Supplementary Materials S3 to Karagicheva J., Liebers, M., Rakhimberdiev, E., Hallinger K.K., Saveliev A., A., Winkler, D. W. 2016 Differences in size between first and replacement clutches match the seasonal decline in single clutches in Tree Swallows *Tachycineta bicolor*. - Ibis 000: 000-000.

Depends: R (>= 3.2.0),

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With this example we illustrate why individual slope cannot be accounted for in a regular regression, without rescaling of dates. In the article we solve this complication using Bayesian approach.

Note: we simulate data with normal distribution. In the paper, we account for the structure of the real clutch data, including two-truncation and underdispersion.

Simulate dataset

We simulate data, in which rates of change (slopes) differ between first and replacement clutches. Size of first clutch generally increases with date (with slope=0.1). Replacement clutches are much smaller that first clutches, and average rate of within-individual decrease in clutch size (from first to second clutch) is -0.3.

```
nIndividuals = 1000

Slope_population <- 0.1
Slope_indiv <- -0.3

Date_first <- runif(nIndividuals, 0, 60)
Date_last <- Date_first + runif(nIndividuals, 10, 40)

Intercepts = rnorm(nIndividuals, 2, 1)

Clutch_first <- Intercepts + Slope_population * Date_first

Clutch_last <- Clutch_first + (Slope_indiv * (Date_last -
    Date_first))

Data <- data.frame(Clutch = c(Clutch_first, Clutch_last),
    Date = c(Date_first, Date_last), ID = rep(1:length(Clutch_first),
        2), attempt = c(rep(1, length(Clutch_first)),
        rep(2, length(Clutch_first))))
```

Linear regression with identity link function and gaussian error distribution

1) not accounting for the clutch type (number of attempt)

```
Model1 <- lm(Clutch ~ Date, data = Data)
summary(Model1)
```

```
##
## Call:
## lm(formula = Clutch ~ Date, data = Data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -11.9752  -2.9900   0.1888   3.3918   9.7739
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  3.667650   0.214872   17.07   <2e-16 ***
## Date        -0.058316   0.004517  -12.91   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.474 on 1998 degrees of freedom
## Multiple R-squared:  0.07701,    Adjusted R-squared:  0.07655
## F-statistic: 166.7 on 1 and 1998 DF,  p-value: < 2.2e-16
```

2) accounting for the clutch type

```
Model1_1 <- lm(Clutch ~ Date * as.factor(attempt),
    data = Data)
summary(Model1_1)
```

```
##
## Call:
## lm(formula = Clutch ~ Date * as.factor(attempt), data = Data)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -7.856 -1.194 -0.037  1.196  8.470
##
## Coefficients:
##                             Estimate Std. Error t value Pr(>|t|)
## (Intercept)                 2.023063   0.153431   13.19   <2e-16 ***
## Date                        0.099779   0.004482   22.26   <2e-16 ***
## as.factor(attempt)2        -5.661428   0.279020  -20.29   <2e-16 ***
## Date:as.factor(attempt)2 -0.079833   0.006023  -13.25   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.445 on 1996 degrees of freedom
## Multiple R-squared:  0.7246, Adjusted R-squared:  0.7242
## F-statistic:  1750 on 3 and 1996 DF,  p-value: < 2.2e-16
```

Visualised outcome from the regressions

```
plot(Clutch ~ Date, data = Data, col = Data$attempt,
    pch = ".", cex = 3, xlim = range(Data$Date))
```

```r
abline(Model1, lwd = 2)

a = Data$Date * coef(Model1_1)[2] + coef(Model1_1)[1]
abline(a = coef(Model1_1)[1], b = coef(Model1_1)[2],
    lwd = 2, lty = 2)
abline(a = coef(Model1_1)[1] + coef(Model1_1)[3], b = coef(Model1_1)[2] +
    coef(Model1_1)[4], col = "red", lwd = 2, lty = 2)
```

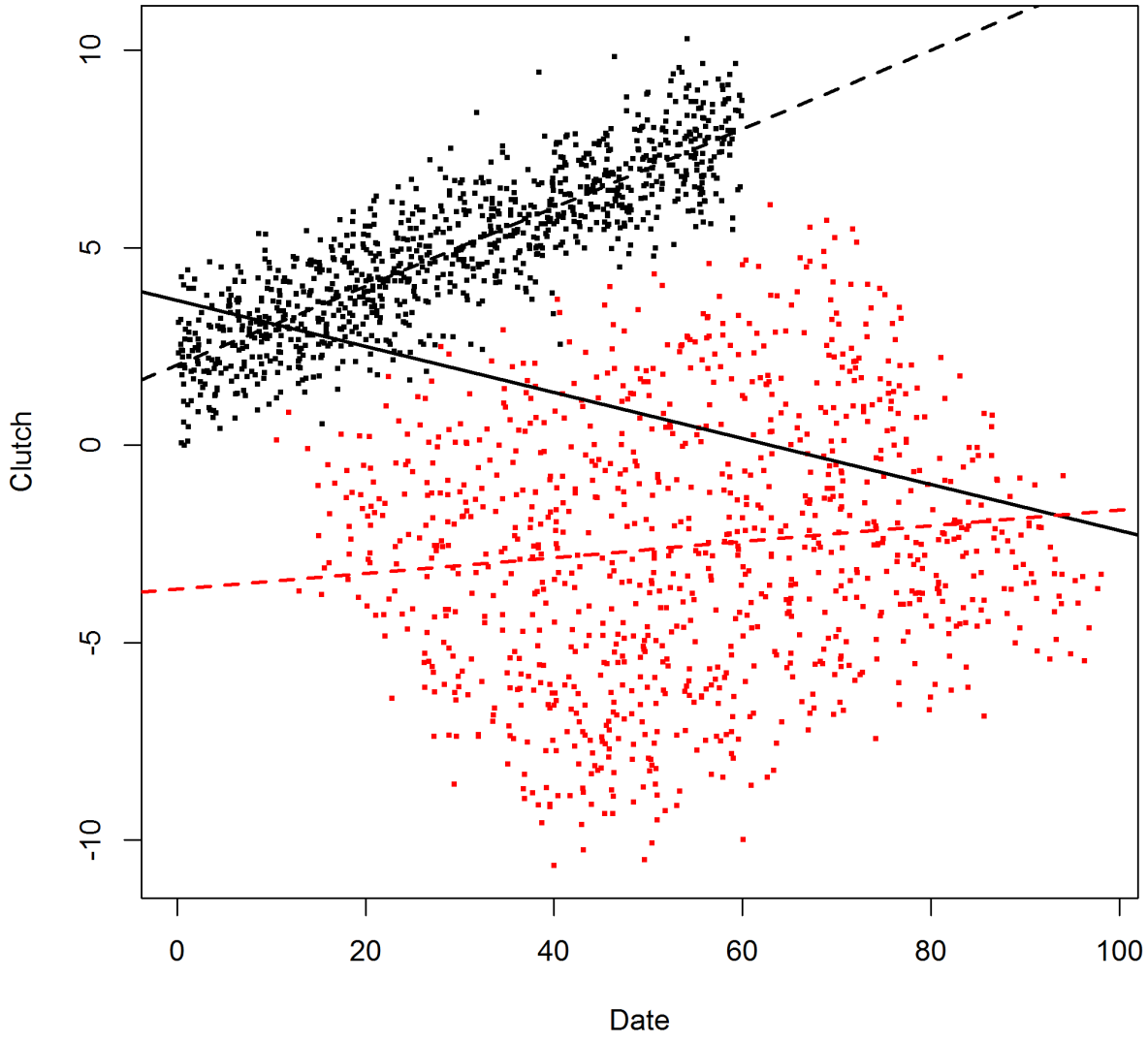

Figure 1. Simulated data and linear regression with unscaled laying dates. Model 1 did not account for the clutch type (1st vs second nesting attempt), and the estimated slope is -0.06. Model1_1 distinguished between the clutch types, and the estimated slope of first clutch was 0.1 and the slope of second clutch was 0.02 .Neither of the models can obtain individual slope between first and second clutches (-0.3), specified in the simulated data.

3) with rescaled laying dates for finding within-individual clutch size decline

Rescale the data to find mean individual slope. To do this, for each individual we assign date of the first clutch 0 and date of replacement clutch the difference between first and second clutches of the same individual.

```
Data$Date_Cor = Data$Date - rep(Date_first, 2)

plot(Clutch ~ Date, data = Data, col = Data$attempt,
    pch = ".", cex = 3)

points(Clutch ~ Date_Cor, data = Data, col = Data$attempt,
    pch = ".", cex = 3)
```

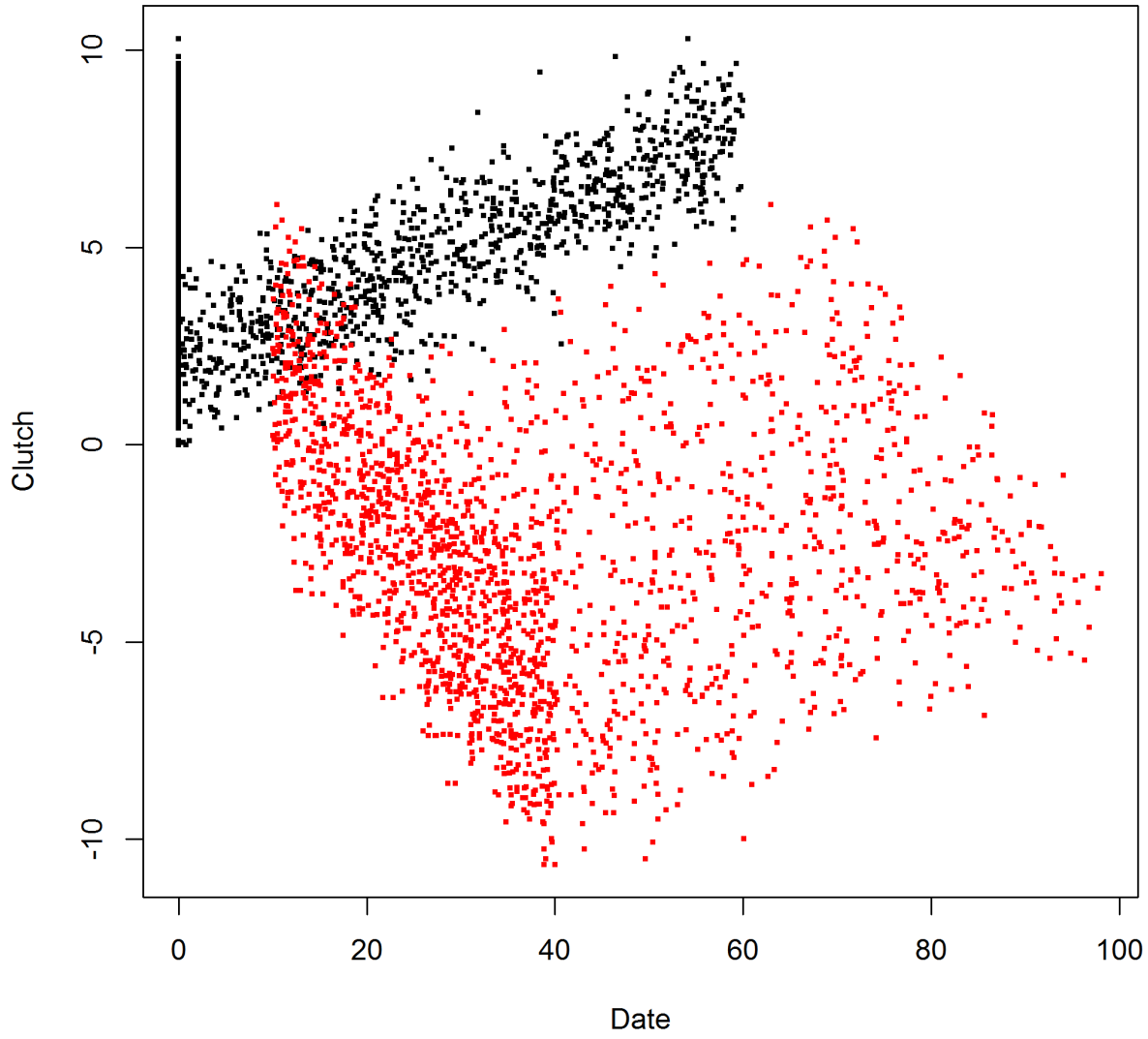

Figure 2. Data rescaling to estimate individual slope betwen first and second clutches.

run regression over rescaled data

```
Model2 <- lm(Clutch ~ Date_Cor, data = Data)
summary(Model2)
```

```
##
## Call:
## lm(formula = Clutch ~ Date_Cor, data = Data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4.9837 -1.5878  0.0235  1.5203  5.3144
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  4.976713   0.060474   82.29   <2e-16 ***
## Date_Cor    -0.300279   0.003221  -93.23   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.013 on 1998 degrees of freedom
## Multiple R-squared:  0.8131, Adjusted R-squared:  0.813
## F-statistic:  8692 on 1 and 1998 DF,  p-value: < 2.2e-16
```

```
plot(Clutch ~ Date_Cor, data = Data, col = Data$attempt,
    pch = ".", cex = 3, xlim = range(Data$Date))
abline(Model2, lwd = 2)
```

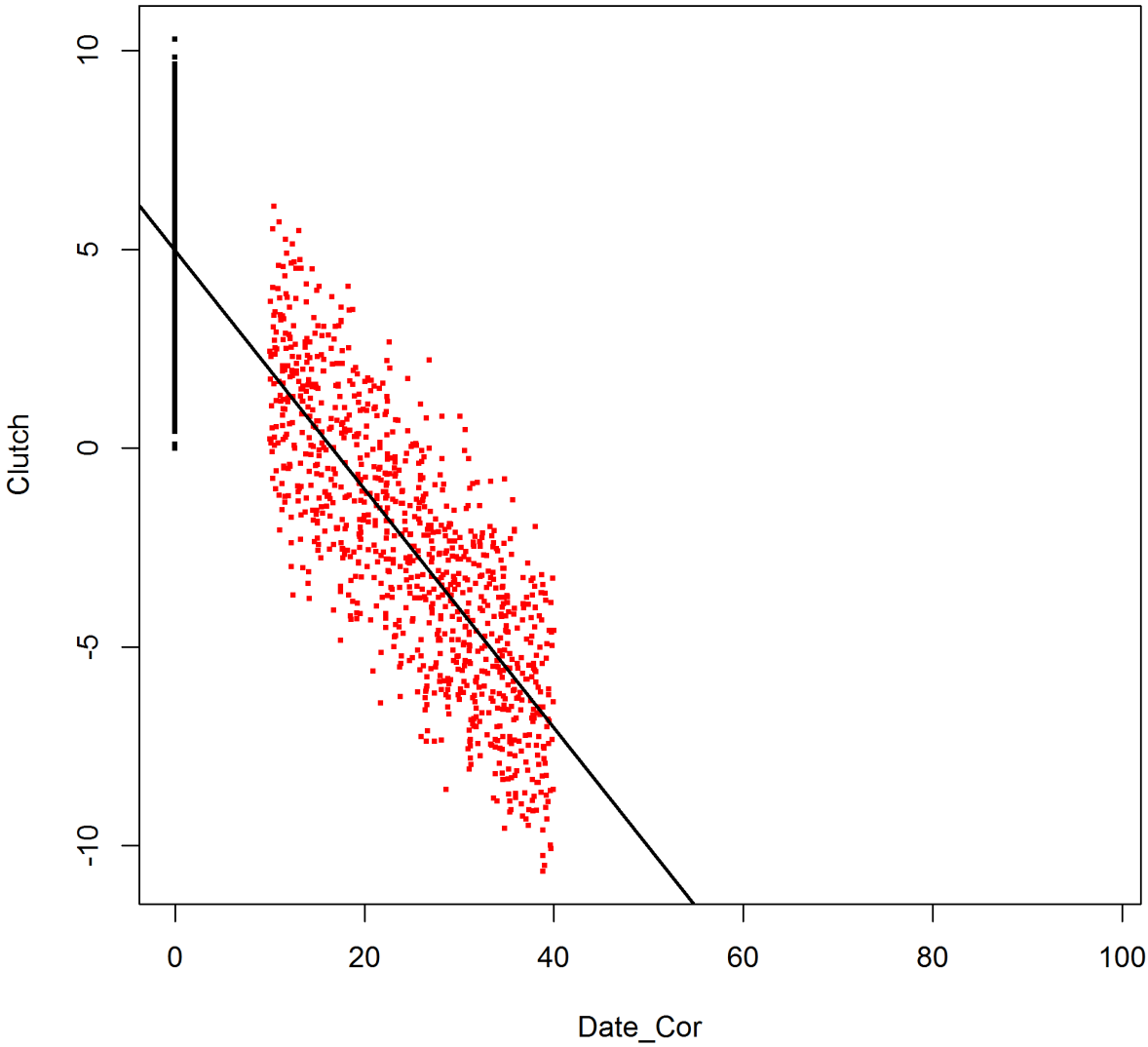

_Figure 3. Slopes estimated with rescaled data. Estimated slope for within-individuals slope in clutch size is -0.3 , the same as the true slope specified in the simulation.

Alternative: use the Bayesian approach discussed in the paper.