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The Use of Hotelling T^2 Statistic in Comparing the Egg Weight of Quail, Brown Strain of the Commercial and Duck

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Abstract: The aim of present study to compare the egg weight characteristics of quail, duck and brown strain chicken using the hotelling T^2 statistics and to study the pattern of charateristics via correlation coefficient. The egg weight was heaviest in duck with average weight of 61.78 g followed by brown chicken strain with average weight of 61.6 g and quail with 10.8 g. Shell weight was heaviest in brown strain with 6.58 g, followed by duck with 6.14 g and quail with 1.11 g. Yolk weight was heaviest in duck with average weight of 22.4 g, followed by brown strain chicken with average weight of 16.09 g and quail with average weight of 4.31 g. Albumen weight was heaviest in brown strain chicken with average weight of 38.9 g followed by duck with average weight of 16.38 g and quail with average weight of 4.93 g. Correlation matrix obtained showed that the pairs of weight characteristics compared were highly and linearly correlated at 1% level of significant. Analysis of variance was carried out to compare the weight characteristics of eggs and it was discovered that the weight characteristics (egg weight, shell weight, yolk weight, albumen weight) of the three poultry species were significantly different. Pair wise comparison were done using LSD and showed that: the mean of the egg weight of brown strain chicken and duck do not differ while other pair comparison differed. All pair comparison of the mean shell weight differed significantly. The pair wise comparison differed in mean yolk weight and in albumen mean weight. Pairwise comparison were carried out using Hotelling T^2 and it was discovered that the mean weight of the egg characteristics differed in the birds.

Key words: Hotelling T^2 statistic, egg weight, quail, brown strain of the commercial and duck

INTRODUCTION

Eggs contain essential nutrient that support life during embryonic growth. Information on egg quality characteristics, utilization and other purposes are limited mostly to that of chicken. Physiologically, reproduction of eggs of most species of birds may have similarities in nutritional composition and potential food usage (Song *et al*., 2000).

Egg quality is composed of those characteristics of an egg that affect its acceptability to consumers (Stadelman, 1977). External factors of the quality characteristics of eggs which include cleanliness, freshness, egg weight and shell quality are important in consumers acceptability of shell eggs.

Earlier investigation of Song *et al*. (2000) on the comparison of weight characteristics between the pairs of pheasant and chuckar birds, quail and pheasant birds, quail and chuckar birds were reported to differ significantly (Song *et al*., 2000). The proportion parts of quail eggs observed in the presents study were similar to the reports of Imai *et al*. (1986) and Beev (1975). In the report of Imai *et al*. (1986) and Beev (1975) the egg of Japanese quail composed of 10.5 g in weight.

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On the shell thickness, the weight of quail egg was the least. In a study of shell weight quality of quail it was reported by Tserveni-Gousi and Yannakopouies (1990), Asmundson and Baker (1940) and Nagarajan *et al.* (1991) that the quail egg is having the least shell weight which conform to the present study.

The use of Hotelling T^2 statistic in comparing means had been studied by many authors among which are Hotelling (1931), Hotelling (1954), Bose and Roy (1938) and by Hsu (1938). Concise derivations of the general distribution have been given by Bowker (1960) and Rao (1965). The aim of this study therefore is to compare the egg weight characteristics of quail, duck and brown strain chicken using the Hotelling T^2 statistic and to study the pattern of the characteristics via the correlation coefficient.

MATERIALS AND METHODS

The eggs were collected in the month of June 2006 from National Veterinary Research Institutes (NVRI) Vom, Nigeria. The eggs were collected on the day they were laid and were brought to the biochemistry laboratory of Animal Science Department, Ahmadu Bello University, Zaria, Nigeria. The various components of the eggs were then measured.

Methodology

Evaluation of weight characteristics

The weights of the eggs were measured after washing and drying with towel to remove contaminants from shell. Eggs were broken gently and the contents poured into Petri dish, Yolk was separated from albumen and the weight was measured. Shell weight was measured after removal of remaining albumen with water and subsequent air drying overnight. The weight of albumen was calculated by subtracting the weights of yolk and shell from the weight of the whole egg. The statistical package used for the analysis is SPSS V.13.

Hotelling T^2 statistic

Derivation of T^2 Statistic as a function of the likelihood Ratio Criterion.

Let $x_1,...x_n$ be from a random sample from normal distribution with mean μ and variance Σ.

To test the hypothesis

H_o: ($\mu = \mu_0$) VS H_1: ($\mu \neq \mu_0$)

Using the maximum likelihood Ratio test

$f(x) = 1/ (2\pi)^{½} I \Sigma I^{½} \exp \{-½\Sigma (x-\mu)^1 \Sigma^{-1} (x-\mu)\}$

$(2\pi)^{-n p ½} I \Sigma I^{-n ½} \exp \{-½\Sigma (x-\mu)^1\Sigma^{-1} (x-\mu)\}$

Where H_o: ($\mu = \mu_0$)

MLE for Σ

$\Sigma = 1/n \Sigma (x_i-\mu_0) \Sigma^{-1}(x_i-\mu_0)^1$

$(2\pi)^{-n p ½} I \Sigma I^{-n ½} \exp \{- ½\Sigma (x_i-\mu_0)^1 \Sigma^{-1} (x_i-\mu_0)\}$

$tr(\sum (x_i-\mu_0)^1 \Sigma^{-1} (x_i-\mu_0)) = tr (n \Sigma \Sigma^{-1}) = np$

$L_o = (2\pi)^{-n p ½} I \Sigma I^{-n½} \exp \{-½ np\}$

$(2\pi)^{-n p ½} I \Sigma I^{-n½} \exp -½ np$

Using similar manipulations

$L_1 = (2\pi)^{-np½} I \Sigma I^{-n½} \exp -½ np$

Thus applying the likelihood ratio criterion, $L_o/L_1 = \pi$

$\Pi = I A I^{½n} / I A+N (x-\mu_0) (x-\mu_0)^1 I$

$\Pi^{2/n} = I A I / I A+N (\bar{x} -\mu_0) (\bar{x} -\mu_0)^1 I$

$I A I / A+N (\bar{x} -\mu_0) (\bar{x} -\mu_0)^1$

$= 1/(1+T^2/N-1)$

$= 1+T^2/N-1$

Where sample variance, $S = A/n-1$

and $T^2 = N (\bar{x} - \mu_0) S^{-1} (\bar{x} - \mu_0)^1$

This was named after Harold Hotelling and it is the extension of the students t-test to multidimensional random variables. Let the response variate X consist of p components distributed according to the multinomal law with mean μ vector and non-singular covariance matrix Σ. All elements of Σ are unknown. Assume that in either condition the variates have a multivariate normal distribution with the same, though unknown, covariate matrix Σ.

The null hypothesis is

$H_o: (\mu_1 \mu_2 \ldots \mu_P)^1 = (\mu_1 \mu_2 \ldots \mu_P)^1$

And the alternative is

$H_o: (\mu_1 \mu_2 \ldots \mu_P)^1 \neq (\mu_1 \mu_2 \ldots \mu_P)^1$

By application of the union – intersection or likelihood-ratio principles the statistic for testing the hypothesis is,

$T^2 = \{N1N2/N1+N2\} (\bar{x}_1 - \bar{x}_2)^1 S^{-1} (\bar{x}_1 - \bar{x}_2)$

The quantity,

$F = (\{N1+N2-p-1/(N1+N2-2) P\}) T^2$.

With the degree of freedom P, N1+N2-p-1.

The decision rule for the test is

Accept $H_o: U_1 = U_2$; if

$T^2 \leq (N1+N2-2) P/(N1+N2-P-1) F$;

With the degree of freedom P, N1+N2-p-1.

And reject otherwise.

RESULTS AND DISCUSSION

The correlation coefficient for the pairs of the weight characteristics for the three poultry species were all highly significant at 1% level Table 1. In a similar study of eggs of quail, duck and mallard, Ricklefs (1977) also found no negative correlation among the pair of equal weight quality. Comparing the weight characteristics of the three poultry species using a one way analysis of variance reveals that there exist a significant difference in all the weight characteristics.

Pairwise comparison were carried out using the Least Significant Difference (LSD) and the following observations were made.

- Egg Weight: The weight differs in all the birds but only that of Brown strain and duck that are not significantly different.
- Shell Weight: The weight differed for all the birds.
- Yolk weight: The weight differed for all the birds.
- Albumen Weight: The weight differed for all the birds.

Table 1: Hotelling T^2 statistic values and its probabilities

Birds	Hotelling T^2-Statistic	Probability
Combined birds	299.004**	0.0001
Quail	18544.938**	0.0001
Brown strain	7676.086**	0.0001
Duck	9149.189**	0.0001

**Highly significant difference

The T^2 Statistic value was greater than the critical region which made the null hypothesis to be rejected and to accept the alternative that, the weight characteristics for the birds were not equal. In conclusion, using Hotelling T^2 in comparing the egg weight characteristics of the poultry species, the finding agrees with the previous of Song *et al*. (2000) that the egg weight characteristics of the poultry species differ.

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