

Mealybug Example: Random vs Fixed Blocks in RCB

A zoo is testing 3 pesticides (Water, Oil and Fungal spores) to control mealybugs on cycad plants. Five cycad plants (blocks) are chosen. The three treatments are randomly assigned to three branches on each plant. The change (before-after) in the number of mealybugs on each branch is recorded.

This example compares an analysis that assumes fixed blocks to an analysis that assumes random blocks for the Mealybug data.

Notes:

1. Use of EMSanova is primarily for illustration. Not required for routine analysis.
2. emmeans() can be used with both fixed effects models or mixed models. But its behavior changes depending on whether the lme4 package has been loaded. Notice the order below (1) run the fixed effects model with lm() and use emmeans, (2) detach emmeans, (3) load lme4 and then reload emmeans!

RCB Blocks as Fixed

```
library(car)
library(emmeans)
library(EMSAov)
Mealybug <- read.csv("C:/hess/STAT512/RNotes/Random2/R2_Mealybugs_RCB.csv", header=TRUE)
str(Mealybug)

## 'data.frame': 15 obs. of 3 variables:
## $ Trt : Factor w/ 3 levels "O","S","W": 3 2 1 3 2 1 3 2 1 3 ...
## $ Block: int 1 1 1 2 2 2 3 3 3 4 ...
## $ Y : int -15 3 15 23 39 65 19 3 30 9 ...

#Important: Need to define block as.factor!!!
Mealybug$Block <- as.factor(Mealybug$Block)

Model1 <- lm(Y ~ Trt + Block, data = Mealybug)
Anova(Model1, type = 3)

## Anova Table (Type III tests)
##
## Response: Y
##          Sum Sq Df F value    Pr(>F)
## (Intercept) 553.15  1  7.8019 0.023443 *
## Trt         1728.13  2 12.1871 0.003729 **
## Block       2745.60  4  9.6812 0.003708 **
## Residuals    567.20  8
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

emmeans(Model1, pairwise ~ Trt)

## $emmeans
## Trt emmean SE df lower.CL upper.CL
## O      32.8 3.77  8  24.1164    41.5
## S      11.8 3.77  8   3.1164    20.5
## W       8.6 3.77  8  -0.0836    17.3
```

```
##
## Results are averaged over the levels of: Block
## Confidence level used: 0.95
##
## $contrasts
## contrast estimate SE df t.ratio p.value
## 0 - S          21.0 5.33  8 3.943  0.0106
## 0 - W          24.2 5.33  8 4.544  0.0047
## S - W           3.2 5.33  8 0.601  0.8236
##
## Results are averaged over the levels of: Block
## P value adjustment: tukey method for comparing a family of 3 estimates
EMSFixed <- EMSanova(Y ~ Trt + Block, data = Mealybug,
                     type = c("F", "F"))
EMSFixed
```

	Df	SS	MS	Fvalue	Pvalue	Sig	EMS
Trt	2	1728.133	864.0667	12.1871	0.0037	**	Error+5Trt
Block	4	2745.600	686.4000	9.6812	0.0037	**	Error+3Block
Residuals	8	567.200	70.9000				Error

```
detach("package:emmeans")
```

RCB Blocks as Random

```
library(lme4)
library(lmerTest)
library(pbkrtest)
library(emmeans)
Model2 <- lmer(Y ~ Trt + (1|Block), data = Mealybug)
summary(Model2)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: Y ~ Trt + (1 | Block)
## Data: Mealybug
##
## REML criterion at convergence: 99.1
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.0208 -0.7069  0.1961  0.4746  1.2777
##
## Random effects:
## Groups   Name                Variance Std.Dev.
## Block    (Intercept)         205.2    14.32
## Residual                    70.9     8.42
## Number of obs: 15, groups: Block, 5
##
## Fixed effects:
##              Estimate Std. Error    df t value Pr(>|t|)
## (Intercept)    32.800     7.431   5.702  4.414  0.00508 **
```

```

## TrtS          -21.000      5.325   8.000  -3.943  0.00428 **
## TrtW          -24.200      5.325   8.000  -4.544  0.00189 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##      (Intr) TrtS
## TrtS -0.358
## TrtW -0.358  0.500
anova(Model2, ddf="Kenward-Roger")

## Type III Analysis of Variance Table with Kenward-Roger's method
##      Sum Sq Mean Sq NumDF DenDF F value    Pr(>F)
## Trt 1728.1  864.07      2      8  12.187 0.003729 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
emmeans(Model2, pairwise ~ Trt)

## $emmeans
##      Trt emmean    SE df lower.CL upper.CL
## 0      32.8  7.43  5.7    14.38    51.2
## S      11.8  7.43  5.7    -6.62    30.2
## W       8.6  7.43  5.7    -9.82    27.0
##
## Degrees-of-freedom method: kenward-roger
## Confidence level used: 0.95
##
## $contrasts
##      contrast estimate    SE df t.ratio p.value
## 0 - S          21.0  5.33   8  3.943  0.0106
## 0 - W          24.2  5.33   8  4.544  0.0047
## S - W           3.2  5.33   8  0.601  0.8236
##
## P value adjustment: tukey method for comparing a family of 3 estimates
EMSRandom <- EMSanova(Y ~ Trt + Block, data = Mealybug,
                      type = c("F", "R"))
EMSRandom

##           Df      SS      MS Fvalue Pvalue Sig      EMS
## Trt        2 1728.133 864.0667 12.1871 0.0037 ** Error+5Trt
## Block      4 2745.600 686.4000  9.6812 0.0037 ** Error+3Block
## Residuals  8  567.200  70.9000

```