International Journal of Research in Agronomy 2024; SP-7(6): 540-545

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
www.agronomyjournals.com
2024; SP-7(6): 540-545
Received: 13-03-2024
Accepted: 17-04-2024

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Principal component analysis of morpho-biometric traits in Indigenous Aseel chicken

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DOI: https://doi.org/10.33545/2618060X.2024.v7.i6Sh.943

Abstract
Study was conducted to explore the relationship among morpho-biometric measurements in Aseel using Principal component analysis with the idea of identifying those components that explain the maximum variation. Two principal components were extracted from morpho-biometric traits in Aseel with eigen values of 11.041 for the first principal component (PC1), 1.197 for the second principal component (PC2) which explained 72% of the total variance present in the sixteen original variables.PC1 had high loadings (correlations between the components and the variables) on comb length (0.919), body weight (0.900) and shank girth (0.900). PC2 loaded heavily on beak length (0.607).The correlation coefficient amongst the various measurement traits were positive and high, all body measurements had high correlation with 40week body weight in Aseel breed.

Keywords: Variance, original, measurements

Introduction

Growth is a fundamental characteristic of living organisms, influenced by both genetic and environmental factors. Understanding growth patterns is crucial for breed improvement in livestock. Traditionally, body weight and conformation have been used to assess growth in chickens (Udeh *et al.*, 2011) [23]. However, these traits likely involve complex interactions between genes and may not fully capture the underlying biological processes due to pleiotropic effects (multiple gene effects) and linkage.

Importance of Body Measurements: Research suggests that body morphometric measurements, such as body length, shank length, and chest girth, can be good indicators of growth in poultry (Ige, 2013; Yunusa and Adeoti, 2014) [12, 25]. These measurements offer a potentially simpler alternative to body weight assessment, particularly in resource-limited settings where access to weighing scales might be limited.

Principal Component Analysis (PCA): Principal Component Analysis (PCA) is a valuable mathematical technique that can be used to analyze multiple correlated variables and transform them into a set of uncorrelated variables called principal components. This approach can be helpful in understanding the underlying structure of growth-related traits in chickens (Rao, 1964; Hotelling, 1933; Pearson, 1901) [20, 11, 19].
India boasts a rich diversity of poultry breeds, with over 20 documented varieties (Panda and Praharaj, 2002) [18]. Poultry plays a significant role in rural livelihoods, providing both animal protein and income for farmers. Among these breeds, Aseel and Kadaknath are gaining popularity due to their desirable production traits and potential disease resistance (Arora *et al.*, 2011; Haunshi *et al.*, 2011) [3, 9].

Study Objective: This study aimed to investigate the relationships between body weight and various body measurements in Aseel chickens. The goal was to identify body measurements that could be used as selection criteria for improving meat production (meatiness) in the following breed, particularly for broiler chickens.

Materials and Methods

Data and farm management: The relevant data for the present investigation was collected from Aseel population, maintained at the poultry farm of department of Animal Genetics and Breeding, LUVAS, Hisar. Fertile eggs were brought from (ICAR-CARI) Izatnagarin 2017 for hatching and thereafter selection of superior stock was done.

Traits: The traits recorded were body length, tarsus length, thigh length, comb length, comb height, wattle length, beak length, back length, head length, neck length, wing length, wing span, breast girth, body weight, breast angle and shank girth. Breast angle was measured with the help of goniometer and remaining traits were measured using measuring tape in centimeter. The measurements were taken as suggested by different workers (Ceballos *et al.* 1989, Francesch *et al.* 2011 and Adeleke *et al.* 2011) [5, 8, 1] for considered traits as beak length: from tip of beak to point of insertion of beak in skull; comb length: from insertion of comb in beak to end of combs' lobe; keel length: distance between vertices of sternum; body length: from the tip of beak to cloaca; breast girth: circumference of the breast around its deepest region; breast angle: from the extreme of the keel of sternum; shank girth: width of shank; back length: from insertion of neck into body to cloaca. In order to avoid between individual variations, all the measurements were taken by the same person.

Statistical analyses: Phenotypic correlations were calculated among linear type traits using standard formula. Principal component analysis (PCA) was carried out using Statistical Package for the Social Sciences (SPSS, 2007) [21] test was performed firstly to check whether the dataset of 81 animals with 11 traits could be factored or not as suggested by Maxwell (1959) [3]. Maxwell (1959) [3] proposed that the test should be used prior to the application of factor analysis. SPSS (2007) [21] was used for carrying out principal component analysis. The rotation of principal components was done using varimax rotation in order to maximize sum of variances of squared loadings. For rotation of principal components, we have used Varimax rotation through transformation of components to approximate a simple structure. KaiserMeyer-Olkin (KMO) test of sampling adequacy was computed to find the validity of set at 1% level of significance. Means, standard deviations and coefficients of variation for different traits were calculated by using descriptive statistics of Statistical Package for Social Sciences, i.e. SPSS (2007) [21].

Results and Discussion

In the present study the least-squares means of various traits were 61.75±0.36 cm,9.56±0.09 cm, 15.09±0.17 cm, 4.90±0.13 cm, 1.75±0.06 cm, 0.06±0.05 cm, 2.06±0.05 cm, 16.09±0.12 cm, 4.70±0.09 cm, 38.86±0.22 cm, 22.99±0.17 cm, 31.57±0.26 cm, 60.52±0.65 degree, 5.07±0.47 cm, 17.41±0.13 cm in males and 53.59±0.23 cm, 7.33±0.06 cm, 11.75±0.10 cm, 1.75±0.10 cm, 0.67±0.04 cm, 2.70±0.03 cm, 1.76±0.03 cm, 14.07±0.08 cm, 3.72±0.05 cm, 35.36±0.14 cm, 19.79±0.11 cm, 27.56±0.18 cm, 48.45±0.4 degree, 4.08±0.29 cm, 14.87±0.08 cm respectively, for females. Effect of sex was highly significant (p<0.01) on all morpho-biometric traits in Aseel except shank girth, effect of hatch was highly significant in traits (p<0.01) beak length, and significant (p<0.05) in body length and wing length. Similar results were estimated by Kalita *et al.* (2012) [12] for breast angle in indigenous chicken in Assam and Moussa *et al.* (2020) [15] for tarsus length. Higher estimates of shank length were observed by Haunshi *et al.* (2011) [9] in Aseel and Kadaknath.

Saikhom *et al.* (2018) [20] reported higher mean beak length (2.38 cm) in Haringhata Black chicken. Lower estimates were observed by Moussa *et al.* (2020) [15] for body length, wing length and wing span in local chicken population in Niger as compared to Aseel breed. Churchil *et al.* (2019) observed lower estimates for comb height, breast angle, shank length, body length while higher. Higher mean body length was found in the findings of Bekele *et al.* (2015) [4] in Indigenous chicken of Ethiopia (36.78 cm) and Egena *et al.* (2014) [6] in indigenous Nigerian chickens (38.77 cm). Higher body conformation in Aseel could be explained by the fact that Aseel breed has been selected naturally or by the farmers in villages for their fighting capability, hence this breed has longer legs, stronger bones and more compact muscle mass.

Table 1: Sex wise least-squares means of morpho-biometric traits in Aseel and Kadaknath along with standard errors

	Aseel	
Traits	**Male**	**Female**
Body L.(cm)	61.75^a±0.36	53.59^b±0.23
Tarsus L.(cm)	9.56±0.09	7.33±0.06
Thigh L.(cm)	15.09±0.17	11.75±0.10
Comb L.(cm)	4.90^a±0.13	1.75^b±0.10
Comb H.(cm)	1.75^a±0.06	0.67^b±0.04
Wattle L.(cm)	0.06^a±0.05	2.70^b±0.03
Beak L.(cm)	2.06±0.05	1.76±0.03
Back L.(cm)	16.09^a±0.12	14.07^b±0.08
Head L. (cm)	4.70±0.09	3.72±0.05
Wing L. (cm)	38.86^a±0.22	35.36^b±0.14
Wing S. (cm)	22.99±0.17	19.79±0.11
Breast G. (cm)	31.57^a±0.26	27.56^b±0.18
Breast A. (degree)	60.52^a±0.65	48.45^b±0.4
Shank G. (cm)	5.07±0.47	4.08^b±0.29
Neck L. (cm)	17.41^a±0.13	14.87^b±0.08
Body weight (g)	2423^a±41.24	1710.36 ^{b}±14.23

Means superscripted with different letters with in a row (between male and female, within breed) differed significantly

Two principal components were extracted from morpho-biometric traits in Aseel with Eigen values of 11.041 for the first principal component (PC1), 1.197 for the second principal component (PC2). The two principal components accounted for 72% of the total variance present in the sixteen original variables.

Communality estimates ranged from 0.606 (back length) to 0.853 (tarsus length) and unique factors ranged from 0.150 to 0.512 for all the considered 16 morpho-biometric traits. Low communality estimates for tarsus length observed in this study indicated that tarsus length is weak in explaining the total variation in body measurements.

PC1 had high loadings (correlations between the components and the variables) on comb length (0.919), body weight (0.900) and shank girth (0.900). PC2 loaded heavily on beak length (0.607).

The correlation coefficient amongst the various measurement traits was positive and high. Highest correlation coefficient was observed amongst body weight and breast angle (0.849) while lowest was observed amongst beak length and comb height (0.287). Further, in the present study, all body measurements had high correlation with 40week body weight in Aseel breed. Correlation co-efficients among different morphometric traits are presented in Table 5

Table 2: Total variance explained in morpho-biometric traits by different components in Aseel

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
1	11.041	64.945	64.945	11.041	64.945	64.945	10.581	62.24	62.24
2	1.197	7.039	71.984	1.197	7.039	71.984	1.656	9.744	71.984
3	0.854	5.024	77.007						
4	0.72	4.235	81.242						
5	0.605	3.558	84.8						
6	0.464	2.73	87.53						
7	0.385	2.262	89.792						
8	0.324	1.904	91.696						
9	0.311	1.83	93.526						
10	0.24	1.409	94.936						
11	0.198	1.164	96.1						
12	0.164	0.966	97.066						
13	0.148	0.87	97.936						
14	0.136	0.801	98.737						
15	0.081	0.474	99.211						
16	0.071	0.416	99.627						

Table 3: Communalities and unique factor of various morpho-biometric traits in Aseel

	Communalities	**Unique Factors**
Body length	0.809	0.191
Tarsus length	0.853	0.147
Thigh length	0.807	0.193
Comb length	0.844	0.156
Comb height	0.682	0.318
Wattle length	0.784	0.216
Beak length	0.488	0.512
Back length	0.606	0.394
Head length	0.543	0.457
Neck length	0.740	0.260
Wing length	0.610	0.390
Wing span	0.656	0.344
Breast girth	0.702	0.298
Body Wt	0.841	0.159
Breast angle	0.775	0.225
Shank girth	0.850	0.150

Table 4: Varimax rotated component matrix of different factors for morpho-biometric traits in Aseel

	Component	
	1	**2**
Body length	0.827	0.352
Tarsus length	0.891	0.242
Thigh length	0.889	0.129
Comb length	0.919	-0.007
Comb height	0.826	-0.023
Wattle length	0.883	-0.058
Beak length	0.347	0.607
Back length	0.740	0.242
Head length	0.696	0.242
Neck length	0.857	0.069
Wing length	0.659	0.42
Wing span	0.786	0.196
Breast girth	0.816	0.19
Body Wt.	0.900	0.178
Breast angle	0.873	0.108
Shank girth	0.900	0.198

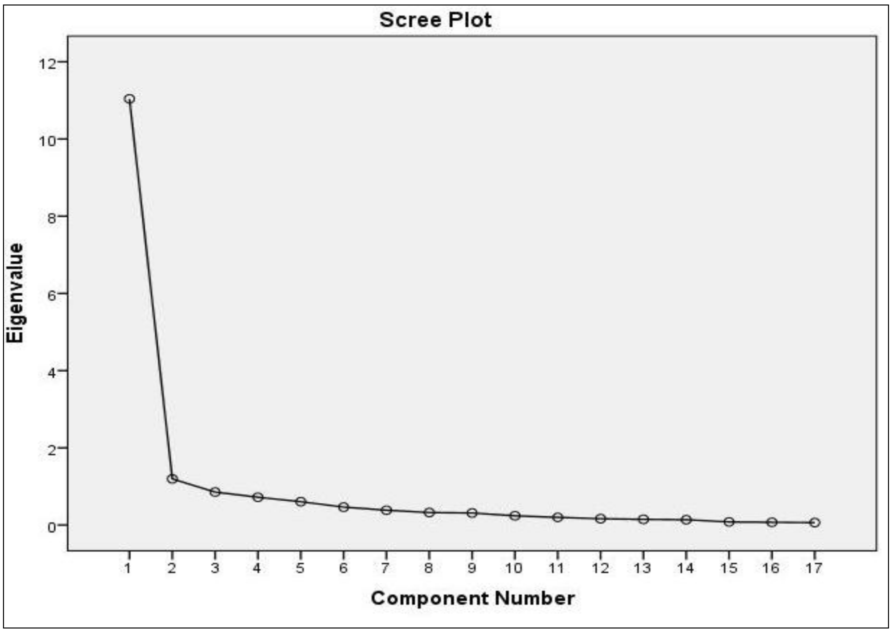

Fig 1: Scree plot showing component number with eigenvalue.

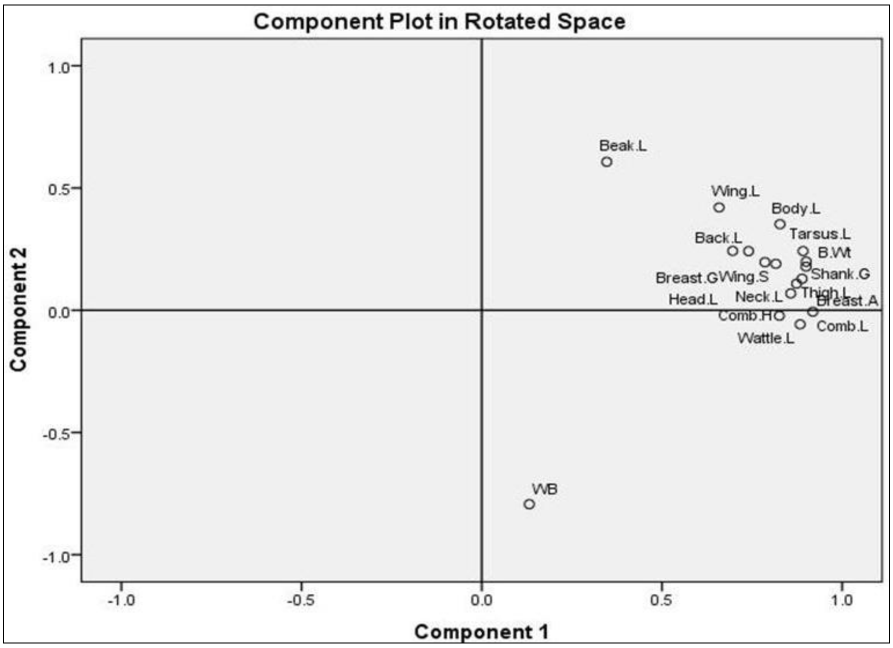

Fig 2: Component plot in rotated space showing different morpho-biometric traits

Table 5: Correlation coefficient of morpho-biometric traits in Aseel

Traits	BL	TL	ThL	CL	CH	WL	BKL	BAL	HL	NL	WL	WS	B G	B. Wt	B A	SG
B L	1															
TL	0.826	1														
THL	0.737	0.809	1													
CL	0.734	0.801	0.787	1												
CH	0.643	0.725	0.696	0.892	1											
WL	0.703	0.762	0.734	0.878	0.780	1										
BKL	0.438	0.475	0.312	0.32	0.287	0.303	1									
BAL	0.708	0.681	0.663	0.627	0.531	0.614	0.371	1								
HL	0.646	0.631	0.657	0.601	0.483	0.546	0.342	0.622	1							
NL	0.769	0.769	0.773	0.744	0.700	0.716	0.372	0.598	0.566	1						
WL	0.745	0.720	0.544	0.623	0.504	0.586	0.448	0.643	0.497	0.530	1					
WS	0.745	0.729	0.703	0.677	0.590	0.649	0.312	0.606	0.573	0.670	0.590	1				
B.G	0.667	0.762	0.778	0.676	0.571	0.642	0.399	0.641	0.602	0.696	0.567	0.680	1			
B. Wt	0.787	0.858	0.857	0.788	0.713	0.708	0.380	0.679	0.656	0.773	0.619	0.680	0.844	1		
B A	0.714	0.76	0.882	0.768	0.641	0.725	0.300	0.615	0.659	0.723	0.515	0.712	0.789	0.849	1	
S G	0.801	0.852	0.789	0.826	0.744	0.802	0.487	0.677	0.630	0.791	0.649	0.736	0.718	0.837	0.808	1

Two principal components were extracted from egg quality traits in Aseel with eigen values of 11.041 for the first principal component (PC1), 1.197 for the second principal component (PC2). The two principal components accounted for 72% of the total variance present in the seventeen original variables. Communality estimates ranged from 0.606 (back length) to 0.853 (tarsus length) and unique factors ranged from 0.150 to 0.512. Yakubu *et al.* (2009) [23] reported high range of communalities (0.755-0.987) for body measurements of Arbor Acre broilers. Higher communality range of 0.785- 0.987 for body measurements of Ross broilers was reported by Mendes (2011) [14]. Significant high correlation was observed amongst the morpho-biometric traits. The positive relationship between bodyweight and most of the body measurements showed that bodyweight can be predicted from body measurements. A similar observation was reported by Ajayi *et al.* (2008) [2]. PC1 had high loadings (correlations between the components and the variables) on comb length (0.919), body weight (0.900) and shank girth (0.900).The results obtained were also in correspondence with the findings of Yakubu *et al*. (2009 a, b) [23] and Saikhom *et al*. (2018) [20] as they also found that PC1 had high positive loadings on body length and body weight in different chicken breeds. PC2 loaded heavily on beak length (0.607). Three principal components were extracted from morpho-biometric traits in Aseel with eigen values of 9.439 for the first principal component (PC1), 1.569 for the second principal component (PC2) and 1.136 for the third principal component. The three principal components accounted for 76% of the total variance present in the seventeen sixteen variables. Communality estimates ranged from body length (0.563) to shank length (0.903) and unique factors ranged from 0.123to 0.437for all the considered 16 morpho-biometric traits. PC1 had high loadings (correlations between the components and the variables) on back length (0.886), head length (0.842) and neck length (0.828). Highest correlation coefficient was observed amongst comb height and comb length (0.950) while lowest was observed amongst wing length and breast girth (-0.014). This finding in this present study agreed with the work of Egena *et al* (2014) [6] who reported low contribution of shank length to PC1 in indigenous Nigerian chickens raised under intensive management.

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