

Randomized Complete Block Designs

Researchers were interested in comparing the effects of four diets (A, B, C, and D) on the average daily gain of calves. On each of 6 farms, 4 pens, each containing 5 calves, were set aside for use in an experiment. Each farm engaged in slightly different management practices. Furthermore farms were spread out over a wide geographic area so that weather conditions and other variables that could affect average daily gain varied from farm to farm. Due to logistical constraints all 5 calves in any pen must be fed the same diet.

1. Describe how you would assign diets to pens.
2. What are the experimental units in this experiment?
3. The researchers used a **randomized complete block design** (RCBD) in this experiment. They randomly assigned the four diets to the 4 pens on each farm so that each diet was used exactly once on each farm. The word *complete* in *randomized complete block design* refers to the fact that all treatments appear in each block. A *block* is just a group of experimental units. Blocks are chosen in such a way that experimental units within a block are more similar to each other than experimental units in different blocks. Describe the blocks in this experiment.
4. The back of this handout contains data, SAS code, and SAS output for the analysis of this experiment. Why is the first *glm* statement inappropriate for the analysis of this data?
5. There is a big difference between the results of the two analyses. What features of the data cause the results to differ?
6. Pretend that the experiment had not included diets C and D so that only 12 pens had been used to study diets A & B (not 24) with 2 pens per farm on each of the 6 farms. Try to fill in the missing entries in the following ANOVA table for the experiment comparing diets A & B.

Source	DF	SS	MS	F	P-VALUE
Farm	_____	2.69174167	_____	_____	_____
Diet	_____	_____	_____	_____	_____
Error	_____	0.04474167	_____		
C. Total	_____	3.02789167			

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/* adg is the mean average daily gain of all calves in a pen. */
/* Average daily gain is (final weight minus initial weight)/number of days on study. */

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```

data one;
  input farm pen diet $ adg;
  cards;
1 1 C 2.19
1 2 D 2.44
1 3 B 3.02
1 4 A 2.66
2 5 D 2.36
2 6 C 2.60
2 7 A 2.85
2 8 B 3.37
3 9 B 2.01
3 10 C 1.30
3 11 D 1.57
3 12 A 1.88
4 13 A 2.63
4 14 B 2.99
4 15 D 2.45
4 16 C 2.17
5 17 D 2.43
5 18 C 2.18
5 19 B 2.82
5 20 A 2.55
6 21 A 1.73
6 22 D 1.49
6 23 B 1.96
6 24 C 1.33
;

```

```

proc glm;
  class diet;
  model adg=diet;
  lsmeans diet / pdiff adjust=tukey;
run;

```

The GLM Procedure
 Class Level Information

Class	Levels	Values
diet	4	A B C D
Number of observations		24

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	1.84988333	0.61662778	2.38	0.1003
Error	20	5.18830000	0.25941500		
Corrected Total	23	7.03818333			

R-Square	Coeff Var	Root MSE	adg Mean
0.262835	22.23331	0.509328	2.290833

Source	DF	Type I SS	Mean Square	F Value	Pr > F
diet	3	1.84988333	0.61662778	2.38	0.1003

Source	DF	Type III SS	Mean Square	F Value	Pr > F
diet	3	1.84988333	0.61662778	2.38	0.1003

Least Squares Means
 Adjustment for Multiple Comparisons: Tukey

diet	adg LSMEAN	LSMEAN Number

A	2.38333333	1
B	2.69500000	2
C	1.96166667	3
D	2.12333333	4

Least Squares Means for effect diet
Pr > |t| for H0: LSMean(i)=LSMean(j)

i/j	1	2	3	4
1		0.7170	0.4939	0.8130
2	0.7170		0.0916	0.2421
3	0.4939	0.0916		0.9455
4	0.8130	0.2421	0.9455	

```
proc glm;
  class farm diet;
  model adg=farm diet;
  lsmeans diet / pdiff adjust=tukey;
run;
```

The GLM Procedure
Class Level Information
Class Levels Values
farm 6 1 2 3 4 5 6
diet 4 A B C D
Number of observations 24

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	6.85591667	0.85698958	70.53	<.0001
Error	15	0.18226667	0.01215111		
Corrected Total	23	7.03818333			

R-Square 0.974103
Coeff Var 4.811877
Root MSE 0.110232
adg Mean 2.290833

Source	DF	Type I SS	Mean Square	F Value	Pr > F
farm	5	5.00603333	1.00120667	82.40	<.0001
diet	3	1.84988333	0.61662778	50.75	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
farm	5	5.00603333	1.00120667	82.40	<.0001
diet	3	1.84988333	0.61662778	50.75	<.0001

Least Squares Means
Adjustment for Multiple Comparisons: Tukey

diet	adg LSMEAN	LSMEAN Number
A	2.38333333	1
B	2.69500000	2
C	1.96166667	3
D	2.12333333	4

Least Squares Means for effect diet
Pr > |t| for H0: LSMean(i)=LSMean(j)

i/j	1	2	3	4
1		0.0010	<.0001	0.0048
2	0.0010		<.0001	<.0001
3	<.0001	<.0001		0.0936