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Use of Factor Analysis Scores in Multiple Regression Model for Estimation of Body Weight from Some Body Measurement in Muscovy Duck

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Abstract: Factor and multiple regression analysis were carried out on morphological traits (body length, body width, bill length, bill width, bill height, shank length, body height, head length, head width, neck length, wing length, chest circumference and body weight) of male and female muscovy ducks. Obvious sexual dimorphism was exhibited between sexes, relationship between body measurement and body weight were examined through factor and multiple linear regression analysis. Three factors had positive significant effect on body weight of the male muscovy representing size and shape while only one factor had positive relationship with body weight in female, accounting for 84.2% and 63.5% of variation in body weight for male and female respectively. The result reveals that body measurements can be better selected for improvement in weight for male muscovy than for females.

Key words: Factor analysis scores, multiple regression, muscovy duck

INTRODUCTION

Muscovy duck is one of the commonest domestic birds among rural populace in Nigeria which help to supplement protein need of the people. Genetic study of this bird is not common. Several studies on growth performance of muscovy duck reported sexual dimorphism with males being 50% heavier than female (Baeza *et al*., 1997; Sazy and Heraut, 1997, Tai and Rouvier, 1998).

Prediction of weight using linear measurement is a common tools in animal breeding, several studies have been carried out to identify interrelationship between live weight and body measurement in birds (Gueye *et al*., 1998, Missohou *et al*., 1997). In prediction analysis it will be erroneous not to separate sexes for any estimation, as doing that will be misleading and inappropriate particularly in muscovy duck.

Multiple regression analysis has been used to interpret the complex relationship among body weight and some body measurement in a number of animals (Cankaya *et al*., 2006; Akar *et al*., 2001). This method has its limitation because of the obvious reason of multicollinearity that is often associated with variable as a result of genetic linkages thus often present misleading interpretation. To provide a suitable prediction model, factor analysis suggested as a better tool because it reduces large number of measure variables to smaller number of factor and provide a regression equation for an underlying process by using observed variable (Tabachnick and Fidell, 2001). Factor scores can be obtain from this as they are uncorrelated or orthogonal, thus solving multicollinearity among variables in the estimation of weight.

The aim of this study is to find out the utility function of factor analysis score in multiple linear regression models in estimation of body weight using some body measurement in male and female muscovy ducks.

MATERIALS AND METHODS

Location: The data used for this study were collected from indigenous muscovy duck reared under semi extensive production system in Doma and Shabu villages of southern Nasarawa State of Nigeria, managed by rural women who keep them for commercial purposes.

Collection of data: Using a 10 kg weighing scale and a measuring tape, information on body weight and body measurement was individually collected from 1250 (350 male and 900 female) adult muscovy ducks from April to October 2008. Body measurements include body length, body width, bill length bill width, bill height, shank length, body height, head length, head width, neck length, wing length and chest circumference. The measurement of this variables were carried out in the morning before they are release to go out for browsing.

Data analysis: Factor analysis was performed using 12 body measurement traits to rank their relative significance and describe their pattern of interrelationship with regards to body weight for each sex. the goal of factor analysis are to determine the

number of fundamental influences underlying a domain of variables, to quantify the extent to which each variable is associated with the factor and to obtain information about their nature from observing which factor contribute to performance on which variable (Tinsley and Brown, 2000) this allows numerous intercorrelated variables to be condense into few dimension called factors.
The following equation was used:

$$Z = \lambda F + \varepsilon$$

Where
Z = Ap x 1 vector of variable
λ = Ap x m matrix of factor loading
F = Am x 1 vector of factors
ε = Ap x 1 vector error (Sharma, 1996)

In this study the correlation matrix of variables was used to obtain eigne values. In order to facilitate interpretation of factor loading (l_{ik}) VARIMAX rotation was used. Factor coefficient were used to obtain factor scores for selected factors(Keskin *et al*., 2007) Factor scores can be derived such that they are nearly uncorrelated or orthogonal, thus the problem of multicollinearity among variables for weight estimate can be solved.
Linear multiple regression analysis was used to explore relationship between variables. The general expression of multiple linear regression model formed for the measurements I, one dependent and p independent variables is given as

$$Y = bo\, X^{b}_{11}\, x^{b}_{12} x^{b}_{13} \ldots\ldots\ldots X_{1p} e \qquad i = 1,2\ldots\ldots$$

Where
b1 = unknown parameter
e = usually assumed to be normally distributed with means zero and variance
Y = the dependent variable or response
$x_{11} x_{12} \ldots\ldots x_{1p=}$ Independent variables or predictors

In the second regression scores values of selected factors were considered as independent variables for predicting body weight using the following equation:

$$BWT = a + b_1 FS_1 + b_2 FS_2 + b_3 FS_3 + b_4 FS_4 + E$$

Where
a is a regression constant its value is zero
$b_1 b_2 b_3 b_4$ = regression coefficient of factor score FS
E is the error term of the regression model
t- test was used for determining significant regression coefficients of the variables (factor). Determination coefficient R^2 was used as predictive success criteria for regression model.

RESULTS AND DISCUSSION

The mean values for body weight and body measurement with respect to sex of the Nigeria indigenous muscovy ducks are presented in Table 1.

Table 1: Descriptive statistics of morphological traits by sex

	Male		Female	
Parameter	Mean	SD	Mean	SD
BWT	3.28	0.58	1.86	0.32
BL	27.45	3.02	23.64	2.16
BWD	16.12	1.95	12.03	1.19
BLT	6.15	4.74	4.60	2.25
BLD	2.95	0.39	2.73	1.33
BLH	1.98	1.25	2.07	1.86
SL	6.24	0.60	5.04	3.23
BH	19.44	4.32	16.79	1.98
HL	5.60	0.95	4.65	0.12
NL	14 98	1.45	13.42	1.67
HD	2.94	1.01	2.55	0.69
WL	29.81	2.03	21.74	3.04
CCR	18.80	1.86	16.3	0.32

Body Weight (BWT), Body Length (BL), Body Width (BWD), Bill Length (BLT), Bill Widt (BLD), Bill height (BLH), Shank length (SL), Body Height (BH), Head Length (HL), Neck Length (NL), Head Width (HD) Wing Length (WL) Chest circumference (CCR)

Sexual dimorphism was in favour of male, Similar result was earlier reported by (Baeza *et al*., 1997; Tai and Rouvier, 1998 and Ogah *et al*., 2009).
Result of correlation coefficient among variables (traits) for the pooled data (male and female) showed some significant at 1 and 5% levels Table 2, an indication that these correlation coefficient may be factorable. The highest correlation was predicted between body width and head length, body weight and body width.
Because of the size dimorphism between male and female, multiple linear regression analysis and factor analysis were performed on data set based on sexes Table 3 and 4. This was to analyze the data set to find out the magnitude of the interrelationship among the independent variables. The standard error, t-value, p-value and VIF values for each regression coefficient (β) based on the result of multiple regression analysis was given in Table 3 for male and Table 4 for female. Body length, bill length, bill height, neck length and head width were found to be insignificant for male Table 3 while body length, bill length, bill height, shank length, head length head width and chest circumference were insignificant for the female traits. Though a number of independent variables were insignificant, lower VIF values which are below 10 for all the variables is an indication of no severity of multicollinearity between the variables (Neter *et al*., 1989).
The result of factor analysis presented that the first four factors of the twelve factors were selected as independent variables for multiple regression model because the 4 factors have eigne values greater than 1 for both the male and female traits .Because eigne values represent variances and that each standardized variable contribute to principal component extraction is 1, a component with the eigne value less than 1 is not as important (Tabachnick and Fidell, 2001; Keskin *et al*.,

Table 2: Coefficient of correlation of the morphological triat of the pool data

	BDW	BL	BWD	BLT	BLD	BLH	SL	BH	HL	NL	HD	WL	CCR
BDW	1.00												
BL	0.56*	1.00											
BWD	0.72**	0.52*	1.00										
BLT	0.18	0.12	0.20	1.00									
BLD	0.12	0.17	0.19	0.09	1.00								
BLH	-0.00	0.03	0.12	0.01	0.03	1.00							
SL	0.23	0.18	0.22	0.05	0.09	0.03	1.00						
BH	0.41	0.32	0.45*	0.09	0.16	-0.05	0.23	1.00					
HL	-0.48*	0.38	0.76**	0.12	0.19	0.16	0.20	0.25	1.00				
NL	0.40	0.40	0.50*	0.09	0.26	0.04	0.31	0.49	0.46*	1.00			
HD	-0.19	-0.14	0.33	-0.06	0.07	0.08	0.05	0.02	0.38	0.11	1.00		
WL	0.59*	0.56*	0.62*	0.17	0.16	-0.01	0.28	0.46	0.45*	0.60*	0.16	1.00	
CCR	0.50	0.03	-0.07	-0.01	0.25	0.46*	0.01	0.33	0.03	0.42	0.21	0.20	1.00

Body weight (BWT) , Body length (BL), Body width (BWD), Bill length (BLT), Bill widt (BLD), Bill height (BLH), Shank length (SL), Body height (BH), Head length (HL), Neck length (NL), Head width (HD) Wing length (WL) and Chest circumference (CCR) * P<0.05, ** P<0.01

Table 3: Result of multiple regression for male muscovy duck

Traits	Coefficient	SE	t-value	p-value	VIF
Constant	-1.386	0.417	-3.321	0.001	-
BL	-0.09	0.007	-1.285	0.200	1.280
BWD	0.056	0.017	3.228	0.001	3.321
BLT	0.008	0.004	1.853	0.065	1.294
BLD	-0.198	0.089	-2.237	0.026	3.348
BLH	-0.033	0.019	-1.713	0.088	1.677
SL	0.113	0.054	2.073	0.39	3.071
BH	-0.019	0.005	-3.535	0.001	1.505
HL	-0.129	0.039	-3.290	0.001	3.944
NL	-0.035	0.018	-1.968	0.050	1.873
HD	-0.040	0.020	-2.070	0.040	1.119
WL	0.058	0.013	4.439	0.000	2.012
CCR	0.207	0.014	14.599	0.000	1.998

Table 4: Result of multiple regression for female muscovy duck

Traits	Coefficient	SE	t-value	p-value	VIF
Constant	-0.642	0.217	-2.928	0.004	-
BL	0.010	0.007	1.481	0.140	1.291
BWD	0.070	0.014	5.131	0.000	1.617
BLT	-0.001	0.006	-0.142	0.887	1.027
BLD	0.009	0.010	0.854	0.394	1.118
BLH	0.012	0.007	1.716	0.087	1.028
SL	0.005	0.004	1.138	0.256	1.077
BH	0.044	0.008	5.31	0.000	1.682
HL	0.001	0.025	0.060	0.952	1.436
NL	-0.078	0.011	-7.158	0.000	2.092
HD	-0.010	0.019	-0.532	-0.595	1.163
WL	0.078	0.007	11.802	0.000	2.586
CCR	6.95 se-006	0.000	0.046	0.963	1.025

2007). The selected four factors explain 69.7% and 54.5% total variance for factor analysis for traits in male and female respectively, Table 5 and 6. Factors 1-4 account for 33.00, 18.72, 10.02 and 8.01% of the variation for male and 21.94, 15.43, 8.74, 8.44% for traits in females of the variation (var) in all variables respectively. After orthogonal rotation the factor loading were presented, the relationship between examined variables and corresponding factor (Table 5 and 6) for male variables, shank length, body width and head length show high correlation with factor 1 body length, wing length and chest circumference were correlated to factor 2, bill height, body height and head width were correlated with factor 3 while bill length to factor 4. In female, body height neck length and wing length were correlated to factor 1, body width, head length and head width were correlated to factor 2, bill length bill width and shank length to factor 3 while factor 4 had body length chest circumference and bill height. The highest values of communalities in the two (male and female) indicate that the variances of the variables were efficiently reflected by the factors in the multiple regression analysis. Factor score values for the four factors which were obtained by means of factor score coefficients given in Table 5 and 6 were used as independent variables in the regression analysis to determine significant factor /s on body weight of male and female muscovy ducks Table 7 and 8. From the result it was found that for male traits analysis, 3 out of the 4 factors had significant effect on body weight. the factors also explain 84.2% of the variance in the male body weight .Meanwhile only 1 of the 4 factors had significant effect on the body weight of the female ducks. In both analysis VIF values for the factors were smaller than 10, the problem of multicollinearity presented in Table 5 and 6 was solved. The 3 factors were found to have significant (at 0.01% level) linear relationship with body weight of the male muscovy duck.

From the above result only the three factors had positive significant effect on body weight of the male muscovy duck thus body weight will be expected to increase as the value of the first 3 factor increase, while in female only the first factor had significant effect on body weight of the female duck and its weight increase with increase in the first factor. This can further be explain that in male body weight is expected to increase when variables in factor 1, 2 and 3 are increase namely shank length, body width, body length, wing length and chest circumference whereas in female body weight is expected to increase when body height, body length and wing length increase.

Conclusion: From this study it can be concluded that there are considerable correlation between body weight

Table 5: Result of factor analysis for male duck

	Factor score coeff				Rotated factor loading				
Variables	F1	F2	F3	F4	F1	F2	F3	F4	Communality
BL	0.058	0.318	0.058	0.064	0.219	0.577	0.093	0.058	0.389
BWD	0.232	0.122	-0.037	-0.041	0.871	0.187	0.017	0.034	0.795
BLT	-0.063	0.044	-0.024	0.912	0.113	-0.016	-0.002	0.970	0.954
BLD	0.174	-0.066	-0.055	0.243	0.797	-0.192	-0.006	0.356	0.797
BLH	0.129	-0.072	0.327	-0.083	0.595	-0.157	0.471	-0.011	0.600
SL	0.23	-0.052	-0.195	-0.084	0.857	-0.133	-0.192	0.002	0.789
BH	0.131	-0.034	-0.658	-0.118	0.281	-0.066	-0.841	-0.107	0.803
HL	0.213	0.020	0.154	-0.072	0.861	0.000	0.265	0.015	0.813
NL	0.192	0.076	-0.020	-0.040	0.728	0.108	0.028	0.025	0.544
HD	0.055	0.001	0.371	-0.122	0.280	-0.001	0.504	-0.092	0.314
WL	-0.018	0.445	0.055	0.022	-0.139	0.838	0.061	-0.036	0.727
CCR	0.012	0.449	-0.116	-0.014	-0.087	0.847	-0.359	-0.072	0.755
Variance	4.028	2.607	1.338	1.092	9.07				
Variance %	0.310	0.201	0.102	0.084	0.697				

Table 6: Result of factor analysis for female duck

	Factor score coeff.				Rotated factor loading				
Variables	F1	F2	F3	F4	F1	F2	F3	F4	Communality
BL	0.276	0.096	0.203	0.294	0.627	0.096	0.169	0.284	0.512
BWD	0.058	0.432	0.001	0.075	0.055	0.800	-0.037	0.052	0.647
BLT	0.073	-0.027	0.812	-0.182	0.060	-0.111	0.847	-0.167	0.761
BLD	0.227	0.165	0.271	0.110	0.490	0.242	0.239	0.097	0.366
BLH	0.023	0.150	-0.061	0.245	0.019	0.271	-0.072	0.242	0.138
SL	0.098	-0.020	-0.323	-0.175	0.327	-0.028	-0.366	-0.198	0.281
BH	0.300	0.006	-0.050	0.000	0.774	-0.046	-0.108	-0.026	0.614
HL	0.036	0.406	-0.106	-0.107	0.037	0.772	-0.150	-0.137	0.639
NL	0.282	0.006	-0.185	-0.188	0.769	-0.025	-0.254	-0.223	0.706
HD	-0.027	0.300	0.146	-0.040	-0.154	0.563	0.139	-0.049	0.362
WL	0.286	0.180	0.006	-0.031	0.771	-0.396	-0.035	-0.046	0.754
CCR	0.012	-0.050	-0.055	0.833	-0.015	-0.142	-0.030	0.861	0.763
Variance	2.633	1.852	1.045	1.013	6.543				
Variance%	0.219	0.154	0.087	0.085	0.545				

Table 7: Result of multiple regression analysis based on the result of factor analysis for male duck

Predictor	Coefficient	SE	t-value	p-value	VIF
constant	3.287	0.015	212.6	0.000	
Factor score1	-0.139	0.015	-9.007	0.000	1.000
Factor scores2	0.518	0.015	33.43	0.000	1.000
Factor scores3	-0.071	0.015	-4.580	0.000	1.000
Factor scores4	0.024	0.015	1.555	0.121	1.000

R = 92.1%, R^2=84.7%, RS (adjusted) 84.5

Table 8: Result of multiple regression analysis based on the result of factor analysis for Female duck

Predictor	Coefficient	SE	t-value	p-value	VIF
constant	1.861	0.015	124 .412	0.000	
Factor score1	0.181	0.015	12.074	0.000	1.000
Factor scores2	-0.023	0.015	-1.506	0.133	1.000
Factor scores3	0.009	0.015	-0.606	0.545	1.000
Factor scores4	0.031	0.015	2.052	0.041	1.000

R = 79.7%, R^2 = 63.5%, RS (adjusted) = 62.9%

and body measurement in male muscovy duck and some body measurement can be use to improve weight in male duck where as in female body measurement might not be a reliable tool for improvement in female muscovy duck weight.

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