

# Nested Mixed Model

```
#rm(list = ls()) # Clean the workspace
#install.packages("lme4") # If necessary install the library
library(lme4) # Call the library to the workspace
library(car) # Call the library to the workspace
library(lsmmeans) # Call the library to the workspace
library(multcomp) # Call the library to the workspace

# Read the data
myfile<-"C:/Users/toledo/Dropbox/UNIPD/Biostatistics Curse R Spring 2018/curso STAT PhD 2018 ANOVA/data/cows.csv"
mydata<-read.table(file=myfile,stringsAsFactors = TRUE,header = TRUE,sep = "\t")

options(contrasts = c("contr.SAS","contr.poly")) # Change contrast options
mydata$parity<-as.factor(mydata$parity) # Set as factor
mydata$herd<-as.factor(mydata$herd) # Set as factor

# Fit the mixed model
model.1<-lmer(milk ~ parity + dim + breed + (1 |breed:herd), data = mydata, REML = TRUE)
summary(model.1) # Results of the mixed model

## Linear mixed model fit by REML ['lmerMod']
## Formula: milk ~ parity + dim + breed + (1 | breed:herd)
## Data: mydata
##
## REML criterion at convergence: 731.2
##
## Scaled residuals:
## Min 1Q Median 3Q Max
## -2.60214 -0.58489 0.03607 0.69114 2.02577
##
## Random effects:
## Groups Name Variance Std.Dev.
## breed:herd (Intercept) 13.34 3.653
## Residual 24.18 4.917
## Number of obs: 124, groups: breed:herd, 6
##
## Fixed effects:
## Estimate Std. Error t value
## (Intercept) 39.339899 5.786365 6.799
## parity1 1.563274 5.101115 0.306
## parity2 3.954127 5.098720 0.776
## parity3 6.092434 5.166230 1.179
## parity4 5.999030 5.412165 1.108
## parity5 10.365640 7.137449 1.452
## parity6 4.777401 6.986695 0.684
## dim -0.052370 0.005915 -8.855
## breedBRUNA -6.890854 3.162900 -2.179
##
## Correlation of Fixed Effects:
## (Intr) party1 party2 party3 party4 party5 party6 dim
## parity1 -0.889
## parity2 -0.899 0.975
## parity3 -0.892 0.960 0.967
## parity4 -0.834 0.903 0.914 0.902
## parity5 -0.645 0.707 0.708 0.694 0.653
## parity6 -0.628 0.690 0.695 0.684 0.656 0.497
## dim -0.313 0.119 0.170 0.145 0.170 0.124 0.097
```

```
## breedBRUNA -0.320 0.034 0.026 0.041 0.009 0.009 0.007 0.067
AIC(model.1) # Akaike's Information Criterion (small is better)

## [1] 753.1553
BIC(model.1) # Bayesian Information Criterion (small is better)

## [1] 784.1784
Anova(model.1, type=3, test.statistic = "F") # ANOVA table SS type III

## Analysis of Deviance Table (Type III Wald F tests with Kenward-Roger df)
##
## Response: milk
##
```

	F	Df	Df.res	Pr(>F)
(Intercept)	46.0339	1	81.073	1.744e-09 ***
parity	2.2011	6	112.369	0.04797 *
dim	77.1992	1	113.791	1.855e-14 ***
breed	4.7359	1	3.987	0.09537 .

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

lsmeans(model.1, "parity") # LSM

## parity lsmean SE df lower.CL upper.CL
## 1 29.40115 1.751183 5.69 25.05979 33.74251
## 2 31.79200 1.681236 4.95 27.62404 35.95996
## 3 33.93031 1.805198 6.56 29.45504 38.40558
## 4 33.83690 2.596578 25.44 27.39972 40.27409
## 5 38.20351 5.228135 103.82 25.24243 51.16460
## 6 32.61527 5.219682 103.97 19.67514 45.55540
## 7 27.83787 5.278241 104.48 14.75257 40.92317
##
## Results are averaged over the levels of: breed
## Degrees-of-freedom method: satterthwaite
## Confidence level used: 0.95

lsmeans(model.1, "breed") # LSM

## breed lsmean SE df lower.CL upper.CL
## BRUNA 29.07129 2.482912 5.89 22.96936 35.17322
## FRISONA 35.96214 2.620832 7.25 29.52127 42.40302
##
## Results are averaged over the levels of: parity
## Degrees-of-freedom method: satterthwaite
## Confidence level used: 0.95

# Model including just fixed effects
model.2<-lm(milk ~ parity + dim + breed + herd%in%breed, data = mydata)
summary(model.2) # Results of the mixed model

##
## Call:
## lm(formula = milk ~ parity + dim + breed + herd %in% breed, data = mydata)
##
## Residuals:
## Min 1Q Median 3Q Max
## -12.3093 -3.0542 0.1615 2.9618 10.1044
##
## Coefficients: (6 not defined because of singularities)
## Estimate Std. Error t value Pr(>|t|)
## (Intercept) 44.240943 5.703326 7.757 4.55e-12 ***
## parity1 1.429784 5.104848 0.280 0.779935
```

```
## parity2          3.626959   5.102358   0.711 0.478675
## parity3          5.531636   5.174263   1.069 0.287359
## parity4          5.595854   5.414718   1.033 0.303639
## parity5         10.171414   7.146107   1.423 0.157439
## parity6          4.657332   6.985627   0.667 0.506346
## dim             -0.053415   0.005962  -8.959 8.86e-15 ***
## breedBRUNA      -12.649202   1.982793  -6.379 4.22e-09 ***
## breedBRUNA:herd1805639 -1.783482   1.393996  -1.279 0.203423
## breedFRISONA:herd1805639      NA          NA      NA      NA
## breedBRUNA:herd1815705   5.961697   1.674231   3.561 0.000546 ***
## breedFRISONA:herd1815705      NA          NA      NA      NA
## breedBRUNA:herd1815741      NA          NA      NA      NA
## breedFRISONA:herd1815741      NA          NA      NA      NA
## breedBRUNA:herd2010103      NA          NA      NA      NA
## breedFRISONA:herd2010103  -7.206510   1.962285  -3.673 0.000371 ***
## breedBRUNA:herd2010147      NA          NA      NA      NA
## breedFRISONA:herd2010147  -5.656240   2.307552  -2.451 0.015799 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.916 on 111 degrees of freedom
## Multiple R-squared:  0.6239, Adjusted R-squared:  0.5833
## F-statistic: 15.35 on 12 and 111 DF,  p-value: < 2.2e-16
```

```
anova(model.2) # ANOVA table SS type III
```

```
## Analysis of Variance Table
##
## Response: milk
##          Df Sum Sq Mean Sq F value    Pr(>F)
## parity      6 1222.54   203.76   8.4321 1.527e-07 ***
## dim         1 1250.49  1250.49  51.7491 7.859e-11 ***
## breed       1 1113.45   1113.45  46.0781 5.845e-10 ***
## breed:herd   4   863.46   215.87   8.9332 2.723e-06 ***
## Residuals  111 2682.25    24.16
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
lsmeans(model.2,"parity") # LSM
```

```
## parity  lsmean      SE df lower.CL upper.CL
## 1      29.68148 0.9365801 111 27.82559 31.53738
## 2      31.87866 0.7811267 111 30.33080 33.42651
## 3      33.78334 1.0210600 111 31.76004 35.80663
## 4      33.84755 2.1296472 111 29.62752 38.06759
## 5      38.42311 5.0167446 111 28.48210 48.36413
## 6      32.90903 5.0058113 111 22.98968 42.82838
## 7      28.25170 5.0683260 111 18.20847 38.29493
##
## Results are averaged over the levels of: herd, dim, breed
## Confidence level used: 0.95
```

```
lsmeans(model.2,"breed") # LSM` ``
```

```
## breed  lsmean      SE df lower.CL upper.CL
## BRUNA  29.19769 1.312593 111 26.59670 31.79868
## FRISONA 36.16657 1.563315 111 33.06875 39.26438
##
## Results are averaged over the levels of: parity, herd, dim
## Confidence level used: 0.95
```