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Phenotypic Variances in 'Djallonke' Sheep reared under Extensive Management System in Tolon District of Ghana

Peter T. Birteeb**, Dickson Donkor
Department of Animal Science, University for Development Studies, Box TL 1882, Tamale, Ghana

Abstract

The study of the phenotypic body traits of the West African Dwarf (Djallonke') sheep in the Tolon District of Ghana is necessary for the attainment of detailed description of this breed. A total of 124 sheep were randomly selected from flocks reared under extensive system by farmers. Biometric traits including live body weight (LW), rump height (RH), height at withers (HW), body length (BL), neck length (NL), ear length (EL) and tail length (TL) were measured, while qualitative traits including coat colour, fur texture and sex were observed. Chi-square and Cramer's V tests revealed that sex was associated with fur texture but not coat colour pattern. Fixed effects of sex and fur texture on biometric traits were tested using GLM, while Principal Component Factor Analysis was used to identify latent factors in body composition. Seven different colour patterns were identified of which white dominated as solid or pairing with brown or black. Male and female sheep were generally similar ($P > 0.05$) in biometric traits except for LW and NL ($P < 0.05$), while animals with smooth fur texture had significantly ($P < 0.05$) higher LW, BL, NL and TL. The overall mean values of 20.73 ± 0.44 kg, 53.26 ± 0.48, 52.79 ± 0.48, 46.95 ± 0.47, 24.29 ± 0.30, 10.61 ± 0.15, and 25.66 ± 0.35 cm were obtained for LW, RH, HW, BL, NL, EL and TL, respectively. Two latent factors (PC's) were extracted to explain a maximum variation of 71.55% with the first PC comprising of RH, HW, BL and TL, which accounted for 52.21% variation to indicate the general body size of the Djallonke' sheep. The second PC seemed to indicate the length of the anterior region. The two PC's could be exploited by researchers and breeders in selection and improvement of the breed.

Keywords: *Body measurements, breed, coat colour, principal component, qualitative traits, WAD*

****Author for Correspondence*** E-mail: bpetert2000@yahoo.com

INTRODUCTION

The sheep industry is a major source of food, income and other animal products that are beneficial to man in improving livelihoods. The lifestyle of humans has improved drastically since the domestication of animals [1]. Sheep, apart from serving as a source of protein in diets, is also kept to play important roles in cultural and social activities [2]. There are many sheep breeds all over the world but the commonest breed in Ghana is the West African Dwarf (Djallonke'), which is famous for its good adaptation to harsh environmental conditions. Recent researches on this breed have been focusing on the exploitations of linear body measurements to understand breed origin, body structure, breed differentiation and characterization [3–5].

Body measurements have been used to evaluate breed performance and to characterize breed of animals. In addition, it has been used as a means of selecting replacement animals [3]. Body size and body shape of sheep can be described using measurements and visual assessments. How those measurements of size and shape relate to the functioning of the individual animal is of paramount importance in livestock production since they affect management decision making [6].

Due to the recent changes in climate, the extensive system of management of livestock exposes animals to the direct effects of various environmental fluctuations, which may affect the phenotypic characteristics of such animals. Climate change has an influence on the nutrition and resistivity of animals to pest and disease infestations. Besides, uncontrolled breeding practised by farmers under the extensive management system has led to gene introgressions, thereby resulting in the eventual dilution of the gene pool of the Djallonke' sheep. Even though the use of visual appraisal as means of assessing and describing animals is an age-long practice, it does not provide distinctive and probabilistic description of variant phenotypes of breeds. Therefore, this research was aimed at studying the phenotypic characteristics of Djallonke' sheep reared under the extensive system of management in Tolon District. The study of the phenotypic body traits of the Djallonke' sheep is necessary for detail description of this sheep breed in the Tolon District of Northern Ghana.

MATERIALS AND METHODS

Study Area and Climate

The Tolon District is located around latitude 9°25' N and longitude 1°03' W, and at altitude 183 m above sea level [7, 8]. The area has a unimodal rainfall pattern which lasts from May to October, with a mean annual rainfall of about 1043 mm. Temperature generally fluctuates between 15 and 42°C with an annual average of about 28.3°C [8].

Data Collection

A total of 124 Djallonke' sheep aged one year or more were randomly sampled from flocks reared under the extensive system by farmers in three selected communities. The parameters measured were live body weight (LW), rump height (RH), height at withers (HW), body length (BL), neck length (NL), ear length (EL) and tail length (TL), while coat colour and fur texture were determined. The bodyweight (kg) of the animals were taken using a mechanical (Camry) hanging scale (of 100 kg maximum capacity). The linear body measurements (LBM's) were taken using a tailor's measuring tape graduated in centimetres. The definitions of anatomical reference points for LBM's and the measurement procedures for all body parameters were done in accordance earlier works in Ethiopia and Ghana [5, 9]. Visual assessments were used in identifying qualitative traits such as; coat colour, fur texture and sex. Animals with rough fur texture were described as those whose coat hairs were attached to each other on the body and appeared uneven, while the smooth fur texture referred to the normal hairs. The following indices were calculated from the mean values of body measurements for each animal, according to the method used on WAD and Yankasa sheep in Nigeria [10]:

Length Index (LI): this is the ratio of the body length to the wither height.

Length Ratio (LR): This is the ratio of the body length to the neck length.

Statistical Analysis

Data obtained was subjected to cross-tabulation to determine if sex was associated with each of fur texture and coat colour. The strengths of the associations were measured using Cramer's V. The distributions of fur texture and coat colour were determined using Chi-square statistics. General Linear Model (GLM) was used to assess the effects of the fixed factors sex, fur texture and colour pattern on the morphological measurements. The GLM model was defined as:

$$BM_{ijk} = \beta_0 + \beta_1 S_i + \beta_2 F_j + \beta_3 C_k + \beta_4 (SF)_{ij} + \beta_5 (SC)_{ik} + \beta_6 (FC)_{jk} + \beta_7 (SFC)_{ijk} + \varepsilon_{ijk}$$

where, BM_{ijk} is the individual biometric trait; β_i are partial regression coefficients (β_0 = overall mean); S_i is the fixed effect of the *i*th sex (i = male, female); F_j is the fixed effect of the *j*th fur texture (j = smooth, rough); C_k is the fixed effect of the *k*th colour category (k = solid colour, pied, tricolour); $(SF)_{ij}$ is the interaction effect of *i*th sex and *j*th fur texture; $(SC)_{ik}$ is the interaction effect of *i*th sex and *k*th colour category; $(FC)_{jk}$ is the interaction effect of *j*th fur texture and *k*th colour category; $(SFC)_{ijk}$ is the interaction effect of sex, fur texture and colour category; ε_{ijk} is the error associated with each record [ε ~N(0,δ)].

Pearson's coefficients of correlation (r) among the various traits were estimated, and then used to run Principal Component Factor Analysis. The purpose of factor analysis is to reduce multiple variables to a lesser number of underlying factors that are being measured by the variables [11]. The new variables are uncorrelated with each other and account for decreasing proportions of the total variance of the original variables. In this study, Kaiser–Meyer–Olkin (KMO) measures of sampling adequacy and Bartlett's Test of Sphericity were computed to test the validity of the factor analysis of the data set. All analysis were done using SPSS version 20 [12].

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RESULTS

Distribution of Qualitative Traits of Djallonke' Sheep

The distribution of the qualitative traits of the present sheep revealed that fur texture was significantly ($P < 0.001$) associated with the sex of animals as most females had smooth fur texture while most males had rough fur texture (Table 1). The Cramer's V of 0.404 indicated a moderate association. Animals in this study were characterized by seven different coat colour patterns which were not equally distributed ($\chi^2 = 87.129$; $P < 0.001$). Most animals had pied colours (brown and white, and black and white) while black-coloured animals were the fewest. There was no association ($P = 0.578$) between coat colour and sex in this Djallonke' sheep. Though all seven coat colour patterns occurred among female animals, the solid black, solid brown and tricolour phenotypes did not occur among males (Table 1).

Table 1: *Distribution of the Qualitative Traits of Djallonke' Sheep.*

Traits	Variant	Male		Female		Both sexes	
		Frequency	%	Frequency	%	Frequency	%
Fur Texture	Smooth	6	4.8	70	56.5	76	61.3
	Rough	20	16.1	28	22.6	48	38.7
	Total	26	21	98	79	124	100
Statistics	Chi-square (P-value)	20.248 (<0.001)				6.323 (0.012)	
	Cramer's V (P-value)	0.404 (<0.001)					
Coat Colour	Black	-	-	2	1.6	2	1.6
	White	6	4.8	19	15.3	25	20.2
	Brown	-	-	7	5.6	7	5.6
	Black and White	9	7.3	27	21.8	36	29.0
	Brown and White	9	7.3	32	25.8	41	33.1
	Black and Brown	2	1.6	5	4.0	7	5.6
	Black and Brown and White	-	-	6	4.8	6	4.8
	Total	26	21.0	98	79.0	124	100
Statistics	Chi-square (P-value)	4.74 (0.578)				87.129 (<0.001)	
	Cramer's V (P-value)	0.196 (0.578)					

P-value = probability with values in parenthesis;

Table 2: *Least Square Means (±S.E.) of Live Weight (kg) and Linear Body Traits (cm) of Djallonke' Sheep as affected by Sex and Fur Texture.*

Body trait	Overall mean	Sex			Fur texture			Colour pattern			
		Male (n=26)	Female (n=98)	P-value	Smooth (n=76)	Rough (n=48)	P-value	Solid colour (n=34)	Pied (n=84)	Tricolour (n=6)	P-value
LW	20.73±0.44	16.86±0.84^{b}	23.04±0.50^{a}	<0.001	22.94±0.63^{a}	18.51±0.62^{b}	0.034	19.93±0.75	20.16±0.55	25.37±1.61	0.404
RH	53.26±0.48	52.33±0.92	53.81±0.55	0.497	54.79±0.69	51.73±0.68	0.073	52.58±0.82	53.16±0.61	55.67±1.76	0.595
HW	52.79±0.48	52.00±0.91	53.26±0.54	0.455	54.13±0.69	51.45±0.67	0.063	52.16±0.81	53.04±0.60	53.69±1.75	0.338
BL	46.95±0.47	45.44±0.89	47.86±0.53	0.120	48.87±0.67^{a}	45.04±0.66^{b}	0.012	45.96±0.79	47.02±0.59	49.67±1.71	0.522
NL	24.29±0.30	21.66±0.56^{b}	25.87±0.33^{a}	<0.001	25.38±0.42^{a}	23.20±0.41^{b}	0.010	24.49±0.50	23.79±0.37	25.67±1.08	0.459
EL	10.61±0.15	10.68±0.28	10.57±0.17	0.780	10.62±0.21	10.60±0.21	0.428	10.58±0.25	10.62±0.19	10.67±0.54	0.649
TL	25.66±0.35	24.49±0.67	26.37±0.40	0.119	26.78±0.51^{a}	24.55±0.49^{b}	0.037	25.15±0.60	25.71±0.44	27.00±1.29	0.778
LI	0.89±0.01	0.88±0.02	0.90±0.01	0.351	0.91±0.01	0.88±0.01	0.371	0.88±0.01	0.89±0.01	0.93±0.03	0.595
LR	1.96±0.02	2.12±0.05^{a}	1.86±0.03^{b}	<0.001	1.95±0.03	1.97±0.03	0.648	1.90±0.04	2.01±0.03	1.93±0.09	0.153

$^{a, b}$*Means with different superscripts in a row differ significantly for sex and fur texture.*

Variabilities in Body Measurements

From the results (Table 2), only the live weight, neck length and length ratio were significantly (P<0.001) influenced by sex, where the ewes (females) were heavier and had longer necks than their male counterparts. Nevertheless the males had higher length ratio. All other traits were statistically similar (P>0.05) for both sexes. The females had higher (absolute) values in all body measurements than males but higher variabilities (as indicated by the S.E.) of all body measurements were rather associated with males. Fur texture also significantly affected live weight, body, neck and tail lengths (Table 2). Animals with smooth fur texture were heavier and had higher values for all linear traits than those with rough fur texture. The coat colour pattern did not have any significant influence on any biometric trait in the present sheep. Considering the body indices, LI showed that relative to height, the present sheep was quite short while LR indicated that relative to neck length, the present sheep was quite longer (Table 2).

Table 3: *Phenotypic Correlations among Linear Body Measurements.*

LW	1.00								
RH	0.67**	1.00							
HW	0.63**	0.94**	1.00						
BL	0.64**	0.59**	0.55**	1.00					
NL	0.60**	0.35**	0.30**	0.49**	1.00				
EL	0.21*	0.45**	0.47**	0.13^{ns}	0.00^{ns}	1.00			
TL	0.43**	0.42**	0.44**	0.32**	0.37**	0.18*	1.00		
LI	0.11^{ns}	-0.26**	-0.36**	0.58**	0.25**	-0.32**	-0.08^{ns}	1.00	
LR	-0.18*	0.07^{ns}	0.10^{ns}	0.22*	-0.73**	0.13^{ns}	-0.16^{ns}	0.15^{ns}	1.00
Trait	LW	RH	HW	BL	NL	EL	TL	LI	LR

******** *Significant at (P < 0.01), * significance at (P < 0.05) and; ^{ns} correlation not significant.*

The Pearson's correlation coefficients were mostly highly significant (P<0.01) and ranged from low to moderate (Table 3). The highest correlation coefficient was obtained between rump and wither heights. Live weight was significantly correlated with all the linear body measurements. The body indices (LI and LR) were mostly negatively correlated or insignificantly correlated with the body measurements.

The KMO statistic (0.734) and Bartlett's Test of Sphericity (x^2 = 413.53; P<0.001) supported the accuracy and the validity of the factor analysis of the data set. Two underlying (PC) factors were extracted to explain a maximum of 71.55% of the total (generalized) variance (Table 4). The first PC which seemed to indicate the general body size (trunk composition) of the sheep had four traits (rump height, body length and tail length) highly loaded on it to explain 52.21% of the total variation. The second PC comprised of neck length and ear length and accounted for 19.34% of the total variance. It seemed to indicate the anterior region. The communalities were generally high except that of tail length (Table 4).

Table 4: *Factor Loadings, Communalities and Explained Variance of Linear Body Measurements of Djallonke Sheep.*

Traits	**Components**		**Communalities**
	1	**2**	
Rump height	0.92	-0.19	0.88
Height at withers	0.91	-0.24	0.88
Body length	0.74	0.33	0.65
Neck length	0.56	0.65	0.73
Ear length	0.49	-0.71	0.74
Tail length	0.61	0.21	0.42
Eigenvalue	3.13	1.16	
Explained variance (%)	52.21	19.34	
Cumulative variance (%)	52.21	71.55	

DISCUSSION

Distribution of the Qualitative Traits of Djallonke' Sheep

Sex is a key determinant of price in livestock marketing as consumers buy animals for specific purposes especially during festive occasions. Fur texture of sheep could also influence price because animals with rough coat might be perceived to be showing signs of ill-health. Meanwhile, the sheep in this study, on the bases of physical appearance, were healthy animals, hence their rough coat could have resulted from exposure to thorny bushes and rains since they were reared under the extensive system. The significant association of fur texture with sex suggest that the underlying cause of rough coat is more conspicuous in males than in females.

The coat colour patterns observed in the present sheep fall within the colours of Djallonke sheep which is usually characterized by coat colours of white, black, red patches or tan with black belly [13, 14]. The present findings agree with the work of researchers in Burkina Faso where they observed colour patterns of white, black, spotted in black, brown and spotted in brown in the Sudan (Djallonke') breeds of sheep [4].

Those researchers observed that animals with colour patterns of spotted in black were the majority with 53.94%, followed by spotted in brown with 23.20% of the population. The proportion for solid white in this study was similar to 20.90% while the proportion for black and white pied was higher than 21.35% reported in WAD sheep in South Western Nigeria [15]. The predominance of white as a solid or pied with other colours may indicate the dominating influence or higher frequency of the underlying allele for white fur. The different colour patterns in the present sheep may be due to uncontrolled breeding since the animals were kept under the extensive management system.

Variabilities in Body Measurements

The higher values of females than males in biometric traits agreed with a general performance record of this breed but disagreed with earlier reports [3, 5, 14, 16]. The present finding may be attributed to the fact that the males that were available and included in this study were mostly growing animals as farmers sold more matured rams during the festive season and/or times when the family needed money. In Nigeria, researchers observed in Ouda sheep that males were higher in linear body measurements but females had higher weights than the males. In a study of on-station sheep in northern Ghana, Djallonke' rams were generally higher in all body measurements than their female counterparts [17, 18]. The average weight of the Djallonke' sheep obtained in this research was much higher than the 16.03 kg obtained in WAD in Nigeria [3]. Weights ranging from 20–35 kg in both sexes were recorded for the same breed in earlier works [13, 14, 19, 20].

The wither height of the present sheep was within the range of 40 to 60 cm which has been reported as the general height of Djallonke' [14, 19]. However, the sheep in this study were slightly shorter in wither height than 54 cm in Djallonke' sheep of Nigeria, and 56.49 cm in Sudan (Djallonke') sheep of Burkina Faso [3, 4]. At the rump, the sheep in this study were slightly shorter than the values of 55.83 and 59 cm for same breed in earlier studies [10, 18, 20]. It was even a very short animal when compared to 66.25 cm of Sahel and 72.57 cm of Yankasa sheep [10, 20]. Researchers reported values of BL, EL and TL to be 54.10, 9.43 and 24.50 cm, respectively [4]. This implied that those sheep were longer than the sheep in this study. But the TL and EL in the present study were higher than those reported in Burkina Faso [4]. The length index of the present Djallonke' sheep was lower than 1.01 and 0.93 for WAD and Yankasa, respectively [10]. This means that in proportion to height, the present sheep was shorter than its WAD counterparts and the Yankasa sheep of Nigeria. The variabilities within the present sheep may be due to environmental factors since the sheep of this study were reared extensively [21]. The variabilities in biometric traits among the different sheep populations, especially the same Djallonke' breed across different geographical locations suggest the differential development of this breed to aid adaptation in different locations.

Correlations among traits are very important in the study of linear body measurements of sheep because they help in determining the magnitude of how one trait affects another. Positive and significant high correlations among the measurements suggest high predictability among the linear body measurements of the Djallonke' sheep. The highest correlation between WH and RH was similarly reported in Djallonke' sheep, Uda sheep and White Fulani cattle [18, 22, 23]. Higher values (0.68 and 0.68) for correlations between BL and RH, and BL and WH were reported in immature Uda sheep in Nigeria [22]. Again, researchers observed a very high correlation (0.91) between live weight and BL in Djallonke' sheep [3]. Higher correlations among body traits are important because they become useful in determination of relatedness of biometric traits as well as in generation of indices that are useful for further analysis.

Principal Component Factor Analysis (PCFA) of body traits in animals helps to determine linear body measurements that cause variation in traits within the same breeds of animals. PCFA has been used to determine body shape in sheep and cattle [18, 22–25]. The high values of the communalities were comparable to earlier reports, and implied that the biometric traits under consideration were important contributors to body variation in Djallonke' sheep [18, 23]. The classification of traits under two factors in the present study agreed with earlier findings in sheep and cattle [18, 22, 23]. The variance accounted for by the first PC in this study was lower than 67.7% recorded in Uda sheep [22]. Similar to the present study, earlier researchers reported that the first factor explained maximum/highest variation [5, 23, 25]. The high loading of the rump height, height at withers, body length and tail length on the first PC is in accordance with other findings in Nigeria [22–23]. These traits are associated with bone development in sheep and so indicate the general body size of the Djallonke' sheep. Thus taller animals will expectedly be longer with longer tails. The two factors obtained could be used to select animals based on a group of variables rather than on isolated traits. These factors could be exploited in breeding and selection programmes to acquire highly coordinated animal bodies using few body components [24]. Animal breeders may target and select animals based on the superiority of the traits on the first factor which will lead to improvement in the body size without necessary influence on anterior structure in Djallonke'.

CONCLUSION

Djallonke' sheep in the Tolon District were characterized by seven coat colour patterns; white, black, brown, white and brown, black and white, black and brown, and brown-black-white with the dominant being brown and white. The fur texture was associated with sex, and the sheep were generally small, standing at 53 cm at the withers and weighing about 20.7 kg. Sex had significant effect on body weight, neck length and length ratio while fur texture had significant effect on body weight, body, neck and tail lengths. Linear body traits were grouped into two principal component factors to explain maximum variation in the Djallonke' sheep and the first component comprising of rump height, height at withers, body and tail lengths seemed to indicate the general body size.

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