Effectiveness of Meloxicam in reducing Lamb Pain from tail docking

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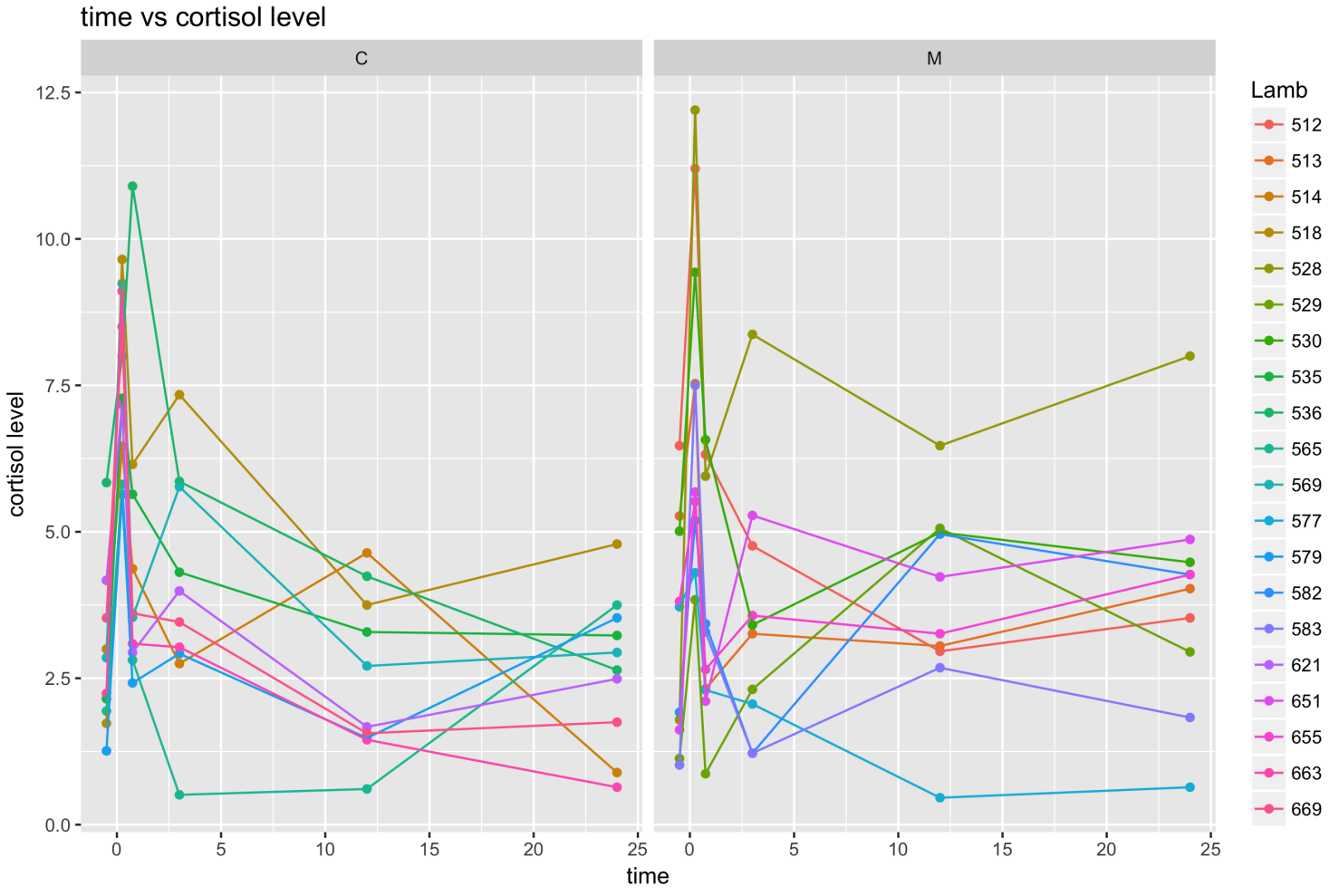
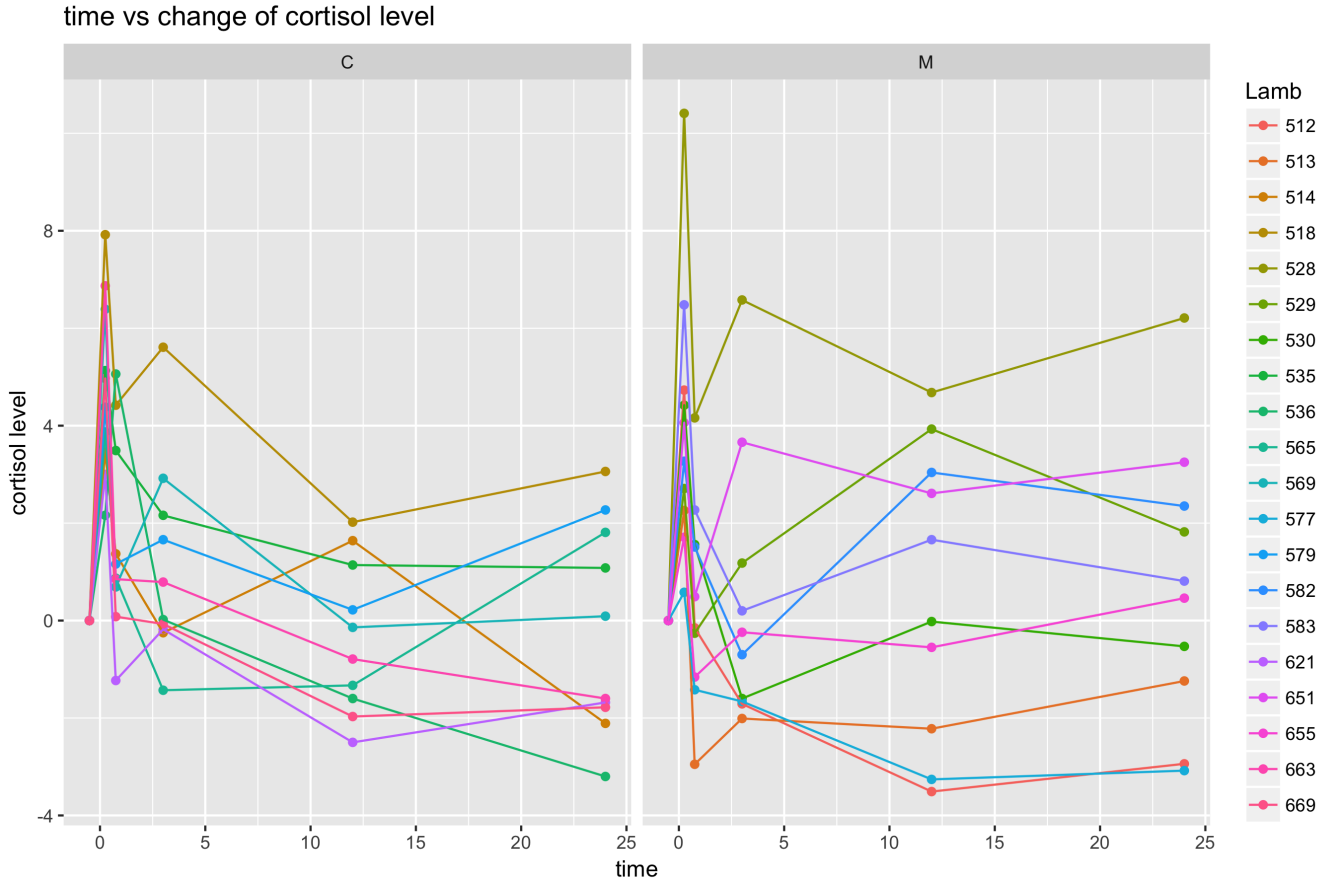
Cortisol Level



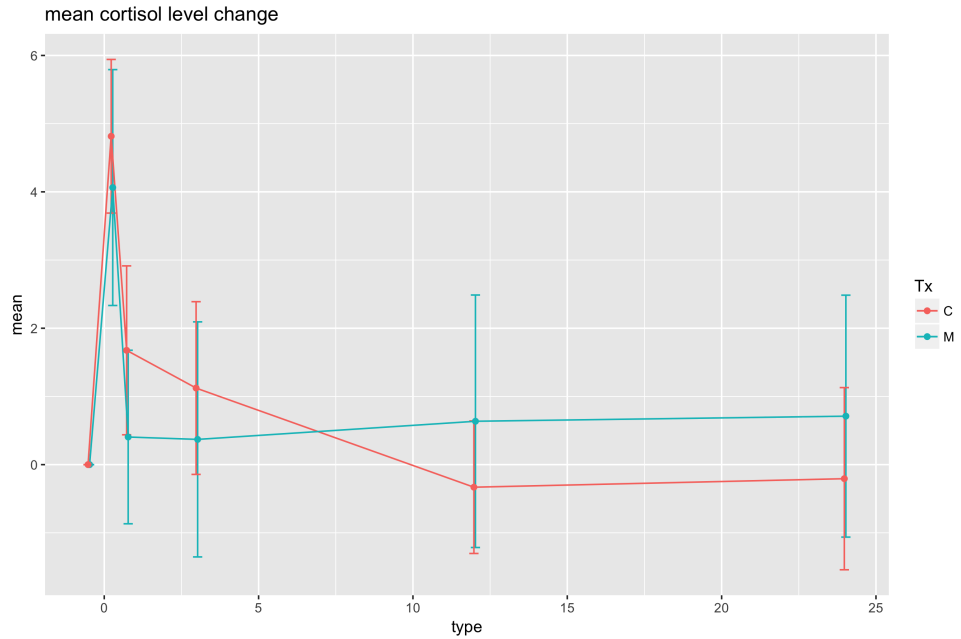
- Plot of original data, time vs cortisol level for each lamb by group. C is the control group, M is the treatment group.

Cortisol Level



- Plot of time vs change of cortisol level for each lamb by group.
- Change of cortisol level at time t = cortisol level at time t - cortisol level at initial time.
- It looks that pain feeling for lambs taking meloxicam varies more than lambs taking placebo.

Cortisol Level



- Mean cortisol level change at time t = (change of cortisol level at time t) / (number of lambs at time t)
- Cortisol level increases after tail docking, and returns to normal after a certain time.
- Lambs taking placebo have higher cortisol level or have more pain feeling 0.25, 0.75, and 3 hours after tail docking, then their cortisol level becomes lower. However, these difference are not significant according to the confidence band in the plot.

Cortisol Level: t-test, F-test

Apply t-test for testing mean difference, and F-test for testing variance difference at each time.

	t=0.25	t= 0.75	t=3	t=12	t=24
t-test	0.48	0.17	0.50	0.19	0.43
F-test	0.05	0.47	0.75	0.55	0.23

Table 1: P-value of each test

- 0.25h after tail docking, the variance difference of cortisol level is significant. We find that cortisol level of lamb ID=528 is much higher than others in the treatment group. After ignoring lamb 528, the variance difference should not be significant.
- Mean and variance are not significant different($p - value > 0.05$) for the control and treatment group. It means that we do not have strong evidence to conclude the effectiveness of meloxicam in reducing lamb pain.

Cortisol Level: Quadratic Model

Fixed Effect Model:

$$y_{ij} = y_{i0} + \beta_0 + \beta_1 t_{ij}^2 + \beta_2 t_{ij} + \beta_3 \mathrm{Tx}_i + \beta_4 t_{ij} \mathrm{Tx}_i + \epsilon_{ij},$$

where

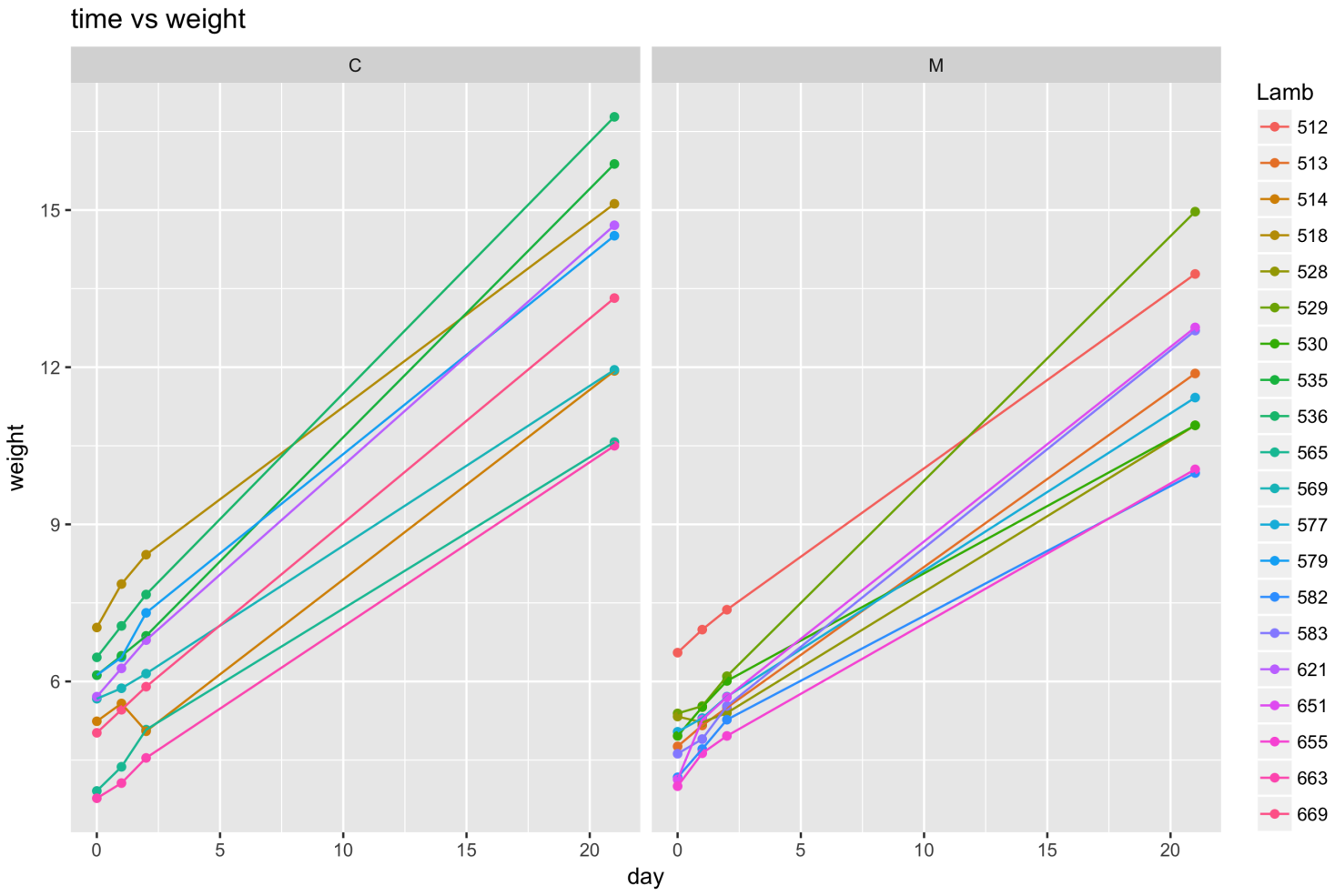
- y_{ij} is cortisol level for the i^{th} lamb, at j^{th} time point.
- y_{i0} is the i^{th} lamb's cortisol level at initial time $t = -0.5$.
- $Tx_i = 1$ if i^{th} lamb belongs to the treatment group, and it's 0 if i^{th} lamb belongs to the control group.
- $t_{i1} = 0.25, t_{i2} = 0.75, t_{i3} = 12, t_{i4} = 24$.

Cortisol Level: Quadratic Model

```
##
## Call:
## lm(formula = value ~ t2 + t + Tx + t:Tx, data = Cort)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4.9267 -1.9699 -0.2952  1.9174  8.2612
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  3.145030   0.529524   5.939 4.68e-08 ***
## t2           0.012710   0.004787   2.655 0.009302 **
## t           -0.448047   0.120738  -3.711 0.000348 ***
## TxM         -0.907804   0.686037  -1.323 0.188926
## t:TxM        0.091175   0.056791   1.605 0.111715
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.57 on 95 degrees of freedom
## Multiple R-squared:  0.1893, Adjusted R-squared:  0.1552
## F-statistic: 5.547 on 4 and 95 DF,  p-value: 0.0004673
```

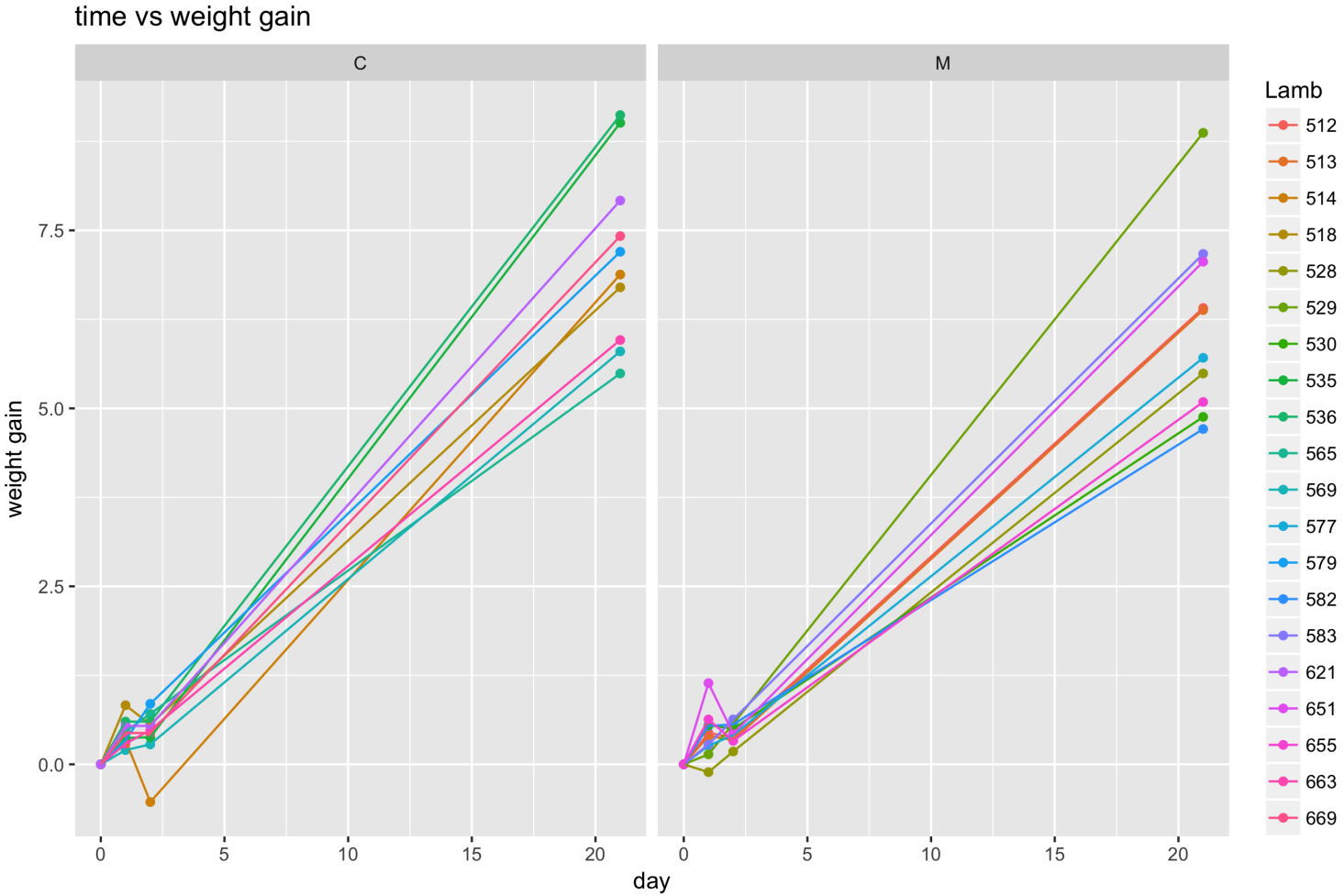
p-value for the interaction term t : TxM is 0.11 which is greater than 0.05, we conclude that the cortisol level trend over time does not have significant difference for lambs taking meloxicam and placebo.

Weight



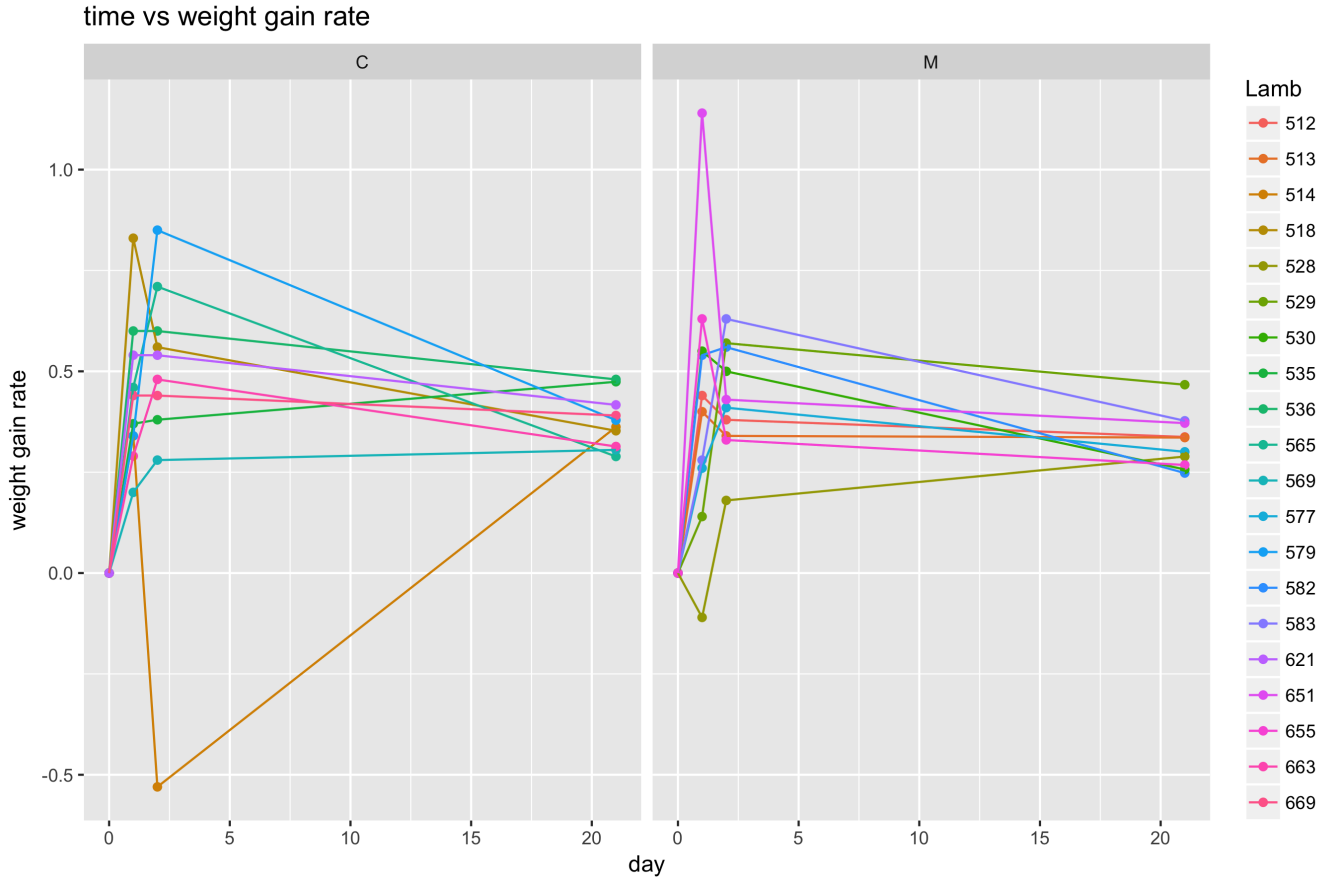
- Plot of original data: time vs weight by lamb by group.

Weight



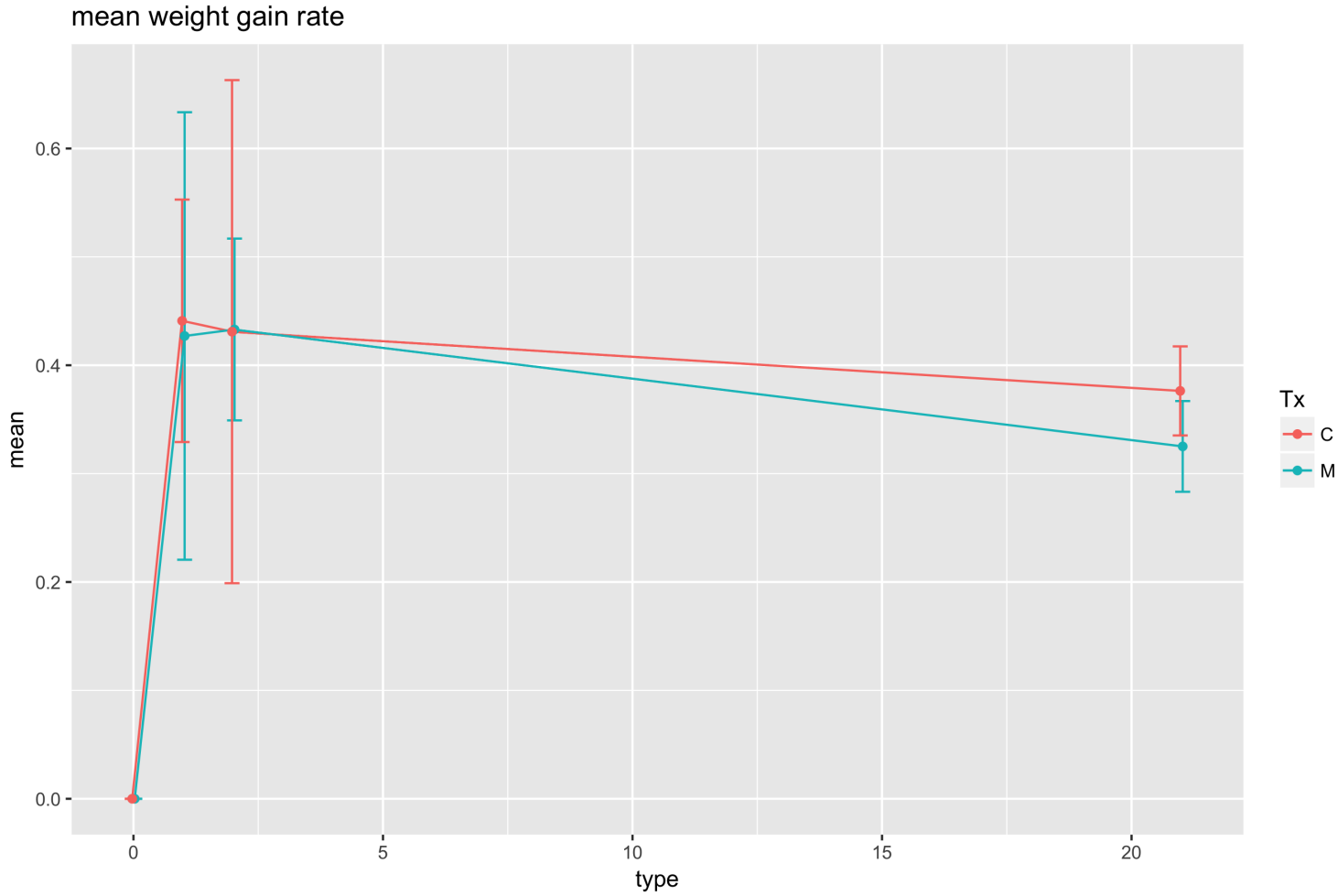
- Plot of time vs weight gain by lamb by group.
- weight gain at time t_i = weight at t_i - weight at t_{i-1}.
- It looks some lambs in the treatment group has lower weight gain than all lambs weight gain in control group.

Weight gain rate



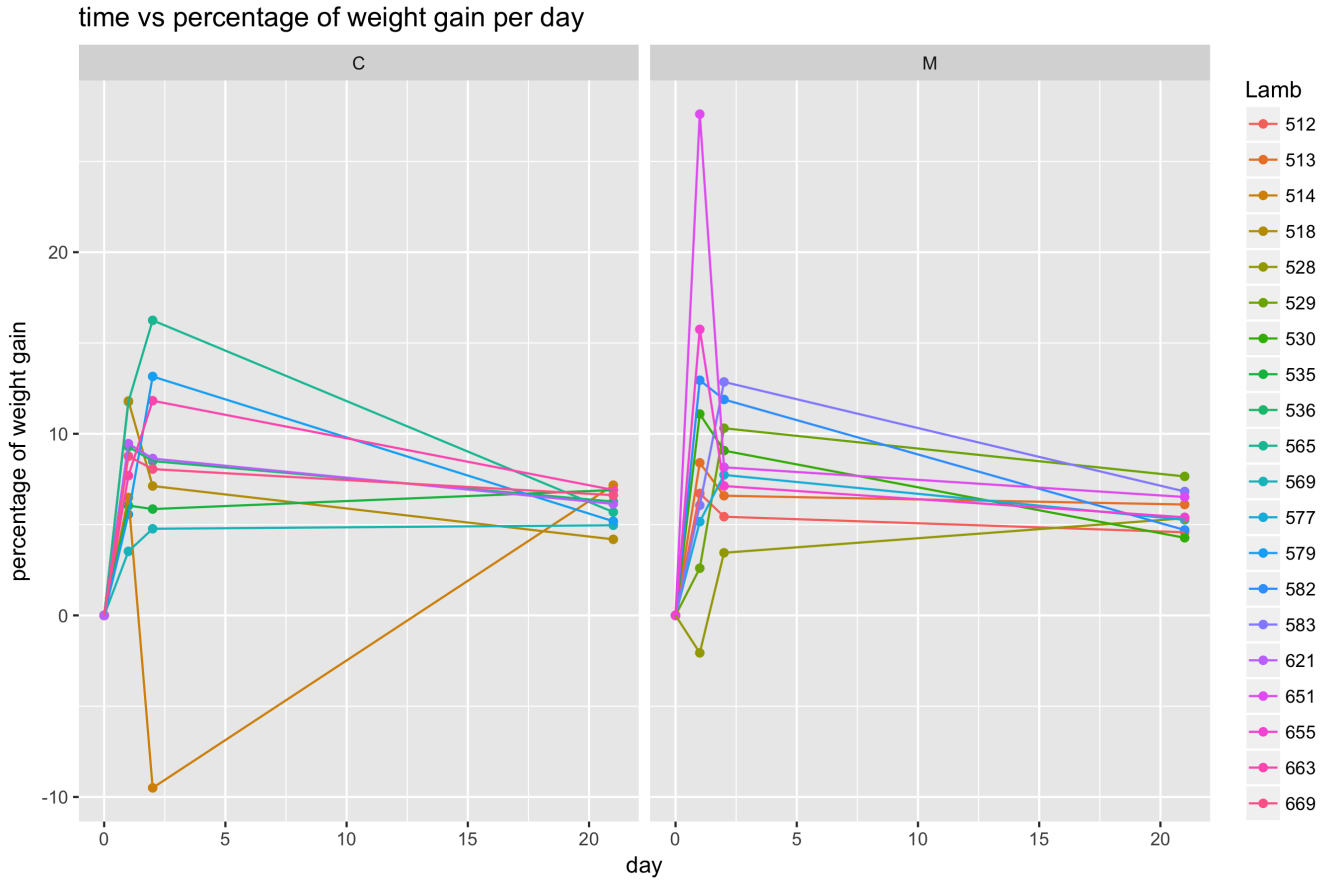
- Plot of time vs weight gain rate.
- weight gain rate at t_i = (weight gain at t_i)/(t_i - t_{i-1}).
- Lamb ID=514 in the control group lost much more weight than others, and lamb ID=651 in the treatment group gains much more weight than others.

Weight gain rate



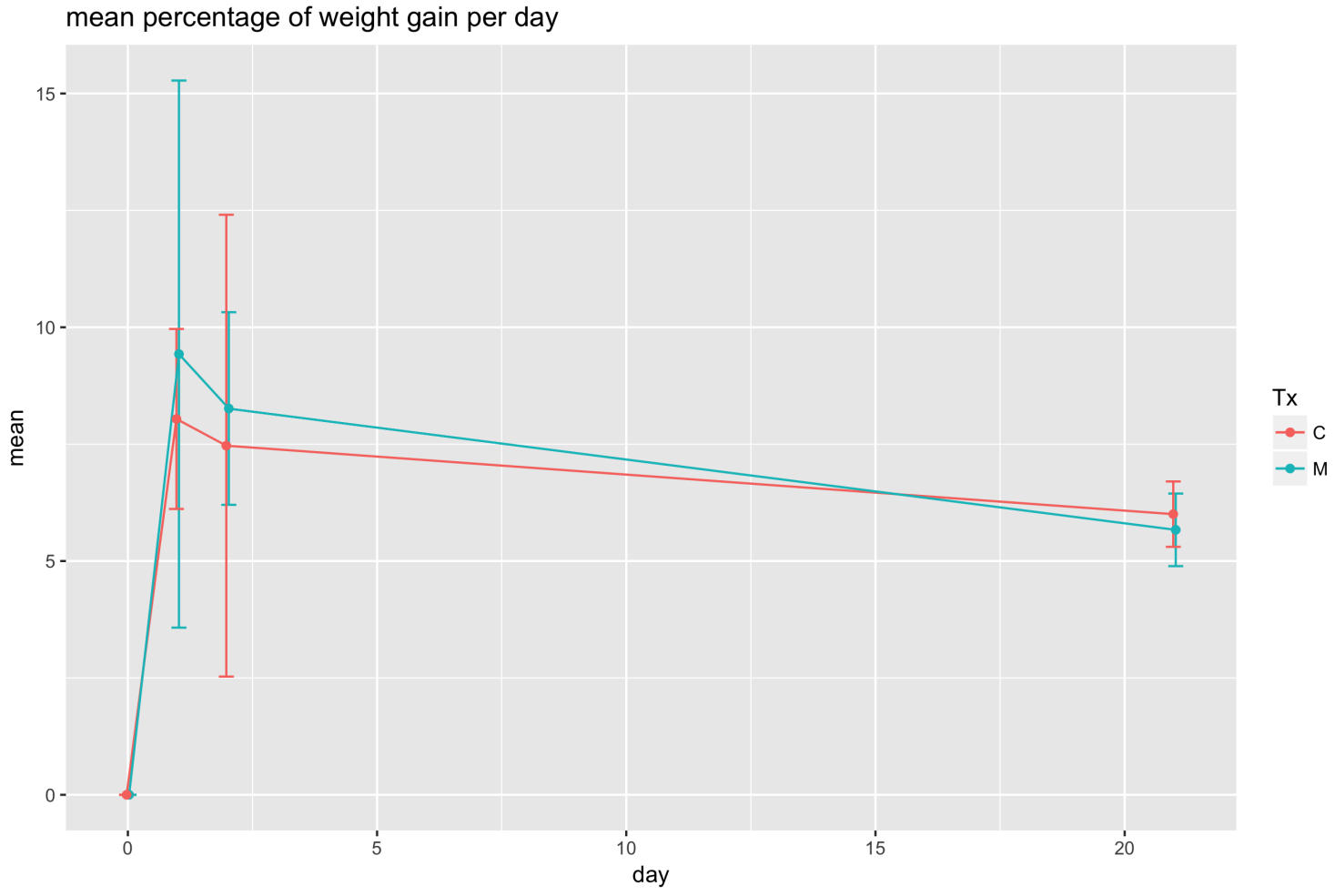
- Plot of time vs mean weight gain rate by group.
- Weight gain rate are quite similar at the early time for both groups, and the average weight is higher after 21 days for the control group.

Percentage of Weight gain rate



- Plot of time vs percentage of weight gain rate.
- percentage weight gain at t_i = (weight at t_i - weight at t_{i-1})*100/(weight at t_{i-1})/(t_i - t_{i-1}).

Percentage of Weight gain rate



- Plot of time vs mean percentage of weight gain rate by group.

Weight gain: t-test and F-test

Apply t-test for testing weight gain rate mean difference, and F-test for testing variance difference at each time.

	t=1	t=2	t=21
t-test	0.9	0.95	0.13
F-test	0.08	0.58	0.91

Table 2: P-value of each test

- All p-value are greater than 0.05, the mean and variance difference of weight are not significant between the two groups at each time point.

Weight gain percentage: t-test and F-test

Apply t-test for testing mean weight gain percentage difference, and F-test for testing variance difference at each time.

	t=1	t=2	t=21
t-test	0.62	0.74	0.477
F-test	0.003	0.016	0.76

Table 3: P-value of each test

- p-value for mean difference are greater than 0.05, the mean percentage of weight gain are not significant between the two groups at each time point.
- p-value for variance difference are less than 0.05 at day 1 and day 2, if we go back to the plot of time vs percentage of weight gain per day, we see that at day 2 one lamb ID $= 514$ in the control group and at day 1 one lamb ID $= 651$ in the treatment group behave quite differently with others. If we ignore these two, the variance difference would not be significant.

Weight: Linear model

Fixed Effect Model:

$$y_{ij} = y_{i0} + \beta_0 + \beta_1 t_{ij} + \beta_2 \mathrm{Tx}_i + \beta_3 t_{ij} \mathrm{Tx}_i + \epsilon_{ij},$$

where

- y_{ij} is weight for the i^{th} lamb, at j^{th} time point.
- y_{i0} is the i^{th} lamb's weight at initial time $t = 0$.
- $Tx_i = 1$ if i^{th} lamb belongs to the treatment group, and it's 0 if i^{th} lamb belongs to the control group.
- $t_{i1} = 1, t_{i2} = 2, t_{i3} = 21$.

Weight: Linear model

```
##
## Call:
## lm(formula = value ~ t * Tx, data = Weight)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.74336 -0.23031  0.00345  0.28093  2.54031
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.08908    0.20151   0.442   0.6601
## t            0.37782    0.01653  22.862   <2e-16 ***
## TxM          0.06095    0.28497   0.214   0.8314
## t:TxM       -0.04974    0.02337  -2.128   0.0377 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.8329 on 56 degrees of freedom
## Multiple R-squared:  0.9426, Adjusted R-squared:  0.9395
## F-statistic: 306.4 on 3 and 56 DF,  p-value: < 2.2e-16
```

- p-value for t : TxM is $0.0377 (< 0.05)$, it means that the weight trend over time is significantly different between this two groups.
- Give time t, the weight trend(gain rate) over time is -0.04974 lower for treatment group than the control group. If we go back to look at the mean weight gain rate plot, the difference is mainly caused by data in day 21.

Conclusion

- After analyzing data using plots, tests and models, we didn't find strong evidence to support the effectiveness of meloxicam in reducing lamb pain in dock tailing.
- Based on plots, we do find some difference between these two groups, we suggest get more convincing result by collecting more data.
- I also think the time scale in the experiment jumps too much, especially in the weight record.
- ...