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VARIABILITY IN SIZE AND SHAPE IN MUSCOVY DUCK WITH AGE: PRINCIPAL COMPONENT ANALYSIS

D. M. Ogah[1], M. Kabir[2]

[1]Animal Science Department, Faculty of Agriculture Nasarawa State University keffi, Shabu-lafia campus
[2]Genetics and Animal Breeding Unit, Department of Animal Science, Ahmadu Bello University, Zaria
Corresponding author: mosesdogah@yahoo.com
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Abstract: Body weight and six linear body measurements, body length (BL), breast circumference (BCC), thigh length (TL), shank length (SL), total leg length (TLL) and wing length were recorded on 150 male and female muscovy ducklings and evaluated at 3, 5, 10, 15 and 20 weeks of age. Principal component analysis was used to study the dependence structure among the body measurements and to quantify sex differences in morphometric size and shape variations during growth. The first principal components at each of the five ages in both sexes accounted between 71.54 to 92.95% of the variation in the seven measurements and provided a linear function of size with nearly equal emphasis on all traits. The second principal components in all cases also accounted for between 6.7 to 16.17% of the variations in the dependence structure of the system in the variables as shape, the coefficient for the PCS at various ages were sex dependent with males showing higher variability because of spontaneous increase in size and shape than females. Contribution of the general size factor to the total variance increase with age in both male and female ducklings, while shape factor tend to be stable in males and inconsistent in females.

Key words: body weight, linear measurements, muscovy duck, principal component

Introduction

Because of the sexual dimorphism in Muscovy duck and its marked effect on muscular and body growth, the assessment of changes in shape and size in muscovy duck will be sex dependent (*Leclerq, 1990; Baeza et al., 1999 and Ogah et al., 2009*). Growth is related to increase in cell number and volume. It is a complex and highly dynamic physiological process that exists from conception until maturity (*Yakubu and Salako, 2009*). It involves an increase in body mass and changes in shape (conformation) of the various components of the body *(Shahin et al., 2002*). These dynamic processes of multidimensional growth are accompanied by concomitant changes in the phenotypic variance and covariances and their components (*Atchney and Rutledge, 1980*). The multivariate technique of principal component have been used to combine weight and body measurements into indexes for defining body size and shape. *Brown et al. (1973)* and *Carpenter et al. (1978)* used principal component analysis to measure the tendency of bull to retain the same shape throughout their pre yearling development (at 4, 8 and 12 months) and found out that the correlation among principal component at different ages imply that selection on a composite character such as weight or general size (first principal component) at younger age may yield bulls which differ in shape at older ages. Similarly, *Shahin and Hassan (2002*) used principal factor analysis to examine changes in sources of variability in body size and shape in three breeds of rabbits (at 6, 8, 10 and 12 weeks) found out that there was an increase in the amount of variation associated with shape characters and decreases in the amount of variation associated with body size with advancing in age.

The concept of size and shape are fundamental to the analysis of variation in living organisms. Parting biometrical variations into size and shape components are often highly desirable, as the size of most organisms is more affected than shape by fluctuation of the external environment (*Jolicoeur and Mosimann, 1960*).

An attempt has been made to evaluate size and shape in muscovy duck at adult age *Ogah et al. (2009)*, using principal component analysis. Since size and shape changes with age, the need to assess these components during growth and there implications to selection and improvement is required.

The objectives of this study were to investigate the potentials of principal components as a means of identifying variation in body size and shape in indigenous muscovy duck, and to also quantify differences between sexes in morphometric size and shape variation during growth.

Materials and methods

Sources of data

One hundred and fifty muscovy ducklings hatched by 60 dams and 10 sires under a mating ratio of 1:6 at the duck unit of the College of Agriculture, Teaching and Research Farm, Lafia, Nasarawa State, Nigeria. The ducklings are made up of 63 males and 87 females. They were selected randomly at 3 weeks of age for evaluation to 20 weeks.

Management of the birds

The ducklings were sexed, wing band and reared separately in a deep litter pens. They were fed on a grower marsh formulated at 20% CP and 2880kcal/.kg . They were allowed access to green vegetation through a walk way attached to each pen. Water was supplied *ad libitum*.

Traits measured

The body weight in grams and dimension in centimetres were recorded for each ducklings at 3, 5, 10, 15, and 20 weeks of age. The linear body dimensions considered were body length (BL), length between the base of the neck and that of caudal end, Shank length (SL), distance from the shank joint to the extremity of the *digitus pedis*, breast circumference (BCC), measured under the wing through the anterior border of the breast bone crest and the central thoracic vertebrae, thigh length (TL), from the end of the drumstick to the body flank, total leg length (TLL), measured as the total length of the leg from the thigh to the extremity of the digitus pedis , wing length (WL) taken from the shoulder joint to the extremity of the terminal phalanx. To ensure accuracy each measurement was taken twice and the mean was use in subsequent analysis. The same person took all measurements and weighing throughout, thus eliminating errors due to person differences as suggested by (*Shahin and Hassan, 2000*).

Statistical analysis

The data was subjected to analysis using the general linear model for the effects of age and sex. The mean, standard errors and coefficient of variation for the body weight and linear measurement at various ages were obtained. Coefficient of correlation between body weight and linear traits in the birds at all ages were estimated. Principal components (PCs) were obtained separately for each sex at various ages (3, 5, 10, 15 and 20 weeks) body weight and linear measurements were all considered, using SPSS (2004) statistical package.

The technique of principal component analysis involves making linear combination of the available variables into factor or component. The procedure reduces a correlation matrix into a set of orthogonal axes or components. Each component explained a proportion of the variation in the correlation matrix and each is independent of the other. The major component explains the largest amount of variation in the variance and covariance structure and minimizes the residual correlation among the variables. Each successive component will explain the largest possible portion of the remaining variation while satisfying the requirement that each component be independent of the other. When the number of components equal the number of original variables 100% of the variation will be explained (*Morrison, 1967 and Gorsuch, 1974*). Because the response variate were in different unit ie (g and cm) the correlation matrix and standardized variate were use in place of the variance and covariance matrix and the actual body measured.

Kaiser-Meyer-Olkin measures of sampling adequacy and Bathlett's test of sphericity were computed to test the validity of the factor analysis of each of the data sets .

The first principal component can be expressed as follows

$Yi=a_{11}x_1+q_{21}x_2+..........a_{p1}x_p$

Or in matrix form

Y=ax

The a_{11} are scaled such that a_1 a_1 =1 , Y1, accounted for the maximum variability of the P variables of any combination.

The variance of $Y_1=\lambda_1$

Next principal component Y_2 is formed such that its variance λ_2 is maximum amount of the remaining variance and that it is orthogonal to the first principal component. That is

a_1 a_2 =0

The weight used to create the principal component are the eigen vectors of the characteristics equation

$(R- \lambda 1)a=0$ where R is the correlation matrix. The λ are the eigen values.

Results and Discussion

Table 1 presents means, standard errors and coefficient of variation for live weight and body measurements at various ages (3, 5, 10, 15 and 20weeeks of age) for male and female of the Nigerian indigenous ducklings. Sex differences were significant for almost all traits in all the ages. For the male ducklings body weight were 193.04±2.47g and 2691.60±30.70g at 3 and 20 weeks respectively, while female recorded 154.60±6.50g and 1504±9.60g also at 3 and 20 weeks respectively. The significant difference in weight and other body measurements with the male having higher weight and larger body dimensions than female ducks noticed in this study have been reported in previous studies (*Baeza et al., 2001; Teguia et al., 2008; Ogah et al., 2009 and Yakubu, 2009*). The values obtained for both sexes for body weight at 10 weeks were slightly lower than what *Teguia et al.(2008)* obtained from African Muscovy duck in Cameroon, the variations might result from genetic composition and level of inbreeding in the population under consideration.

Table 1 . Mean±standard error and coefficient of variation for live body weight and measurements in male and female muscovy duck at different ages

	Male mean±se	CV	Female mean±se	CV	sign. diff
At week 3					
Body weight (g)	193.04±2.47	17.44	154.60±0.50	26.41	**
Body length (cm)	13.90±0.41	16.09	12.34±0.12	14.17	*
Breast circumference(cm)	12.26±0.24	6.67	12.38±0.23	10.33	ns
Thigh length (cm)	1.74±0.03	5.67	1.55±0.06	14.75	ns
Shank length (cm)	2.83±0.06	6.93	2.20±0.05	8.83	*
Total length (cm)	6.77±0.02	12.62	5.43±0.03	2.67	**
Wing length(cm)	6.89±0.11	5.48	5.66±0.07	5.57	*
At week 5					
Body weight (g)	470.99±3.33	14.23	357.99±1.07	18.12	***
Body length (cm)	17.88±0.12	24.42	15.35 ±0.12	19.41	**
Breast circumference(cm)	16.87±0.23	9.61	14.83±0.23	16.18	**
Thigh length (cm)	2.83±0.03	8.73	2.58±0.05	20.41	*
Shank length (cm)	4.29±0.08	11.25	2.94±0.08	16.18	**
Total length (cm)	9.84±0.03	21.60	8.48±0.08	4.21	*
Wing length(cm)	7.50±6.08	9.21	6.68±0.10	7.13	*
At week 10					
Body weight (g)	1348.50±19.8	14.41	1094.30±11.40	17.11	***
Body length (cm)	26.46±0.25	19.23	24.33±0.13	15.21	**
Breast circumference(cm)	26.85±0.36	8.92	25.10±0.27	14.21	*
Thigh length (cm)	5.61±0.01	7.43	2.84±0.08	20.13	***
Shank length (cm)	5.80±0.05	7.88	4.30±0.08	13.01	**
Total length (cm)	14.48±0.05	16.34	10.17±0.12	4.32	***
Wing length(cm0	20.56±0.10	7.77	19.02±0.16	7.23	**
At week 15					
Body weight (g)	2399.20±24.10	12.32	1290.90±8.70	16.21	***
Body length (cm)	36.68±0.15	15.22	30.61±0.16	13.71	**
Breast circumference(cm)	33.07±0.34	8.01	27.83±0.23	10.51	**
Thigh length (cm)	7.65±0.06	6.44	4.63±0.11	12.11	***
Shank length (cm)	6.53±0.06	9.47	6.18±0.08	11.01	ns
Total length (cm)	18.71±0.19	11.76	14.45±0.12	3.12	***
Wing length(cm0	32.49±0.11	7.76	29.17±0.23	4.21	**
At week 20					
Body weight (g)	2691.60±30.70	10.21	1504.40±9.60	8.40	***
Body length (cm)	47.87±0.20	11.54	37.71±0.87	7.32	***
Breast circumference(cm)	39.33±0.12	8.33	31.89±0.28	9.41	***
Thigh length (cm)	8.88±0.03	5.98	6.84±0.12	8.53	***
Shank length (cm)	6.59±0.05	8.82	6.59±0.12	6,71	ns
Total length (cm)	20.52±0.23	10.34	16.86±0.33	2.97	***
Wing length(cm)	36.99±0.16	5.23	32.95 ±0.23	2.21	**

***=P<0.001, **=P<0.01, *=P<0.05

In both sexes the variation in weight and other body measurements decreases with advancing in age, with variability higher in the body weight than other body measurements. This similar trend was recorded by *Shahin and Hassan*

(2002) on rabbit breeds. Between the sexes variation in both body measurements and weight were higher in females than in males.

Bivariate correlation

Table 2 . Phenotypic correlation among body weight and linear type traits of the two sexes of muscovy duck by age

	Male							Female						
	BW	BL	BCC	Tl	Sl	TLL	WL	BW	BL	BCC	TL	SL	TLL	Wl
At Week 3														
BL	.92							.93						
BCC	.96	.88						.86	.84					
TL	.70	.72	.72					.73	.56	.62				
SL	.45	.48	.45	.82				.75	.72	.56	.50			
TLL	.45	.44	.54	.71	.81			.83	.70	.68	.93	.57		
Wl	.65	.59	.62	.87	.59	.60		.77	.67	.52	.64	.70	.77	
At Week 5														
BL	.80							.85						
BCC	.76	.72						.92	.79					
TL	.93	.72	.76					.76	.69	.88				
SL	.78	.82	.80	.81				.77	.56	.65	.57			
TLL	.88	.71	.76	.91	.75			.68	.59	.68	.51	.62		
Wl	.95	.77	.76	.98	.84	.94		.94	.83	.81	.71	.84	.63	
At week 10														
BL	.56							.48						
BCC	.99	.54						.80	.53					
TL	-.12	.06	-.13					.94	.72	.82				
SL	.94	.66	.94	-.41				.92	.68	.79	.96			
TLL	.92	.62	.92	-.19	.86			.55	.70	.59	.67	.65		
Wl	.96	.49	.96	-.03	.85	.82		.98	.58	.86	.96	.96	.65	
At week 15														
BL	.96							.85						
BCC	.97	.90						.92	.90					
TL	.50	.43	.55					.95	.83	.96				
SL	.89	.82	.87	.53				.78	.68	.89	.89			
TLL	.94	.95	.85	.33	.87			.92	.76	.93	.96	.95		
Wl	.91	.98	.83	.32	.82	.95		.85	.89	.87	.82	.71	. 80	
At week 20														
BL	.61							.40						
BCC	.50	.72						.87	-.20					
TL	.92	.68	.62					.90	-.10	.97				
SL	.70	.61	.73	.75				.64	-.20	.78	.79			
TLL	.90	.73	.56	.83	.69			.98	.10	.93	.92	.67		
Wl	.76	.58	.68	.70	.95	.76		.87	.56	.84	.88	.69	.92	

BW= body weight, BL= body length , BCC= breast circumference, TL= thigh length , TLL= total leg length and WL= wing length

Coefficient of correlation between body weight and body measurements for the male and female at 3, 5, 10, 15 and 20 weeks of age are given in Table 2. The magnitude of the correlations among variables was similar for male and female at between 3 to 10 weeks except at 20 weeks of age . Highly significant ($P<0.01$) correlation existed among the body weight and the linear body measurements of the duck. Body weight was positively correlated with various body dimension at weeks 3 for both sexes. In males, negative correlation between body weight and thigh length was noticed at week 10, similarly, in female negative correlation was noticed between body length and other linear traits at week 20. The estimate of correlation in this study are comparable to those reported earlier by (*Teguia et al., 2008; Ngopongora et al., 2004 and Ogah et al., 2009*). The high positive correlation among traits suggest that they are under same gene action and can be predicted from one another singly or in combination. Whereas, the varying correlation between the phenotypic traits at adult stage between the male and female duck was similar to what *Yakubu (2009)* reported and suggested sexual differences in the genetic architecture of the birds.

Varimax rotated independent factors

Principal component at week 3 . The principal component obtained for male and female muscovy duck at 3 weeks of age are presented in Table 3. The first principal component from week 3 represented as ($PC1_3$) for the male and female show nearly identical coefficient for each of the seven traits considered. The two PCs obtained representing 87.71 and 85.53% of the variability of the original variables leaving 12.29 % to 14.47% to the special factors, for male and female respectively. The fact that all coefficient are positive indicates that animals are being contrasted on a within measurement bases i.e. animal above average for same measures and below for others will show positive or negative deviations (*Brown et al., 1973*). They further added that the larger a PC (either negatively or positively) they greater its value as a discriminatory measure. On this basis PC1 was interpreted as a measure of general size (*Wright, 1933; Jolicoeur and Mosimann ,1960; Carpenter et al., 1971*). In this study $PC1_3$ (general size) is characterized by high positive loading (factor –variate correlation) on all traits except for shank length and total leg length in male and thigh length in female ducklings.

Table 3: Explained variation associated with rotated factor analysis with communalities of each variable by sex and age

	Male			female		
	Common factor		communality	common factor		communality
Week 3.	**F1**	**F2**		**F1**	**F2**	
BWT	.949	,266	.971	.817	.541	.961
BL	.909	.282	.906	.893	.341	.913
BCC	.917	.307	.935	.757	.412	.743
TL	.552	.780	.913	.272	.937	.951
SL	.191	.919	.880	.833	.233	.748
TLL	.217	.881	.823	.436	.882	.968
WL	.516	.668	.712	.586	.599	.707
% var	**71.536**	**16.172**		**75.190**	**10.338**	
Week 5						
BWT	.808	.521	.924	.747	.616	.938
BL	.404	.832	.866	.792	.415	.799
BCC	.472	.761	.802	.840	.461	.918
TL	.869	.458	.965	.892	.248	.858
SL	.482	.811	.890	.346	.843	.813
TLL	.859	.431	.923	.302	.805	.739
WL	.858	.500	.986	.650	.687	.895
% var.	**84.336**	**6.470**		**77.012**	**8.386**	
Week 10						
BWT	.980	-.101	.971	.959	.223	.969
BL	.668	.230	.526	.301	.888	.879
BCC	.974	-.122	.964	.819	.332	.781
TL	-.043	.979	.964	.851	.492	.966
SL	.975	.035	.952	.855	.457	.940
TLL	.947	-.158	.921	.341	.839	.820
WL	.930	-.028	.867	.928	.360	.991
% var.	**73.016**	**14.982**		**79.265**	**11.381**	
Week 15						
BWT	.931	.334	.978	.653	.701	.917
BL	.953	.226	.960	.383	.894	.946
BCC	.853	.426	.911	.700	.693	.971
TL	.195	.970	.979	.776	.602	.964
SL	.834	.403	.858	.916	.344	.958
TLL	.972	.132	.963	.864	.490	.987
WL	.967	.111	.947	.424	.858	.916
% var.	**82.202**	**12.007**		**88.356**	**6.752**	
Week 20						
BWT	.481	.853	.959	.947	.227	.948
BL	.107	.939	.893	-.022	.993	.987
BCC	.849	.111	.734	.965	-.020	.932
TL	.695	.615	.862	.976	-.054	.956
SL	.815	.384	.862	.806	-.150	.672
TLL	.546	.731	.811	.972	.118	.959
WL	.881	.391	.929	.925	-.224	.909
% var.	**92.952**	**13.061**		**74.810**	**16.080**	

The second principal component (PC_2) accounted for additional 16.172% and 10.338% of the total variation in male and female respectively. Magnitude of the coefficient in the PC are non identical in both sexes, similarly, not all measurements have same signs. The inequalities of the respective coefficient for the two sexes will cause differences of an indeterminate magnitude in the relationship of these PC values to the individual body measurements. Shank and total leg length had the highest loading for the male while thigh length had the highest loading for the female. In both cases representing "length" .This factor is mutually orthogonal to the first, present pattern of variation in the different part of the body (shape) independently of general body size (*Brown et al., 1973 ; Shahin and Hassan, 2002*).

Principal component at week 5. Principal components were obtain using the body measurements at week 5 , the two PCs in both sexes accounted for 90.805% and 95.108% of the total variation in male and female respectively . The $PC1_5$ (the general size component) accounted for a larger portion of variation in female than in male(85.393% and 84.331%).The respective coefficient were also sex specific, an indication of sex effect in growth as earlier outline by (*Baeza et al., 2001*). The $PC1_5$ loaded high for most variable except body length, breast circumference and shank length for the male, and shank length and total leg length for the female. Dimensional relationship changes with age when compare the two PCs at week 3 and week 5. Similar to what Brown et al. (1973) reported, indicating the effect of age in shape and size in the bird.

Principal component at week 10. The first PC (general size) in male and female accounted for 73.02% and 79.29% of the total variation respectively, is characterized with positive high loading for all traits other than thigh length in male and body length and total leg length in female. The second $PC2_{10}$ loaded high for thigh length in male and body length and total leg length in female. There were also changes in dimensionality in the variable coefficient result from changes in age in both sexes.

Principal component at week 15. Variation occur also in the general size factor –variate correlation in male and female (82.20% and 88.36%) . There was similarity in factor loading in the PC1 and PC2 between week 10 and week 15 in male with slight variation in the female, an indication of maturity and little differentiation as the bird get older.

Principal component at week 20. The first PC 1_{20} accounted for 92.95% and 74.81% of the total variation in male and female representing the general size. There was similarity in variable loading between male and female at this age , with body length loading high in the second PC in both sex. The coefficient for PC1 for the male were all positive and significant., while in female negative values were obtained for body length , this could be sex dependent outlying the non significance of body length in size description at this stage of development.

Conclusion

Separating biometrical variations into size and shape component is often desirable as these components explain the genetic and environmental influence on performance of animal which changes with age. Contributions of the general size factor to the total variance increases with age while shape factor tend to be fairly stable in male, in female similar pattern was noticed from week 3 to 15, while shape factor have no specific pattern. This results explain that variations associated with body size in muscovy duck increases with age.

Varijabilnost veličine i oblika mošusnih pataka sa godinama: analiza glavnih komponenti

D. M. Ogah, M. Kabir

Rezime

Telesna masa i šest linearnih telesnih mera, dužina tela (BL), obim grudi (PKB), dužina bataka (TL), dužina piska (SL), ukupna dužina nogu (TLL) i dužina krila su evidentirani na 150 muških i ženskih mošusnih pataka i ocenjivani u uzrastu od 3, 5, 10, 15 i 20 nedelja starosti. Analiza glavnih komponenata - Principal component analysis je korišćena za proučavanje strukture zavisnosti između telesnih mera i da se kvantifikuju razlike između polova u varijacijama morfometrijskih veličina i oblika tokom rasta. Prva glavna komponenta u svakom od pet ispitivanja kod oba pola iznosila je između 71,54 do 92,95%. Varijacija u sedam mera je obezbedila linearnu funkciju veličine sa gotovo jednakim naglaskom na sve osobine. Druga glavna komponenta u svim slučajevima takođe čini između 6,70 do 16,17% varijacija u strukturi zavisnosti sistema u promenljivim vrednostima kao što su oblik, koeficijent za PC u različitim uzrastima bili su zavisni od pola, gde je za muška grla utvrđena veća varijabilnost zbog spontanog povećanje u veličini i obliku od ženki. Doprinos faktora opšte veličine na ukupno variranje se povećava sa uzrastom i kod muških i ženskih pačića, dok oblik kao faktor ima tendenciju da bude stabilan kod muških, ali je nedosledan kod ženskih pačića.

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