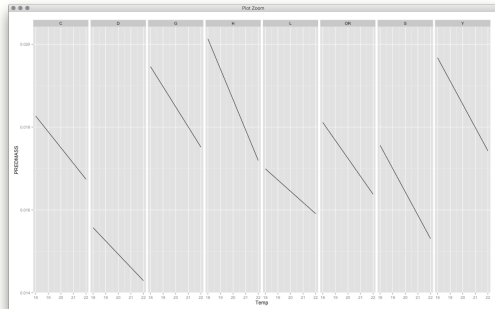


Advancing in R mixed models



Outline

- What are mixed models?
- Distinguishing random and fixed effects
- When should we (or shouldn't we) use mixed models?
- Analytic considerations
- Coding considerations

Why use mixed models?

- Address some problems of fixed effects models:
 - Pseudoreplication
 - Hierarchical data structure
- Informative:
 - Decompose variation of design into sampling unit
 - Quantify which sampling unit explains most of the variation

Pseudoreplication

- Involves repeated sampling of the same group
 - e.g., Spatial: same area many times,
 - Temporal: same individual many times
- Violates assumption that errors are independent
- Inflates sample size and df
 - Sample 5 indivs 100 times each
 - $N = 500$ or $N = 5$?

Fixed vs random effects

- Fixed effects
 - Describe mean of response variable
 - Have meaningful levels
 - Male/female, old/young, types of forest
- Random effects
 - Describe variance of response variable
 - Assumed to represent large population
 - Levels contain little useful information
 - Populations (A,B,C,D), individuals (Aa1,Aa2,Aa3,... Aa100)

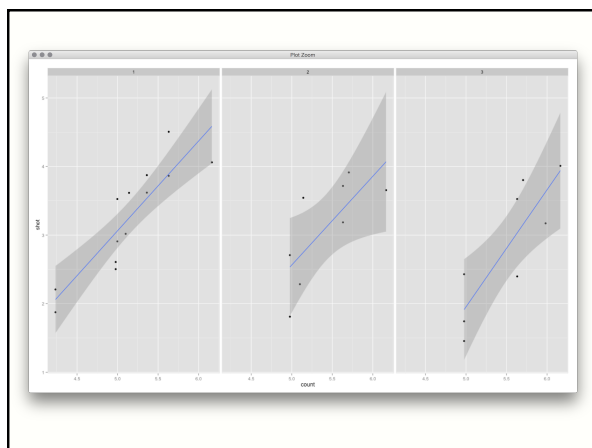
Random effects

- Variance components
 - Calculate the variance explained by the random effects
 - Individual, population, residual
- Best linear unbiased predictors (BLUPs)
 - The deviation from the mean for an individual in a group
 - Extracted from random effects

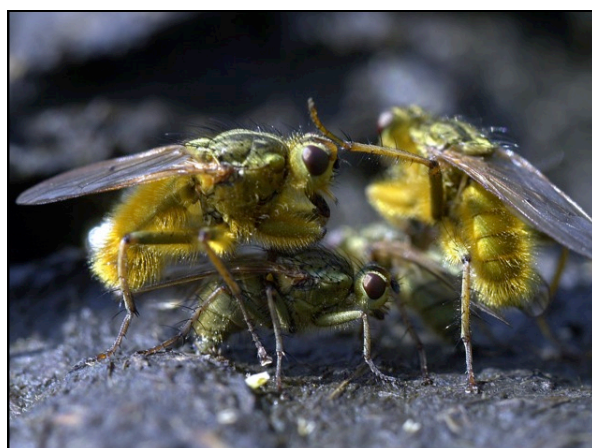
Why not mixed models?

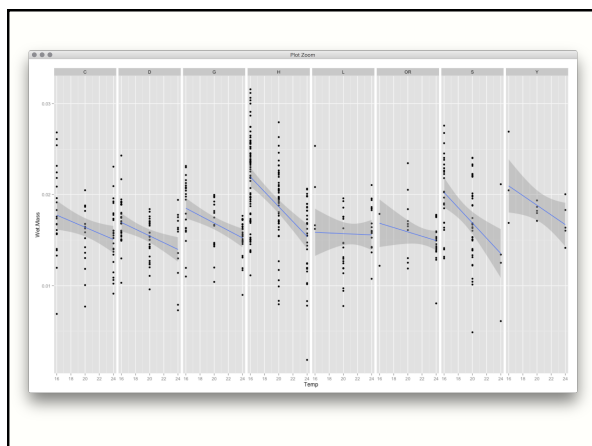
- Analytically, conceptually, and computationally challenging
- Theory remains poorly understood
 - e.g., how many denominator df?
- Many advanced methods for fixed models not yet implemented for mixed models





```
Linear mixed model fit by REML ['lmerMod']
Formula: shot ~ prev * count + (1 | moor) + (1 | drive)
Data: GROUSE
REML criterion at convergence: 38.5
Scaled residuals:
    Min       1Q   Median       3Q      Max
-1.39713 -0.55498  0.01077  0.54603  1.47802
Random effects:
 Groups   Name      Variance Std.Dev.
 drive    (Intercept) 0.04510  0.2124
 moor     (Intercept) 0.08102  0.2846
 Residual                    0.13114  0.3621
Number of obs: 29, groups: drive, 12; moor, 5
Fixed effects:
              Estimate Std. Error t value
(Intercept) -1.06344    1.93232   -0.550
prev         -0.65963    1.04190   -0.633
count        0.93763    0.36771    2.550
prev:count   0.04772    0.19226    0.248
Correlation of Fixed Effects:
```





```
Linear mixed model fit by REML ['lmerMod']
Formula: Wet.Mass ~ Temp + (Temp | Population) + (1 |
Maternal.Fam) + (1 | Paternal.Fam)
Data: MFLIES

REML criterion at convergence: -4198.8

Scaled residuals:
    Min       1Q   Median       3Q      Max
-3.6319 -0.5534  0.0936  0.6216  2.6972

Random effects:
Groups      Name                Variance Std.Dev. Corr
Paternal.Fam (Intercept) 4.181e-06 0.002045
Maternal.Fam (Intercept) 1.488e-06 0.001220
Population   (Intercept) 2.358e-05 0.004856
Temp        3.764e-08 0.000194 -0.97
Residual    1.139e-05 0.003375
Number of obs: 504, groups: Paternal.Fam, 20; Maternal.Fam,
20; Population, 8
```

```
Fixed effects:
              Estimate Std. Error t value
(Intercept)  2.666e-02  2.183e-03  12.214
Temp        -4.689e-04  9.068e-05  -5.171

Correlation of Fixed Effects:
(Intr)
Temp -0.937
```