

DIFFERENTIAL EFFECT OF WEIGHT-CLASS AND SEX ON CORRELATION BETWEEN ZOOMETRIC TRAITS IN YOUNG JAPANESE QUAIL (*Coturnix japonica*)

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ABSTRACT

The present study examined whether early growth rate and sex perturb the direction of correlation between body weight and length of body parts of young Japanese quail aged 1 – 6 weeks. Sixty quail of mixed sexes were studied. Zoometric traits including Body weight at hatch, and Body weight, BW (g); Body length, BL (cm); Body girth, BG (cm); Wing length, WL (cm); and Shank length, SL (cm) at age 1 – 6 weeks and their intervallic growth rates were determined. Birds were classified based on body weight growth potential in the period spanning age 0 – 3 weeks such that birds with a growth rate equal to or greater than 1 standard deviation point above the group mean were classified as “Heavy”, birds with a growth rate equal to or lower than 1 standard deviation point below the group mean were classified as “Light”, while with a growth rate between (above 1 standard deviation below the group mean and below 1 standard deviation above the group mean) were classified as “Medium” weight. The sex of each bird was determined based on the appearance of secondary sexual characteristics between age 4 and 6 weeks. All zoometric trait data were subjected to Pearson’s bivariate correlation analysis by use of SPSS 21 (IBM SPSS). Formal Logic arguments were used to interrogate the correlation matrixes to determine the number and percentage of instances in which there was concordance/discordance in the direction of correlation between trait pairs across Weight classes. The resulting data was subjected to Chi-squared analysis. The direction of correlation between traits was significantly ($p < 0.05$) perturbed by sex, and weight class. There was a significant ($p < 0.05$) bias towards concordance of the direction of correlation between weight classes and between sex classes than might be observed by chance, which points point to the operation of shared mechanisms underpinning correlation between traits across classes. Body weight class and Sex significantly ($p < 0.05$) differentially perturbed the direction of correlation between weight classes. Specifically, there was a greater tendency for concordance (in the direction of correlation) between sexes than between body weight classes. Generally, the significant ($p < 0.05$) perturbation of the direction of correlation of body weight at each of age 1 – 6 weeks and other zoometric traits was similar in both sexes. These results reveal that the application of general notions of correlation between body weight and zoometric traits to a specific set of contexts such as sex or weight class subgroups during animal breeding or management processes is far from ideal and should be avoided as it should lead to unreliable predictions and accordingly, outcomes.

Keywords: Weight class, sex, correlation, zoometric traits, Japanese quail.

INTRODUCTION

Sheer body weight is a useful metric for determining the value of farmed birds, which are sold on a live body weight or carcass weight basis, but a more sophisticated measure of the value of a bird is based on the proportionate contribution of its most valuable parts (Breast, Drumstick, Thigh, Wing, and Gizzard) to the live body weight or overall carcass weight,

irrespective of whether such birds are sold whole or as parts/pieces/specialized-cuts. The change in length of body parts (Body length, BL; Body girth, BG; Wing length, WL; and Shank length, SL) in standard deviation terms, for each increase of one standard deviation in body weight (otherwise known as the coefficient of correlation between a pair of traits) can serve as a guide to the direction of change and

extent/strength of change in body part sizes as body weight changes. Indeed, the correlation between body part length traits is independently useful. Beyond its utility in the production setting, the correlation between traits is useful in the animal breeding setting for: judging the expected response of traits to the primary selection of a trait to which they are correlated and can indeed be coopted as a tool for indirect selection; constructing selection indexes used in the selection of multiple traits, and; for gaining additional information on breeding value. Although we and others (Toye *et al.*, 2013) have shown that the correlation between traits is influenced by genotype (species, breed, strain, line etc) and the environment (biotic and abiotic surroundings, nutrition etc) the emerging picture is that the nature of perturbations of inter-trait correlation is likely to vary from genotype to genotype and from one environment to the other, the existing body of knowledge is far from exhaustive insofar as it does not cover the effects of genotype and environment on all possible trait relationships. The practical relevance of the knowledge of how genotype and environment affect the correlation between traits in a specific trait of interest cannot be overemphasized. Such information has the potential to allow optimal use of the knowledge of relationships between traits for production and/or breeding purposes and to save errors, losses or wastage that may arise from use of general theories of correlation between traits to specific circumstances where they may not necessarily apply. In the present study, we sought to contribute to the body of knowledge of the factors that perturb correlation between traits by examining whether the early growth rate and sex of young Japanese quail perturbs the direction of correlation between body weight and length of body parts of young Japanese quail aged 1 – 6 weeks. Outcomes of the present study provide vital data for assessing the body-parts-yield implication of sorting birds by weight class and/or sex for market, and also for selective breeding of birds within specific weight classes for market purposes.

MATERIALS AND METHODS

Birds: A total of 60 quail of mixed sexes hatched from eggs produced by a random-bred population of NVRI Vom origin (National

Veterinary Research Institute, Vom, Nigeria) quail stock, maintained at the Department of Animal Production, Faculty of Agriculture, University of Ilorin, were studied.

All birds were fed a conventional quail diet (24% Crude Protein 2800 kcal Energy) *ad libitum* and had unrestricted access to drinking water throughout the experiment period.

Zoometric Traits: Body weight at hatch, and Body weight, BW (g); Body length, BL (cm); Body girth, BG (cm); Wing length, WL (cm); and Shank length, SL (cm) at age 1 – 6 weeks were determined for each bird as described previously (Ojo *et al.*, 2013).

Growth Rate: The growth rate of body weight from Hatch to age 3 weeks was derived from primary data by use of the formula of Maciejowski and Zieba (1982).

Classification by growth rate: Birds were classified by use of a rule-based system. Specifically, body weight growth potential in the period spanning age 0 – 3 weeks (early growth rate) was calculated for all birds, and birds with a growth rate equal to or greater than 1 standard deviation point above the group mean were classified as “Heavy”, birds with a growth rate equal to or lower than 1 standard deviation point below the group mean were classified as “Light”, while with a growth rate between (above 1 standard deviation below the group mean and below 1 standard deviation above the group mean) were classified as “Medium” weight.

Sexing: The sex of each bird was determined based on the appearance of secondary sexual characteristics between age 4 and 6 weeks.

Pearson's Bivariate Correlation: For each of 12 sets/sub-sets of data corresponding to data for All, Male, Female, All Heavy, All Medium, All Light, Male Heavy, Male Medium, Male Light, Female Heavy, Female Medium and Female Light quail respectively, the bivariate correlation between 40 trait vectors (BW, BL, BG, WL, SL trait values at age 1 – 6 weeks) was determined, yielding 12 separate 40 x 40 correlation matrixes.

The levels of correlation between traits were determined by the use of the Pearson's method (Falconer, 1989) implemented in SPSS 21 (IBM SPSS, 2008):

$$r = \text{Cov}(X, Y) / \sqrt{(\text{Var}(X) \cdot \text{Var}(Y))}$$

Absolute Correlation values between 0 and 0.3 (including the range covering 0 and -0.3), 0.3 and 0.7 (including the range covering -0.3 and -0.7) and 0.7 and 1.0 (including the range covering -0.7 and -1.0) were classed as “Weak”, “Moderate” and “Strong” Correlations respectively.

Concordance/Discordance of Direction of Trait-Pair Correlation Across Sex, Weight Class and Weight Class within Sex Class Groups: Formal Logic arguments were used to interrogate the correlation matrixes to determine the number and percentage of instances in which there was concordance/discordance in the direction of correlation between trait pairs across Weight classes (H, M, L), Sex classes (Male, Female), Weight classes in the female sex (FH, FM, FL) and Weight classes in the male sex (MH, MM, ML). The resulting data was subjected to an analysis of counts (Chi-squared analysis) to determine: (a) whether the concordance to discordance (C:NC) ratio across Weight classes (H, M, L), Sex classes (Male, Female), Weight classes in the female sex (FH, FM, FL) and Weight classes in the male sex (MH, MM, ML) deviated from what would be expected by chance (b) whether there was a significant difference in the way that sex (on the one hand) and weight class (on the other) perturbed the direction of correlation between sexes, and; (c) whether Sex significantly perturbed the effect of weight class on the direction of correlation between traits i.e. whether the tendency of the direction of correlation to remain the same across all weight classes (H, M, L) varied from one sex to the other (varies between male and female birds).

RESULTS AND DISCUSSION

Effect of weight class on direction of correlation between body weight and other zoometric traits

The direction of correlation between body weight and other zoometric traits at weeks 1 – 6 exhibited a significantly ($p < 0.05$) greater tendency to concur between weight classes than might occur by chance (Figure 1, Table 1).

Effect of Sex class on direction of correlation between body weight and other zoometric traits

The direction of correlation between body weight and other zoometric traits at weeks 1 – 6

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Differential effect of Sex and Weight Class on the direction of correlation between Zoometric traits

The data showed that with respect to correlation between Body weight at each of weeks 1 -6 and 29 other biometric traits measured over a 6 week period, there was a significant ($p < 0.05$) difference in the way that sex (on the one hand) and weight class (on the other) perturbed the direction of correlation between sexes i.e. the concordance to discordance (C:NC) ratio between sex classes differed from the C:NC ratio between weight classes (Table 1).

Effect of weight class on direction of correlation between body weight and other zoometric traits in Male and Female birds

The direction of correlation between body weight at weeks 1, 3, 4 and 5 and other zoometric traits exhibited a greater tendency ($p < 0.05$) to concur between weight classes than might occur by chance in Male birds (Table 2). Also, a significant ($p < 0.05$) bias towards concurrence between weight classes was observed in female birds. However, at age 2 weeks, only male showed a significant ($p < 0.05$) bias (upward) in concordance of correlation between weight classes relative to chance, and at week 6, the reverse was observed, in which only female birds showed a significant ($p < 0.05$) bias (upward) in concordance of correlation between weight classes relative to chance (Table 2).

Sex-dependent effect of Weight Class on the direction of correlation between Zoometric traits

The data showed that with respect to correlation of Body weight at each of weeks 1, 3, 4 and 5 with 29 other biometric traits measured over a 6 week period, Sex did not significantly ($p > 0.05$) perturb the effect of weight class on the direction of correlation between traits i.e. the tendency of the direction of correlation to remain the same across all weight classes (H, M, L) did not vary from one sex to the other (Table 2).

The data showed that with respect to correlation of Body weight at each of weeks 2 and 6 with 29 other biometric traits measured over a 6 week period, Sex significantly ($p < 0.05$) perturbed the effect of weight class on the direction of correlation between traits i.e. the tendency of the

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CONCLUSION

These results show that: The direction of correlation between traits is perturbed by sex, and weight class; There is a bias towards concordance of the direction of correlation between weight classes and between sex classes than might be observed by chance, and point to the operation of shared mechanisms underpinning correlation between traits across classes; Body weight class and Sex differentially perturb the direction of correlation between weight classes, specifically, there is a greater tendency for concordance (in the direction of correlation) between sexes than between body weight classes; Generally, the perturbation of the direction of correlation of body weight at each of age 1 – 6 weeks and other zoometric traits is similar in both sexes; The application of general

notions of correlation between body weight and zoometric traits to a specific set of contexts such as sex or weight class subgroups during animal breeding or management processes should be avoided as it leads to unreliable predictions and accordingly, outcomes.

REFERENCES

- Maciejowski, J. and Zieba, J. (1982). Genetics & Animal Breeding. Part A. Biological & Genetic Foundations of Animal Breeding. Elsevier Scientific publishing Co. Amsterdam. Oxford. New York. PWN – Polish Scientific.
- Ojo, V., Ajayi, A. O., and Toye, A.A (2013). Growth Rates of Body Weight and Linear measurements in Japanese Quail. *Nigerian Journal of Genetics*, 27: 14 – 39.
- Toye A. A., F. E. Sola-Ojo, O. M. Olaniyan and V. Ojo (2013). The nutrigenetic effects of *Moringa oleifera* seed meal on the biological growth programme of young broiler chickens. *Agrsosearch* (2013) 13 No.1: 149 – 163.

Table 1. Sex and Weight Classes Concordance of the direction of bivariate correlation between Body weight at each of weeks 1 - 6 and 29 other biometric traits in Japanese quail.

TRAIT 1	GROUP	C	NC	TOTAL	C (%)	NC (%)	p-value (Obs. vs. Chance)	p-value (Wt.C vs. S)
Wt_wk1	Weight Class	13	16	29	45	55	*	***
	Sex	27	2	29	93	7	***	
Wt_Wk2	Weight Class	18	11	29	62	38	***	***
	Sex	27	2	29	93	7	***	
Wt_Wk3	Weight Class	19	10	29	66	34	***	***
	Sex	28	1	29	97	3	***	
Wt_wk4	Weight Class	21	8	29	72	28	***	***
	Sex	28	1	29	97	3	***	
Wt_Wk5	Weight Class	20	9	29	69	31	***	***
	Sex	27	2	29	93	7	***	
Wt_Wk6	Weight Class	20	9	29	69	31	***	***
	Sex	27	2	29	93	7	***	

C= Concordance, NC = Non-concordance, NS = Not significant ($p > 0.050$), Wt = body weight, Obs. = Observed C:NC ratio, Wt.C=Body weight Class, S = sex, * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$.

The data showed that with respect to correlation of Body weight at each of weeks 2 and 6 with 29 other biometric traits measured over a 6 week period, Sex significantly ($p < 0.05$) perturbed the effect of weight class on the direction of correlation between traits i.e. the tendency of the direction of correlation to remain the same across all weight classes (H, M, L) varied from one sex to the other (Table 2).

CONCLUSION

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	Sex	27	2	29	93	7	***	
Wt_Wk2	Weight Class	18	11	29	62	38	***	***
	Sex	27	2	29	93	7	***	
Wt_Wk3	Weight Class	19	10	29	66	34	***	***
	Sex	28	1	29	97	3	***	
Wt_wk4	Weight Class	21	8	29	72	28	***	***
	Sex	28	1	29	97	3	***	
Wt_Wk5	Weight Class	20	9	29	69	31	***	***
	Sex	27	2	29	93	7	***	
Wt_Wk6	Weight Class	20	9	29	69	31	***	***
	Sex	27	2	29	93	7	***	

C= Concordance, NC = Non-concordance, NS = Not significant ($p > 0.050$), Wt = body weight, Obs. = Observed C:NC ratio, Wt.C=Body weight Class, S = sex, * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$.

Table 2. Weight Classes Concordance of the direction of bivariate correlation between Body weight at each of weeks 1 - 6 and 29 other biometric traits in Male and Female Japanese quail.

TRAIT 1	GROUP	C	NC	TOTAL	C (%)	NC (%)	p-value (Obs. vs. Chance)	p-value (F vs. M)
Wt_wk1	Female x Weight Class	14	15	29	48	52	**	ns
	Male x Weight Class	14	15	29	48	52	**	
Wt_Wk2	Female x Weight Class	11	18	29	38	62	ns	***
	Male x Weight Class	23	6	29	79	21	***	
Wt_Wk3	Female x Weight Class	18	11	29	62	38	***	ns
	Male x Weight Class	19	10	29	66	34	***	
Wt_wk4	Female x Weight Class	19	10	29	66	34	***	ns
	Male x Weight Class	18	11	29	62	38	***	
Wt_Wk5	Female x Weight Class	18	11	29	62	38	***	ns
	Male x Weight Class	19	10	29	66	34	***	
Wt_Wk6	Female x Weight Class	17	12	29	59	41	***	*
	Male x Weight Class	11	18	29	38	62	ns	

C= Concordance, NC = Non-concordance, NS = Not significant ($p > 0.050$), F = Female, M=Male, Obs. = Observed
C:NC ratio, * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$.

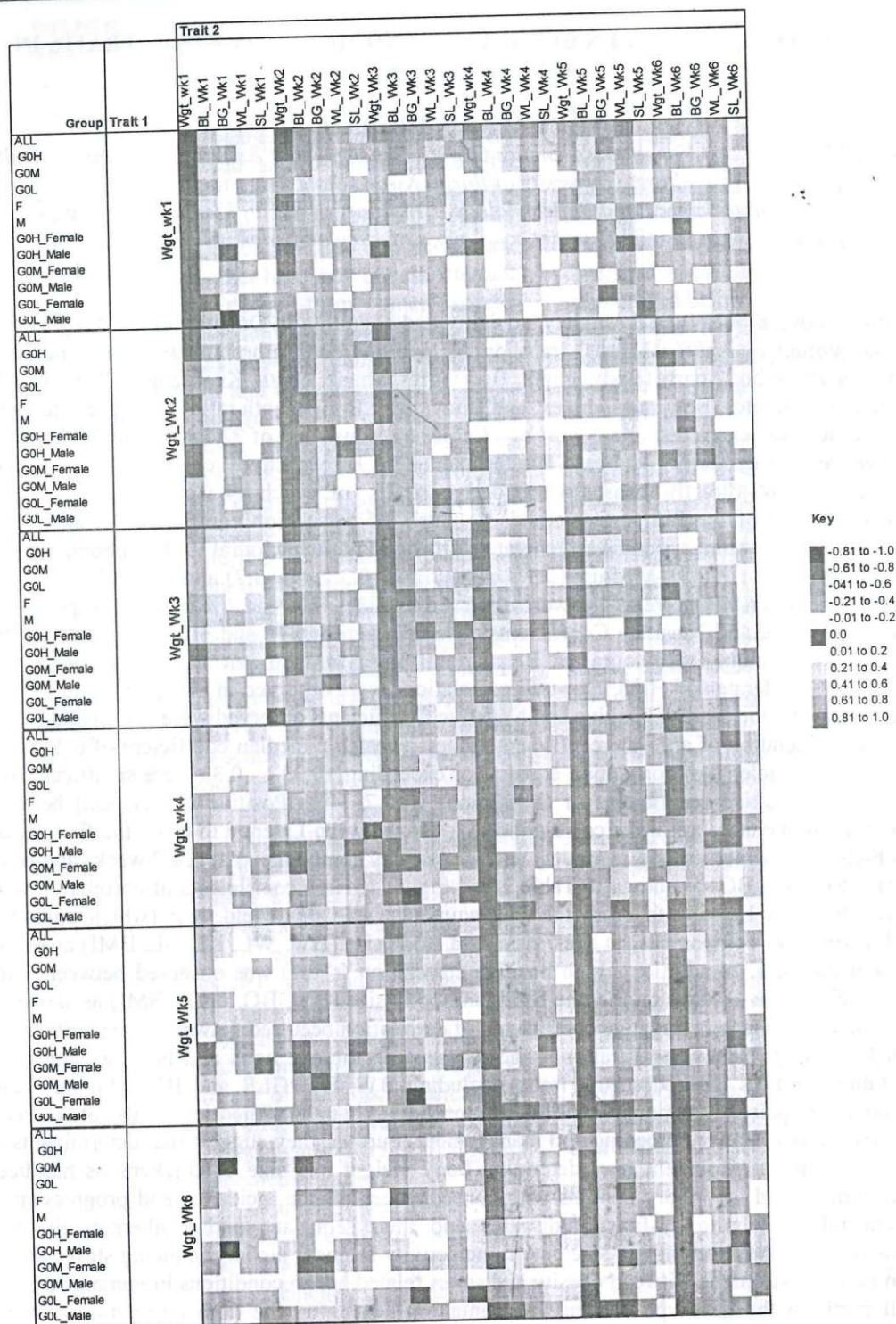


Figure 1. Heat map of Correlation between Body weight at each of weeks 1 - 6 and 29 other biometric traits in Japanese quail classified by Body weight, Sex and a combination of Sex and Body weight class.