STAT 512 Homework Assignment 2: Due in class, Friday September 19, 2014

Conway et al. (2002) conducted a study to investigate the effects of diclazuril in preventing coccidial infection in commercially raised chickens. Four different medication regimens were used, each administered through diet, along with a control (or "unmedicated" condition) for a total of 5 treatments. The weight gain of the birds during the treatment period was one of the dependent variables considered. Groups of chickens were housed in pens, and a diet/regimen was applied to each pen as described in the paper:

"*The [available pens were] divided into 10 blocks of five pens each. The five treatments were assigned at random to one pen in each block in a randomized complete block design. Fifty (25 male and 25 female) 1-d-old Ross* $\times$ *Cobb broiler chickens were randomly allocated to each pen ... records maintained include initial and final weight of birds by pen ...*"

The following mean weight gains (per animal) were reported by treatment:

treatment	unmedicated	SAL 28	DIC 28	DIC 35	DIC 42
weight gain (kg)	2.657	2.725	2.861	2.867	2.890

1. Identify the experimental units used in this study.

2. What do you think of the randomization reported in the text above? Does it appear to have been done appropriately, or would you have recommended something else?

3. Suppose the error mean square in the ANOVA for weight gain had the value of 0.04000. Test the hypothesis of equality of means for all 5 treatments. (Report the appropriate p-value.)

4. An unblocked (CRD) experiment of the same size might have been executed by randomly assigning 10 pens of chickens to each treatment. Such an experiment would have presumably led to less experimental control (more "noise" in the data) because the pens would have been more widely distributed in the experimental facility; temperature, light, and other environmental characteristics might have been more variable across the 50 pens than would have been the case across the 5 pens in a block, et cetera. Supose σ^2 for the CRD is actually 0.06000 (kg^2). What value of σ^2 would be needed for the CBD so that:

   (a) the squared length of 90% CI's for any estimable function of treatment parameters is the same for each design

   (b) the power of the level 0.10 test for equality of all treatments is the same for both designs if, in fact,

$$\tau_1 = \tau_2 = \tau_3 + 0.1 = \tau_4 + 0.1 = \tau_5 + 0.1$$

5. For the CBD discussed, fully characterize the following matrices. (For this problem and the next, work out the matrix algebra "by hand", using block notation like $\mathbf{1}_5$ and $\mathbf{J}_{3\times 5}$ to avoid writing down large matrices element-by-element. You can check work work numerically using R, but there is value in seeing how the structures of these relatively simple matrix forms are related.)

(a) $\mathbf{X}_1$ and $\mathbf{H}_1$

(b) $\mathbf{X}_2$

(c) $\mathbf{X}_{2|1} = (\mathbf{I} - \mathbf{H}_1)\mathbf{X}_2$

6. Suppose that the first two treatments discussed ("unmedicated" and "SAL 28") are actually the same. That is, there were 5 pens of chickens in each block, but only 4 treatments, and 2 of the pens in each block received treatment 1. Fully characterize

   (a) $\mathbf{X}_2$

   (b) $\mathbf{X}_{2|1}$

   for this design. (Note that $\mathbf{X}_1$ and $\mathbf{H}_1$ have not changed.) Using the explicit value of $\mathbf{X}_{2|1}$ for this design, prove that $\tau_1 - \tau_2$ is estimable.

Reference: Conway, D.P., G.F. Mathis, M. Lang. (2002). "The Use of Diclazuril in Extended Withdrawal Anticoccidial Programs: 1. Efficacy Against *Eimeria* spp. in Broiler Chickens in Floor Pens," *Poultry Science* **81**, 349-352.