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An evaluation of ratios as a measure of carcass traits using mature indigenous chickens in Limpopo Province of South Africa

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Abstract

Live weight and weight of body parts of 60 mature indigenous chickens were collected to investigate whether the use of ratios in poultry science may cause misinterpretation of data and misleading conclusions. Three villages from Mukula Tribal land in Thulamela municipality from Vhembe District in Limpopo Province of South Africa were identified for the purpose of this study. Five mature chickens were bought from each village, weighed, killed, dressed and cut to get the body parts using the standard procedures. This was done across the four distinct seasons from March 2005 to March 2006. The data was collected using a weighing scale with variables of interest being the sex, season and village. Summary statistics were computed and data was analyzed in two separate ways using the Statistical Analysis Software Packages as follows: Firstly each individual body part was expressed as ratio of body weight and data analyzed using a simple analysis of variance (ANOVA) procedure. Secondly, live body weight was used a covariate in the analysis of other body parts using the ANCOVA procedures. Ratios suggested differences gizzard, liver, head and feet and body length due to sex and in gizzard, liver and body length due to village which were not apparent with ANCOVA. The results from this study suggested that ratios did not remove the variation due to differences in sex and village and may lead us to wrong conclusions. From this study, one can draw conclusions that use of ANCOVA gives us the exceptional method for interpreting the data correctly.

Keywords: Ratios, ANCOVA, live weight, body parts
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Introduction

Most morphological traits and physiological functions vary with body size. The ecological physiologists commonly divide individual values for variables of interest logical by corresponding measures of body size to adjust data that vary in magnitude or intensity with body size of the animal being studied (Packard & Boardman, 1988). In an attempt to remove this variation, the data are analyzed as ratios of body size, for example ratio of a chicken breast divided by the mass of the chicken (Wallis, 1999). These ratios are formed in an attempt to increase the precision of data gathered in planned experiments.

When a plot of a physiological variable (y) against a measure of body size (x) yields a straight line that passes through the origin, then the variable changes isometrically (Wallis, 1999; Mulaudzi, 2006). In this relationship, doubling the body mass also doubles the dependent variable. Functionally, isometry occurs when Y = Mx. Alternatively, allometry obtained whenever such a plot yields either a curved line or a straight line that does not intersect the Y-axis at zero. Most physiological variables change with body size and that is isometric relationships. Allometric relationships cannot easily be analyzed as ratios and instead require other statistical methods like analysis of covariance (ANCOVA) (Packard & Boardman, 1987; Wallis, 1999).

The use of ratios may lead investigators to draw different (incorrect) conclusions than they would have reached by examining the data with Analysis of Covariance, a statistical procedure combining regression with the Analysis of Variance (Fisher, 1932; Cochran, 1957). The Analysis of Covariance is a statistical procedure that is superior to most statistical analyses on ratios (Anderson & Lydic, 1977). When ANCOVA is combined with a visual examination of data displayed in a bivariate plot, it affords an exceptional method for interpreting data correctly (Packard & Boardman, 1988). The ratios of body part to whole mass always lie between 0 and 1 and so their distribution cannot be normal. Distributions that can be used for ratios are distributions for continuous random variables with values between 0 and 1 (Mulaudzi, 2006). One of the basic assumptions of ANOVA is normality of error terms. Thus, ANOVA on ratios is not appropriate, even if data are normal, ratios are not.

Some of the general statistical properties of ratios of random normal variables have been known to statisticians for some time (Atchley *et al*., 1976). The majority of biological variables are not distributed as the typical normal distribution but rather as a truncated normal or related distribution. For example, body weights, heights, etc., do not exist below zero; however, the normal distribution extends from negative to positive infinity. In this case, one must look for methods of analysis that do not depend on the normality assumption.

Most authors indicated that the use of ratios may lead investigators to draw different or incorrect conclusions than they would have reached by examining data with other statistical procedures. The analysis of covariate and ratios were used in this study to compare the growth of chickens and body parts.

Materials and Methods

The research was conducted in the Mukula tribal land, Vhembe District of Northern Province, South Africa. Mukula is situated about 20km on the North Eastern side of Thohoyandou. This area falls between latitudes of 30^o 33' 00" and 30° 36' 00", and longitudes of between 22° 51' 00" and 22°52' 30". It experiences mild to moderate winters (mean 8 – 15 °C), hot summers (mean 23 – 27 °C) and an annual rainfall of 750 mm - 1000 mm per annum. This area has about 15000 inhabitants. Indigenous poultry keepers were selected from the three villages namely Phindula, Satani and Mukondeni. Five chickens were bought, weighed and sacrificed from each village in all the four seasons. Data on body weight and body parts were individually collected and weighed from 60 mature Venda indigenous chickens using an electronic weighing scale over a year from March 2005 to March 2006.

Measurements on live body weight, body length, crop, gizzard, small intestine, liver, head & feet were collected on individual chickens. The variables of interest were the season, sex and village. Data was analyzed in two separate ways using the Statistical Analysis Software Packages (SAS, 2006). First each individual body part was expressed as ratio of body weight and data analyzed using a simple analysis of variance (ANOVA) procedure of SAS (2006). Secondly, live body weight was used a covariate in the analysis of other body parts using the ANCOVA procedures of SAS (2006).

Results and Discussion

The summary statistics of the data were computed and presented in Table 1. The mean values for live weight and body parts as summarized in Table 1 showed slight differences when both ANCOVA and Ratio were used for all the body part. However, the difference is not significant for all procedures.

Table 1 Least square means for the body parts analysed by ANCOVA and ratio

Variable	ANCOVA		RATIO	
	Mean	SE	Mean	SE
Small intestine	0.140	0.195	0.158	0.230
Crop	0.048	0.032	0.053	0.037
Gizzard	0.070	0.018	0.076	0.019
Liver	0.039	0.014	0.044	0.018
Head & feet	0.092	0.033	0.098	0.021
Live weight*	1.482	0.398		

*Is the same for the two analytical methods.

Table 2 presents the probability values for season, sex and village for various body parts. The results indicate that there is no difference in small intestines and crop when both ANCOVA and ratios were used. These suggest that forming ratios removed the variation in two of the six body parts presented (see column on LWT). This results support the findings by Packard & Boardman (1988) who reported that forming ratios effectively corrected the data for differences in body size from the hatchling turtles. In contrast, Wallis (1999) reported that forming ratios failed to remove the variation in body mass for 10 of the 14 carcass parts that were used in his investigation. In four instances from this study, namely the gizzard, liver, head and feet and body length, ratios suggested differences between sexes which ANCOVA did not support. For gizzard, liver and body length, ratios suggested differences in village which were not apparent in ANCOVA.

Table 3 presents the coefficient of variation and root mean squares associated with the ANCOVA and ratios. From this table it is evident that the coefficient of variation and root mean squares for both ANCOVA and ratios did not differ significantly which may suggest same conclusions from the both procedures.

Table 2 Probability (P) values for season, sex and village for various body parts analysed by ANCOVA and analysed by ratios. The bold figures indicate P values where the two Analytical methods led to different conclusions. The column entitled LWT is the P values for the regression of each body part against live weight

Part	ANCOVA				RATIO		
	Pseason	Psex	Pvillage	LWT	Pseason	Psex	Pvillage
SI	0.005	0.55	0.003	0.82	0.002	0.73	0.002
Crop	0.41	0.09	0.03	0.009	0.42	0.09	0.02
Gizzard	0.004	**0.32**	**0.48**	<.0001	0.002	**0.009**	**0.02**
Liver	0.007	**0.25**	**0.68**	0.05	0.009	**0.006**	**0.05**
H& F	0.35	**<.0001**	0.36	0.02	0.08	**0.004**	0.73
BL	**0.05**	**0.006**	0.52	<.0001	**0.001**	**0.09**	**0.0001**

From the results of this study, analysis of body parts as ratios may be an unsatisfactory way of removing variation due to live weight looking into differences in sex and season. Despite the reservations by many physiologists (Dinkel *et al.*, 1965) and systematists (Wallis, 1999) regarding the use of ratios to scale data, ratios still continue to enjoy wide use.

Table 3 The Coefficient of Variation and the root mean squares associated with the Probabilities of ANCOVA and Ratio

Part	ANCOVA		RATIO	
	CV	Root MSE	CV	Root MSE
SI	119.2	0.167	120.8	0.191
Crop	62.91	0.03	65.96	0.035
Gizzard	17.43	0.012	21.87	0.016
Liver	32.09	0.012	34.18	0.014
H& F	22.56	0.020	19.31	0.018
BL	6.86	24.48	16.09	0.04

The use of ratios to scale data will not lead investigators invariably to incorrect conclusions, in some instances, as in this data, ratios led to the same conclusions as did ANCOVA (when the level of significance was set at $P = 0.05$). This was also evident in the studies of hatchling turtles as reported by Packard & Anderson (1988). From this study it is evident that ratios are adequate for scaling data when coefficient of

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variation for the numerator variable is substantially greater than the coefficient of variation for the denominator variable and also that treatment effects sometimes are so pronounced that almost any analysis including ratios will reveal their existence.

Conclusions

The results showed that ratio did not remove the variation due to body weight and that analysis of ratios led to incorrect conclusions. However, it does not mean that ratios cannot be used. If they are used and there is little variation in body weight, then expressing body parts in percentages matters little as it was evident in small intestines and crop. The results from this study suggest that we use ANCOVA as an exceptional method on analyzing the data for variables which vary allometrically with body weight as it gives the correct conclusions. Hence, it affords an exceptional method for interpreting the data correctly. Likewise, for variables which vary isometrically with live weight ANCOVA will be an acceptable analytical method.

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