Blue	0.070	0.028	2.500	0.034
Yellow - Black	Yellow-Blue	0.056	0.028	1.985	0.117
Yellow - Red	Yellow-Red	-0.014	0.028	-0.497	0.873

Conclusions

There was no significant difference between body weights of lambs at recruitment although black tag group lambs tended to be lighter than yellow tag and red tag lambs. The inclusion of weight at recruitment into all statistical models reduced the effect of any confounding due to random differences in the starting weight of lambs. However, if differences in starting weights between groups are not due to random variation—such as a selection bias from differential allocation of individual lambs to procedure groups—statistical adjustment is not possible and any inference on causation for procedure differences between groups may not be valid.

A significant procedure effect was observed in:

- Individual timepoint (revisit) weights
- Total weight gain
- Fleece weights



Repeated measures analysis also indicated there were differences between procedures in the rate of weight gain. Pairwise comparisons identified differences between black tag and red tags and between black tag and yellow tag groups. No difference was identified between red tag and yellow tag groups for weight at any individual reweight time point, for overall weight gain or for rate of weight gain and there was no difference in fleece weight between red and yellow tag groups.

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