APPLICATION OF COVARIANCE ANALYSIS TO FEED/ RATION EXPERIMENTAL DATA

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ABSTRACT

The use Analysis of Covariance (ANOCOVA) to feed/ration experimental data for birds was examined. Correlation and Regression analyses were used to adjust for the covariate – initial weight of the experimental birds. The Fisher's F statistic for the straight forward Analysis of Variance (ANOVA) showed significant differences among the rations. With the ANOVA, the calculated F statistic was 4.025, with a probability of 0.0149. On the other hand the F calculated using the ANOCOVA was 2.25 with a probability greater than 0.05. This was not significant (as $f_{0.05} = 2.93$). This means that by using ANOVA, the calculated F will be over estimated and a researcher may arrive at a false conclusion indicating that there were treatment differences when actually there may be none.

Keywords: *Analysis of Covariance, Analysis of Variance, Regression and Correlation, F-statistic, Probability*

INTRODUCTION

Researchers of feed/ration experiments generally analyse the data using straight forward Analysis of Variance (ANOVA) (Asiedu Ansah, 1999; Yirenkyi, 1996; Asamoah, 1996). Analysis of variance is the arithmetical process for partitioning the total sum of variation into components associated with recognized sources of variation (Steel and Tore, 2003).

However, it has been shown that there is a relationship between the initial weight of the experimental animals (the covariate or the independent variable) and the final weight (the dependent or response variable). Asiedu-Ansah (1999) found that birds with initial higher body weights had significantly higher body weight gains than those with low and medium initial body weights and indicated a positive correlation between initial weight and the weight gain of the birds. This positive relationship between initial weight and final weight is a justification for an adjustment in the weight gain for the effect of the initial weight.

ANOCOVA represents a marriage between correlation and regression on one hand, and ANOVA on the other (Hicks, 1973). The regression analysis is used to build a quantitative model relating the covariate (initial weight) to the response variable (weight gain). ANOVA is used to compare the ration effects but the ANOCOVA involves adjusting the weight gain (response) for the effect of the initial weight (covariate) before the comparison (Cochran, 1976). Without this adjustment the initial weight could inflate the variation within the rations and make the true difference in the weight gains due to the rations more difficult to detect (Cochran and Cox, 1977)

The objective of this study was to demonstrate the abuse of the ANOVA for the analysis of feed/ration experimental data and show the efficiency of ANOCOVA in analysing such data.

MATERIALS AND METHODS

Data Used

The data used was from an experiment carried out at the Poultry Section of the Department of Animal Science, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi. Two hundred and ten unsexed broiler chickens were put on seven rations labelled simply as -T_o, T_1, T_2, T_3, T_4, T_5, and T6. Thirty birds were put on each ration. The ration included maize, wheat bran, oyster shell, vitamin premix, salt, cocoa pod husk, soya bean meal and fish meal in various percentages (Table 1).

A Completely Randomised Design (CRD) was used for the experiment and the study was conducted during seven feeding times with each treatment replicated three times. Each replicate consisted of ten broiler chicks. At the start of the experiment, the initial weights of the chicks were measured and then the final weights at the end of the experiment were also measured. The difference between the final weights and the initial weights gave the weight gains. All weights were recorded in grams.

Analysis of Variance (ANOVA)
The character of interest with respect to the ANOVA was the weight gains among the different treatments. The objective of the analysis was to isolate and assess sources of variation associated with the independent experimental variables (the rations) and to determine how these variables interact and affect the response (weight gain). The variation in the response measurements (weight gain) was partitioned into components that reflected the effects of the independent variable. The reason for this procedure was that the total variation in the data could be attributed to the random error, the variability among measurements under constant conditions, as well as variability due to the lack of uniformity in the values of the independent variables (Mont-gomery, 1984)).

Table 1: The composition of the seven rations

	Rations						
Igredients[1]	**T_0**	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**
MAIZE	57	54	51	54	51	54	51
WHEAT BRAN	13	8.5	4	8.5	4	8.5	4
OYSTER SHELL	2	2	2	2	2	2	2
VIT. PREMIX	0.5	0.5	0.5	0.5	0.5	0.5	0.5
SALT	0.5	0.5	0.5	0.5	0.5	0.5	0.5
CPH[2]	0.0	7.5	15	7.5	15	7.5	15
SBM[3]	8	8	8	8	8	8	8
FISH MEAL	19	19	19	19	19	19	19

CPH[2] = Cocoa Pod Husk
SBM[3] = Soya Bean Meal
$T_0 - T_6$ = Rations containing the various ingredients in column 1.

Assuming a linear relationship, the statistical model can be written as:-
$Y_{ij} = \mu + \gamma_{ij} + \varepsilon_{ij}$ where Yij is the ith observed variable (weight gain). μ is a parameter common to all the treatments called the overall mean weight gain and γ_{ij} is the treatment effect (with respect to the rations) and ε_{ij} - is a random error component (Smith, 1957).

Regression and Correlation Analysis
A regression analysis was used in deriving an equation of the line which describes the shape of the relationship between initial weight and the weight gain. A correlation analysis was used to measure the closeness of the relationship between the two variables. In this case the Pearson's Product–Moment Coefficient of Correlation (r) was used to measure the linear relationship between the weight gain and the initial weight of the birds, as both variables are continuous (Montgomery et al, 2001).

The regression model is of the form:-

$Y = \beta_o + \beta_1 x + \varepsilon$ where β_o is the intercept (the point where the regression line cuts the y-axis), β_1 is the slope (the change in the weight gains for every unit change in the initial weight) and the ε the random error.

Covariance Analysis

The Covariance Analysis was used to remove the effect of the linear relationship between the initial weight and the weight gain. In general it can be said that since the initial weight (x) cannot be controlled in the experiment it should be observed alongside with weight gain (y) (Box, et al 1978).

Assuming a linear relationship between x and y the appropriate statistical model will be:

$\mathbf{y_{ij} = \mu + r_i + \beta(x_{ij} - \chi_{..}) + \varepsilon_{ij}}$: where i=1,2……..a and j= 1,2 ……n, μ is the initial or overall mean weight gain, β is the linear regression coefficient indicating the dependency of y_{ij} on x_{ij}, $\mathbf{r_i}$ is the effect of the ith treatment (ie the rations) and ε_{ij} is the random error component. The variable being analysed, the dependent variable (response variable) is denoted by y_{ij} (the $_j$th observation on the response taken under the $_i$th treatment) whilst the variable used in the control of error and adjustment of the means is the independent variable or covariate denoted by $x_{ij.}$

From the equation, the analysis of covariance model is a combination of linear models employed in the analysis of variance and regression. This means that we have treatment effects $\mathbf{r_i}$ as in one-way classification analysis of variance and a regression coefficient β as in regression analysis.

The covariate is expressed as $\mathbf{(x_{ij} - \chi_{..})}$ instead of $\mathbf{x_{ij}}$ so that the parameter μ is preserved as the overall mean. (Scheffe, 1974)), (Mead et al, 2003)

If there were no concomitant variable, we would have had the total sum of product, total sum of squares for initial weight, error sum product and error sum of squares for initial weight equating to each other and finally being equal to zero (Cochran, 1977).

However, because of the presence of the concomitant variable (covariate), we adjust the total sum of squares for weight gain and the error sum of squares for weight gain by the regression of weight gain on initial weight. The adjusted error sum of squares has *k(n-1)1* degrees of freedom instead of k(n-1) degrees of freedom because of an additional parameter (the slope β_1) which has been fitted to the data.

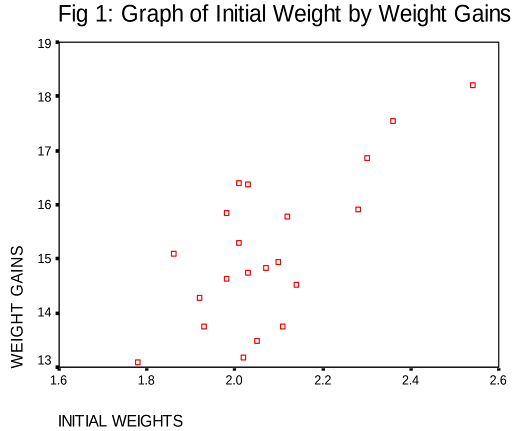
RESULTS AND DISCUSSION

The relationship between initial weight and final weight, as reported by Asiedu Ansah, (1999) was confirmed by a correlation coefficient of 0.725 (p= 0.002<0.05); hence r is significantly different from zero. Again the relationship between the initial weight and the weight gains is depicted in Figure 1. The slope (β_1) for this relationship is equal to 5.792. Table 2 depicts the actual means and the adjust3ed means for the treatments.

From Table 3(a) it can be concluded that there are significant differences among the rations as the F value is 4.11 with a probability of 0.0138 which is also less than 0.05 and therefore significant at less than 5%. The differences seen could be probably due to the fact that the weight gain of the birds was not adjusted to take care of its relationship with initial weight of the birds.

Graphica eight and weight gains.

Fig 1: Graph of Initial Weight by Weight Gains



The table of means (both actual and adjusted) is presented in Table 2

Table 2: Treatment Means (Weight Gains) – (in 10gms)

Treatment[1]	Actual Means	Adjusted Means
T_0	16.77	15.63
T_1	13.73	14.35
T_2	14.32	14.20
T_3	16.24	15.40
T_4	13.97	14.58
T_5	15.47	14.62
T_6	15.66	14.82

[1]T_o – T_6 are the various rations

Table 3(a): Analysis of Variance for the Fed Ration Data

Source of Variation	Df	S	Msq	F
Treatment	6	24.66	4.11	4.025
Error	14	14.30	1.025	
Total	20	38.96		

(Pr>f) <0.0149. Hence treatments are significantly different

Comparing the adjusted treatment means with the actual or unadjusted treatment means, it can be seen that the adjusted treatment means are much closer together and this was another justification for the Covariance analysis.

It can also be concluded that some of the apparent differences among treatments were due to unequal or differences in initial weight of the birds. This implies that the heavier body weight birds relatively gained more weight than the lighter ones.

From Table 3(b) it can be seen that there are no significant differences among the ration means as the F was 2.25 and less than the 5 % critical value of 2.93. This stands from the fact that in the ANOCOVA the weight gains were adjusted to remove the covariate (initial weight), which has been proved or known to be associated with the weight gain. It was found that after taking care of the initial weight of the birds the treatment means were found not to be significantly different. The adjustment did not only provide a more valid estimate of the ration effects but also reduced the random variation in the experiment and hence the standard error of the treatment means and differences between means (Mead *et al*, 2003).

The use of Analysis of Variance has been the tool for the analysis of feed ration experiments. However from the use of ANOCOVA it has become clear that there is the need now to free the experimental error from variability due to identifiable and controllable extraneous causes. These extraneous or concomitant variables cannot be held fixed, but can be measured alongside the variable of interest.

Table 3(b): Analysis of Covariance for the Feed Ration Data (CRD with one Covariate)

Source of Variation	df	Sum of Squares			Adjusted for Regression			
		x	xy	y	y	df	Mean square	f
Treatment	6	0.21	1.89	24.35		13	0.71	
Error	14	0.41	1.65	14.26	9.18	19		
Total	20	0.62	3.54	39.01	18.80			
Adjusted Treatment					9.62	6	1.60	2.25

Critical 0.05, (6,13) = 2.93
Not significant

However, after adjusting for the covariate (concomitant), it was observed that there were no significant differences in the mean weight gains among the treatments. It is therefore recommended that Covariance analysis should be adopted for the analysis of feed ration experiments in order to see the real difference among the various treatments.

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