

Morphological Characteristics of the Indigenous West African Dwarf Goat in the Four Agro-Ecological Zones in Sierra Leone

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Abstract

Data collected from 230 West African Dwarf (WAD) goats in four agro-ecological zones in Sierra Leone. They consist of 110 males and 120 females classified into five age groups as follows: Kids (below one year), Yearling (1 – 2 years), Young adult (2 – 3 years), Adults (3 – 4 years), Mature (4 - 5 years), and Old (over 5 years). Predefined Adapt Map protocol used to determine the collection of body measurements for Chest (Heart) girth (CG), Height (HW), Body Length (BL), Width of pin bones (PB), Width of points of shoulder bones (SB), Ear length, Horn length and Scrotal circumference using a measuring tape. Body weight measurements obtained using digital hanging scale. Coat color data obtained by visual observation. The data analyzed using Variance Model (ANOVA) procedures of Statistical Analysis System (SAS) version 6.12 Software and post hoc mean separation done using Duncan Multiple Range Test (DMRT). In conclusion, indigenous WAD goats show little morphological variation across agro-ecological zones. Minor variations occur between male and female goats in their respective age groups. Body weights can be predicted from both body length and hearth girths. Therefore urgent need is required to select, multiply and distribute high performing males to many communities nationwide identified with high levels of inbreeding.

Keywords: WAD goats; Agro-ecological zones; Morphological traits.

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1. Introduction

Unlike many countries in the West Africa sub-region, there is limited available data on animal genetic resources in Sierra Leone which is often quite old dating back to the 1960s and 70s. A lot of changes have taken place since then in terms of agro-ecology and management system. The WAD goat is the only indigenous goat breed in Sierra Leone and until recently there has been an increase in crossbreeding of the WAD goat with other breeds obtained from the sub region and beyond.

West African dwarf goat are hardy, small, early maturing, prolific, non-seasonal breeder [1] and plump, measuring less than 50cm in height and weighing between 20 – 25 kg [2] and they are trypanosome tolerant.

West African dwarf goats possess the widest margin for adaptation amongst the ruminants[3] and have quite specific physiological properties that have made them acclimatize in the tropics easily. Their coat colour may vary from white, brown, black and sometimes various combinations of these colours. There could be presence or absence of wattle or beard in the breed. Majority of the studies on the West African dwarf goats were conducted in herds maintained at research stations [4]. Even though the extensive system of husbandry is the commonest type, little effort has been made in a way of characterizing and determining the adaptive and productive potential of these West African dwarf goats under the system. Characterizing the indigenous goats phenotypically is one of the cheapest, indirect and alternative ways of improving their productivity [5].

phenotypic characterization of AnGR is the process of identifying distinct breed populations and describing their external and production characteristics in a given environment and under given management, taking into account the social and economic factors that affect them [6].

The objective of this study is to update information on the morphological characteristics of the indigenous WAD goat in the four agro-ecological zones in Sierra Leone.

2. Methodology

A sample survey was conducted in order to collect primary data from the indigenous goat population (WAD goats) in the four agro-ecological zones in Sierra Leone: Coastal plains (CP); Savanna Woodland (SW); Transitional rainforest (TRF) and Rainforest (RF) in Sierra Leone.

A predefined Adapt Map protocol was used to determine the collection of body measurements for Chest (Heart) girth (CG), Height (HW), Body Length (BL), Width of pin bones (PB), Width of points of shoulder bones (SB), Ear length, Horn length and Scrotal circumference using a measuring tape. Body weight measurements were obtained using a digital hanging scale. Coat color data was obtained by visual observation. A total of 230 goats were sampled consisting of 110 males and 120 females classified into five age groups such as Kids (below one year), Yearling (1 – 2 years), Young adult (2 – 3 years), Adults (3 – 4 years), Mature (4 - 5 years), and Old (over 5 years) [7].

Coat color distribution and the mean body length was measured and recorded. Correlation coefficients (r) between live weight and other body measurement traits were found

The data collected were analyzed with Analysis of Variance Model (ANOVA) procedures of the Statistical Analysis System (SAS) version 6.12 Software. Descriptive summary statistics were calculated and post hoc mean separation done using the Duncan Multiple Range Test (DMRT). Pearson correlation coefficient (r) values for the goat populations across the four ecological zones were also computed using same software to assess the relationship between body measurement traits. Finally, regression analyses were carried out to predict body weights of the goat populations from the various traits measured.

3. Results and discussion

3.1 Morphological characterization

3.2 Coat color

The most frequent coat color was plain black, followed by brown with black spots, plain brown and finally white with spots (Figure 1). The results show the same pattern with respect to coat color between and within these indigenous goat sampled. Similar coat pattern and color were also reported by other researchers in Africa[8, 9,] The color black is reported to have superior adaption to seasonal cold weather or cold nights as the black pigment helps them to warm up earlier than goats with other coat colors[10].

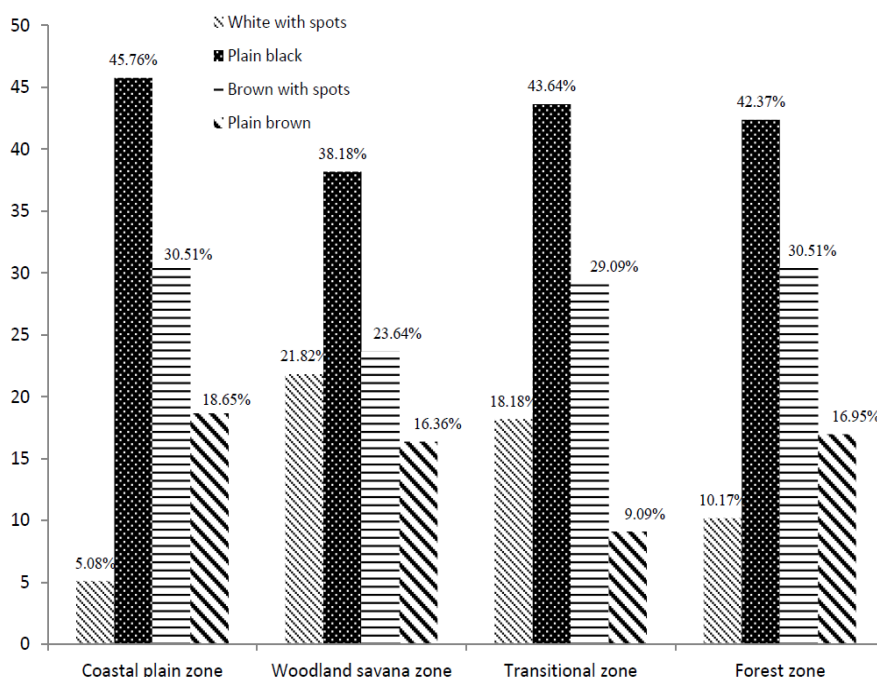


Figure 1: Coat color of goats sampled from the various agro-ecological zones

3.3. Body weight

Average body weight of goats under 1 year and the yearling (between 1 to 2 years) varied significantly ($P < 0.05$) among the male goat populations. The less than 1 year male kid goat (7.56 kg) and yearling (17.78kg) in the woodland savanna were significantly heavier than those from the other three agro-ecological zones (Table 1). There were also significant differences in female under 1 year kid goats, young adults (2 to 3 years) and mature adults (4 to 5 years). For the female under 1 year, kid goats from the woodland savanna were heavier (8.32kg) as compared to those from the other three zones. With respect to the young female adults (2 to 3 years), although goats from transitional zone were heavier (19.1Kg), but there was no significant difference in weight with those from the woodland savanna (17.80kg) (Table 1). Similarly, although mature goats from the forest zone were heavier (31.40Kg), but the differences in weight were not significant in matures goats from the coastal plains in Adonkia, Western area (31.08Kg). Overall mean weights increased with the age of the sampled goats.

Table 1: Descriptive statistics for live body weight measurements for indigenous WAD goats

Variables	Goat ecotypes						P	Overall Mean
	Sex	Age (yr)	AEZ1: Coastal plains (Adonkia Peninsular)	AEZ2: Woodland savanna (Makeni)	AEZ3: Transitional zone (Bonthé)	AEZ4: Forest zone (Kenema)		
Body weight (kg)	Male	Kid: under 1	5.40 ^b	7.56 ^a	5.42 ^b	5.66 ^b	0.0001	6.01
		Yearly :1-2	16.40 ^{ab}	17.78 ^a	15.40 ^b	16.54 ^{ab}	0.0531	16.53
		Young adult:2-3	18.52 ^a	20.04 ^a	18.10 ^a	18.12 ^a	0.1622	18.70
		Adult:3-4	20.14 ^a	25.8 ^a	26.7 ^a	23.28 ^a	0.2067	23.98
		Mature:4-5	26.82 ^a	27.72 ^a	27.58 ^a	29.28 ^a	0.4875	27.85
		Old: over 5	31.6 ^a	-	-	31.02 ^a	0.7810	31.31
	Female	Kid: under 1	5.12 ^b	8.32 ^a	5.16 ^b	5.44 ^b	0.0019	6.01
		Yearly :1-2	14.96 ^{ab}	17.00 ^a	14.86 ^{ab}	14.30 ^b	0.1183	15.28
		Young adult:2-3	15.54 ^b	17.80 ^{ab}	19.18 ^a	15.48 ^b	0.0099	17.00
		Adult:3-4	25.44 ^a	26.12 ^a	25.52 ^a	25.88 ^a	0.9402	25.74
		Mature:4-5	31.08 ^a	27.40 ^b	24.06 ^c	31.40 ^a	0.0006	28.51
		Old: over 5	28.56 ^a	29.40 ^a	28.08 ^a	29.34 ^a	0.7723	28.85
		Adult:3-4	10.00 ^a	10.40 ^a	10.60 ^a	10.80 ^a	0.6515	10.45
		Mature:4-5	10.00 ^b	11.60 ^a	9.80 ^b	9.80 ^b	0.0607	10.30
Old: over 5	10.80 ^a	11.80 ^a	11.40 ^a	11.00 ^a	0.1935	11.00		

Means in the same row followed by the identical superscript are not significantly different from each other at 0.05 (DMRT)

3.4. Ear length

Ear lengths were not significantly different across the age categories among male goats. However, in female goats, there were significant ($P = 0.0001$) differences in ear length in kid goats under 1 year, with ear length being significantly longer (7.80 cm) in goats found in the woodland savanna (Table 2). Average ear length of yearling varied significantly ($P = 0.0396$) among the female goat populations. Although ear length of yearling in the woodland savanna was significantly longer (9.80cm) comparatively, it was not significantly different from goats in the coastal plains (9.60cm) or from goats in the forest zone (Table 2).

Table 2: Descriptive statistics for ear length measurements for indigenous WAD goats

Variables	Goat ecotypes						P	Overall Mean
	Sex	Age (yr)	AEZ1: Coastal plains	AEZ2: Woodland savanna	AEZ3: Transitional zone	AEZ4: Forest zone		
Ear length (cm)	Male							
		Kid: under 1	5.20 ^a	5.60 ^a	5.40 ^a	5.60 ^a	0.8578	5.45
		Yearly :1-2	5.80 ^b	10.00 ^a	7.60 ^{ab}	9.40 ^a	0.0692	8.20
		Young adult:2-3	9.40 ^a	10.40 ^a	10.60 ^a	9.40 ^a	0.1871	9.95
		Adult:3-4	9.60 ^a	10.60 ^a	10.20 ^a	9.20 ^a	0.1704	9.90
		Mature:4-5	10.20 ^a	10.80 ^a	10.40 ^a	10.80 ^a	0.5790	10.55
		Old: over 5	11.60 ^a	-	-	11.80 ^a	0.4502	11.70
	Female							
		Kid: under 1	5.40 ^b	7.80 ^a	5.00 ^b	5.40 ^b	0.0001	5.9
		Yearly :1-2	9.60 ^a	9.80 ^a	8.00 ^b	9.40 ^a	0.0396	9.2
		Young adult:2-3	10.00 ^a	10.80 ^a	10.40 ^a	9.60 ^a	0.2048	10.2
		Adult:3-4	10.00 ^a	10.40 ^a	10.60 ^a	10.80 ^a	0.6515	10.45
		Mature:4-5	10.00 ^b	11.60 ^a	9.80 ^b	9.80 ^b	0.0607	10.30
		Old: over 5	10.80 ^a	11.80 ^a	11.40 ^a	11.00 ^a	0.1935	11.00

Means in the same row followed by the identical superscript are not significantly different from each other at 0.05 (DMRT)

3.5. Horn length

Similar to ear length, differences in horn lengths were not significantly different across the age categories among male goats. However, in female goats, there were significant ($P = 0.0090$) differences in ear length in kid goats under 1 year, with ear length being significantly longer (5.40 cm) in goats found in the transitional zone (Table 3). Average horn length of young adults between 2 to 3 years varied significantly ($P = 0.0022$) among the female goat populations. Horn lengths were significantly longer (9.80cm) in goats from the woodland savanna, but not significantly different from the horn length in goats in transitional zone (9.40cm) (Table 3).

Table 3: Descriptive statistics for horn length measurements for indigenous WAD goats

Variables	Goat ecotypes						P	Overall Mean
	Sex	Age (yr)	AEZ1: Coastal plains (Adonkia Peninsular)	AEZ2: Woodland savanna (Makeni)	AEZ3: Transitional zone (Bonthe)	AEZ4: Forest zone (Kenema)		
Horn length (cm)	Male	Kid: under 1	4.20 ^a	4.80 ^a	4.60 ^a	4.00 ^a	0.2761	4.4
		Yearly :1-2	8.40 ^{ab}	9.20 ^a	7.60 ^b	9.00 ^a	0.0756	8.55
		Young adult:2-3	8.00 ^b	10.20 ^a	8.20 ^{ab}	9.00 ^{ab}	0.1080	8.85
		Adult:3-4	10.60 ^a	9.60 ^a	8.80 ^a	9.60 ^a	0.5514	9.50
		Mature:4-5	10.60 ^a	11.20 ^a	11.20 ^a	10.60 ^a	0.6472	10.90
		Old: over 5	11.60 ^a	-	-	11.80 ^a	0.4810	11.90
	Female	Kid: under 1	3.80 ^b	3.40 ^b	5.40 ^a	4.20 ^b	0.0090	4.2
		Yearly :1-2	7.40 ^a	8.40 ^a	8.40 ^a	8.20 ^a	0.7678	8.1
		Young adult:2-3	7.00 ^b	9.40 ^a	9.80 ^a	7.00 ^b	0.0022	8.3
		Adult:3-4	10.40 ^a	10.60 ^a	10.00 ^a	10.40 ^a	0.7639	10.35
		Mature:4-5	11.20 ^a	11.40 ^a	9.60 ^b	11.00 ^{ab}	0.0815	10.80
		Old: over 5	10.80 ^{ab}	11.80 ^a	10.00 ^b	11.60 ^a	0.0736	11.05

Means in the same row followed by the identical superscript are not significantly different from each other at 0.05 (DMRT)

3.6. Height at Withers

There were also significant ($p < 0.05$) variations in linear body measurements among the goat populations: goat in the transitional zone, with an average height of 53.40 cm (adult), 56.40 cm (mature adult) at withers in males was significantly taller than all goats from the other agro-ecological zones, while female goats from the same agro-ecological zone stated above were the tallest with 53.40 cm (adult) and 57.40cm (mature) height at withers (Table 4). Body size is a suitable criterion for classification since it gives clues to potential performance.

Tropical goats are classified based on body size: large (>65 cm at the withers), small (51 to 65 cm) and dwarf (<50 cm) [11].

Table 4: Descriptive statistics for height at withers measurements for indigenous WAD goats

Variables	Goat ecotypes						P	Overall Mean
	Sex	Age (yr)	AEZ1: Coastal plains (Adonkia Peninsular)	AEZ2: Woodland savanna (Makeni)	AEZ3: Transitional zone (Bonthe)	AEZ4: Forest zone (Kenema)		
	Male	Kid: under 1	40.20 ^a	36.20 ^a	39.00 ^a	39.20 ^a	0.2594	38.65
		Yearly :1-2	47.40 ^a	45.40 ^a	50.00 ^a	47.20 ^a	0.1929	47.50
		Young adult:2-3	47.20 ^a	49.80 ^a	48.00 ^a	46.20 ^a	0.4952	47.80
		Adult:3-4	47.00 ^b	48.00 ^b	53.40 ^a	48.20 ^b	0.0214	49.15
		Mature:4-5	50.00 ^{bc}	52.40 ^b	56.40 ^a	49.40 ^c	0.0005	52.05
		Old: over 5		-	-		0.4502	48.80
	Female	Kid: under 1	39.20 ^a	39.80 ^a	38.60 ^a	38.60 ^a	0.7399	39.05
		Yearling :1-2	46.60 ^a	50.00 ^a	50.00 ^a	47.20 ^a	0.3830	48.45
		Young adult:2-3	49.00 ^a	54.20 ^a	47.40 ^a	47.20 ^a	0.1312	49.45
		Adult:3-4	44.80 ^b	45.80 ^b	53.40 ^a	47.20 ^b	0.0054	47.80
		Mature:4-5	50.20 ^b	55.40 ^a	57.40 ^a	49.60 ^b	0.0152	53.15
		Old: over 5	49.60 ^c	62.60 ^a	60.00 ^b	50.00 ^c	0.0001	55.55

Means in the same row followed by the identical superscript are not significantly different from each other at 0.05 (DMRT)

3.7. Heart girth

The heart girth of male goat from the woodland savanna in northern Sierra Leone was significantly ($P = 0.0586$) larger in under 1 year kid goat (34.40cm) than those from the other agro-ecological zones, with the exception of goat in the transitional zone (Table 5). The result is also true for young adult and adult male goats. Among the female goat population, there were significant differences in kid goats under 1 years ($P = 0.0015$), young adults ($P = 0.0195$) and adults ($P = 0.0015$). Like the results for the male goats, heart girths in female goats from both the woodland and transitional agro-ecological zones were not significantly different from each other (Table 5).

Table 5: Descriptive statistics for heart girth measurements for indigenous WAD goats

Variables	Goat ecotypes						P	Overall Mean
	Sex	Age (yr)	AEZ1: Coastal plains (Adonkia Peninsula r)	AEZ2: Woodland savanna (Makeni)	AEZ3: Transitional zone (Bonthe)	AEZ4: Forest zone (Kenema)		
Hearth girth (cm)	Male	Kid: under 1	33.60 ^{ab}	34.40 ^a	34.00 ^a	31.60 ^b	0.0586	33.40
		Yearly :1-2	58.00 ^a	61.40 ^a	60.80 ^a	56.80 ^a	<i>0.1890</i>	59.25
		Young adult:2-3	49.80 ^b	59.00 ^a	58.40 ^a	50.40 ^b	0.0283	54.40
		Adult:3-4	55.60 ^b	62.20 ^a	60.60 ^{ab}	55.60 ^b	0.0476	58.50
		Mature:4-5	59.40 ^a	59.20 ^a	60.40 ^a	59.40 ^a	<i>0.9482</i>	59.60
		Old: over 5	48.80 ^a	-	-	48.80 ^a	<i>0.7810</i>	63.70
	Female	Kid: under 1	37.80 ^a	38.80 ^a	33.40 ^a	33.20 ^a	0.0015	35.80
		Yearly :1-2	54.60 ^a	58.20 ^a	60.20 ^a	54.40 ^a	<i>0.3330</i>	56.85
		Young adult:2-3	54.20 ^b	62.80 ^a	57.40 ^{ab}	54.80 ^b	0.0195	57.30
		Adult:3-4	57.40 ^a	59.60 ^a	58.80 ^a	49.00 ^b	0.0015	56.20
		Mature:4-5	59.40 ^a	56.80 ^a	58.40 ^a	58.80 ^a	<i>0.6984</i>	58.35
		Old: over 5	61.40 ^a	57.00 ^b	57.80 ^{ab}	61.80 ^a	0.0499	59.50

Means in the same row followed by the identical superscript are not significantly different from each other at 0.05 (DMRT)

3.8. Scrotal circumference

Table 6: Descriptive statistics for scrotal circumference measurements for indigenous WAD goats

Variables	Goat ecotypes						P	Overall Mean
	Sex	Age (yr)	AEZ1: Coastal plains (Adonkia Peninsular)	AEZ2: Woodland savanna (Makeni)	AEZ3: Transitional zone (Bonthe)	AEZ4: Forest zone (Kenema)		
Scrotal circumference	Male	Kid: under 1	8.40 ^{bc}	10.20 ^a	9.40 ^{ab}	7.80 ^c	0.0025	8.95
		Yearly :1-2	17.00 ^a	18.80 ^a	13.60 ^b	17.40 ^a	0.0024	16.70
		Young adult:2-3	19.60 ^a	20.00 ^a	18.40 ^a	19.00 ^a	<i>0.6636</i>	19.25
		Adult:3-4	20.80 ^a	21.80 ^a	20.80 ^a	20.20 ^a	<i>0.3213</i>	20.90
		Mature:4-5	20.40 ^b	22.60 ^a	21.20 ^{ab}	21.20 ^{ab}	<i>0.1049</i>	21.35
		Old: over 5	22.20 ^a	-	-	21.80 ^a	<i>0.6502</i>	22.00

There were significant differences in scrotal circumference in kid goats ($P = 0.0025$) and yearling ($P = 0.0024$); with goats from the woodland savanna having the largest scrotal circumference (10.20cm). In the yearlings, goats from the transitional zone had the smallest scrotal circumference (13.60cm); whilst, no significant differences were observed in the scrotal circumferences of goats from the other agro-ecological zones (Table 6).

Means in the same row followed by the identical superscript are not significantly different from each other at 0.05 (DMRT)

3.9. Shoulder point

In the male goat population, there were significant differences in shoulder points in adults ($P = 0.0441$) and mature ($P = 0.0001$); with goats from the woodland savanna having the widest shoulder points, though not significantly different from the shoulder points of goats from the transitional zone (Table 7). Similar results were also observed in female goats, with significant differences in shoulder points in kids ($P = 0.0011$), young adults ($P = 0.0489$), adults ($P = 0.0079$), mature ($P = 0.0001$) as well as those over 5 years old ($P = 0.0001$) (Table 7). Again, goats from the woodland savanna predominate; though not significantly different from female goats from the transitional zone (Table 7).

Table 7: Descriptive statistics for shoulder point measurements for indigenous WAD goats

Variables	Goat ecotypes						P	Overall Mean
	Sex	Age (yr)	AEZ1: Coastal plains (Adonkia Peninsular)	AEZ2: Woodland savanna (Makeni)	AEZ3: Transitional zone (Bonthe)	AEZ4: Forest zone (Kenema)		
Shoulder point (cm)	Male	Kid: under 1	7.00a	7.80a	6.60a	7.00a	0.2106	7.10
		Yearly :1-2	13.00a	13.20a	13.80a	13.60a	0.5723	13.40
		Young adult:2-3	13.20a	14.20a	12.80a	13.40a	0.2217	13.40
		Adult:3-4	12.60c	15.80a	15.20ab	13.20bc	0.0441	14.20
		Mature:4-5	14.60b	20.80a	22.20a	14.80b	0.0001	18.10
		Old: over 5	13.40a	-	-	14.00a	0.7850	13.70
	Female	Kid: under 1	8.00b	9.40b	6.20c	8.00b	0.0011	7.90
		Yearly :1-2	12.80a	13.40a	13.00a	12.60a	0.6649	12.95
		Young adult:2-3	12.80ab	13.40a	13.80a	11.80b	0.0489	12.95
		Adult:3-4	11.80b	14.00a	14.00a	11.60b	0.0079	12.85
		Mature:4-5	13.60b	20.80a	22.00a	14.00b	0.0001	17.60
		Old: over 5	12.60b	21.40a	20.80a	12.80b	0.0001	16.90

Means in the same row followed by the identical superscript are not significantly different from each other at

0.05 (DMRT)

3.10. Pin bone width

The results for pin bone width are similar to those already reported for the shoulder point. In male goats, there were significant differences in young adults ($P = 0.0087$) and mature goats ($P = 0.0090$). In female goat population, significant ($P < 0.05$) differences were observed in all age categories with the exception of adult aged 3 to 4 years (Table 8).

Table 8: Descriptive statistics for pin bone width measurements for indigenous WAD goats

Variables	Goat ecotypes						P	Overall Mean
	Sex	Age (yr)	AEZ1: Coastal plains (Adonkia Peninsular)	AEZ2: Woodland savanna (Makeni)	AEZ3: Transitional zone (Bonthe)	AEZ4: Forest zone (Kenema)		
Pin bone width (cm)	Male	Kid: under 1	12.80ab	13.40a	12.00b	11.80b	0.0786	12.50
		Yearly :1-2	15.20a	16.20a	16.40a	15.60a	0.4147	15.85
		Young adult:2-3	18.80a	18.20a	16.00b	18.20a	0.0087	17.80
		Adult:3-4	19.80a	19.80a	18.40a	19.40a	0.2589	19.35
		Mature:4-5	20.60b	21.40b	24.20a	20.40b	0.0090	21.65
		Old: over 5	20.20a	-	-	20.00a	0.2513	20.10
		Female	Kid: under 1	13.00b	15.00a	12.00b	11.80b	0.0034
	Yearly :1-2		19.20a	19.60a	14.60b	15.80b	0.0001	17.30
	Young adult:2-3		19.80a	20.00a	16.80b	19.60b	0.0012	19.05
	Adult:3-4		19.20a	18.80a	17.80a	19.20a	0.6234	18.75
	Mature:4-5		19.60b	23.40a	25.00a	20.40b	0.0002	22.10
	Old: over 5		18.60b	22.40a	20.80ab	18.60b	0.0065	20.10

Means in the same row followed by the identical superscript are not significantly different from each other at 0.05 (DMRT)

3.11. Body length

The body length of male goat from the woodland savanna was significantly different ($P = 0.0203$) for kid goat (34.80cm) than those from the other agro-ecological zones, with the exception of goat in the transitional zone (Table 9). But for young adults, goats from the transitional zone had a significantly larger body length (56.00cm). Among the female goat population, there were significant differences in kid ($P = 0.0057$), yearling

($P = 0.0045$), young adults ($P = 0.0019$) and adults over 5 years ($P = 0.0001$). Like the results for the male goats, body length in female goats from both the woodland and transitional agro-ecological zones were not significantly different from each other (Table 9).

The results of the body length and body weight seems to correspond with each other, and it had been reported that heart girth and live body weight show that the body weight of goats can be predicted from heart girth measurements of goats, which is in agreement with other findings[12,13,14] (Sowande and his colleagues 2010; Cam and his colleagues 2010 Khan H, Muhammed, 2006).

Table 9: Descriptive statistics for body length width measurements for indigenous WAD goats

Variables	Goat ecotypes						P	Overall Mean
	Sex	Age (yr)	AEZ1: Coastal plains (Adonkia Peninsular)	AEZ2: Woodland savanna (Makeni)	AEZ3: Transitional zone (Bonthé)	AEZ4: Forest zone (Kenema)		
Body length (cm)	Male	Kid: under 1	31.40ab	34.80a	34.80a	29.00b	0.0203	32.50
		Yearly :1-2	47.60c	52.20b	56.00a	46.00c	0.0001	50.45
		Young adult:2-3	47.40a	47.60a	51.40a	47.60a	0.3787	48.50
		Adult:3-4	51.60b	50.20b	59.40a	44.20c	0.0002	51.35
		Mature:4-5	54.60ab	53.40b	59.60a	53.20b	0.0882	55.25
		Old: over 5	52.00a	-	-	51.80a	0.4702	51.90
	Female	Kid: under 1	40.00a	40.60 ^a	34.00 ^b	35.80 ^b	0.0057	37.60
		Yearly :1-2	48.60 ^b	49.80 ^b	54.60 ^a	45.60 ^b	0.0045	49.65
		Young adult:2-3	45.60 ^b	51.40 ^a	54.60 ^a	46.00 ^b	0.0019	49.40
		Adult:3-4	57.00 ^a	57.00 ^a	58.20 ^a	59.60 ^a	0.3609	57.95
		Mature:4-5	54.20 ^a	55.40 ^a	59.00 ^a	53.40 ^a	0.1745	55.50
		Old: over 5	51.00 ^c	61.40 ^a	59.80 ^a	54.60 ^b	0.0001	56.70

Means in the same row followed by the identical superscript are not significantly different from each other at $p < 0.05$ (DMRT)

3.12. Relationship between body weight and other body measurements

The correlation coefficient analyses were carried out in the present study to figure out and establish the relationship between live body weights with other body measurement traits of goat populations found in Sierra Leone (Table 10). Accordingly, correlation coefficients (r) between live weight and other body measurement traits were found positive with the presence of highly significant ($P = 0.0101$) association of body weight with body length ($r = 0.9899$), and a negative non-significant ($P = 0.2965$) association of body weight with heart girth ($r = 0.7035$) for male goats. Moreover, a highly non-significant r -values were also obtained for the female goats as indicated in Table 10. The present high correlations between heart girth and live body weight show that the body weight of goats can be predicted from heart girth measurements of goats, which is in agreement with other finds[12,13,15]. Results of the linear regression analyses of body weight with heart girth showed a moderately high relationship between these variables with a coefficient of determination values of $R^2 = 0.783$; $y = 1.0628x + 32.776$ and $R^2 = 0.6548$; $y = 0.8032x + 37.751$ for the male and female goats, respectively (Figure 1). The regression between body weight and body length was also significant at $R^2 = 0.7687$; $y = 0.7789x + 32.178$ and $R^2 = 0.9151$; $y = 0.797x + 35.008$, for male and female goats, respectively (Figure 1). These findings indicate that an increase of one cm of heart girth or body length resulted in an increase of 1.0628 and 0.7789 kg of live weight, respectively, for male goats and similarly, an increase of one cm of heart girth or body length resulted in an increase of 0.8032 and 0.797 kg of live weight, respectively, for female goats. These results are in line with findings on goats elsewhere[16,17,]. The high and significant correlation coefficient between body weight with heart girth and body length suggest that either of these variables or their combination would provide a good estimator for predicting live body weight in the various agro-ecological zones of Sierra Leone, especially in areas where weighing scale is not available. Moreover, such relatively high relationship of heart girth with weight could be used as a proxy to estimate live body weight for indigenous goats for countries like Sierra Leone where formal breed data recording schemes are not well established. In general, such assessment of body measurements in goats remains very important for avoiding the errors of visual determination of animal weights in areas where weighing balance cannot be assessed

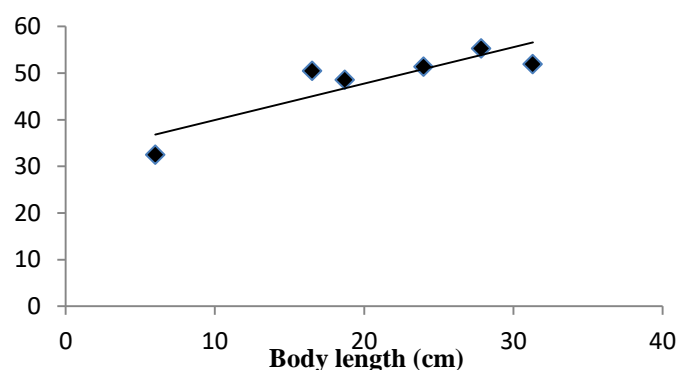


Figure 2

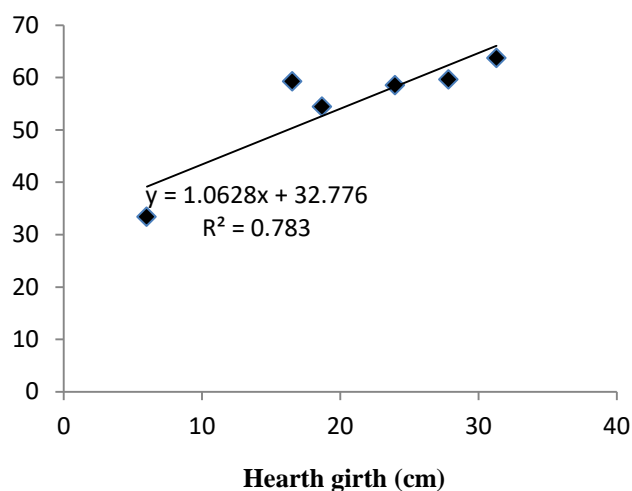


Figure 3

4. Conclusions

- Coat color distribution was observed to be solid black (42.48%); brown with spots (28.43%); brown (15.27%) and white with spots (13.81%).
- There was no significant difference between male and female goats in all age categories in body length, heart girth, ear length, horn length, scrotal circumference, shoulder point and pin bone width.
- The presence of high correlations between body length, heart girth and live body weight shows that the body weight of goats can be predicted from body length and heart girth measurements. Body weights can be reliably predicted from both body length and hearth girths.
- In conclusion, the indigenous WAD in Sierra Leone shows little morphological variation across agro-ecological zones.
- Minor variations occur between male and female goats in their respective age groups. However, more females than male goats were available especially so for the higher age groups. Male goats are most often slaughtered either for sale of meat or in traditional ceremonies.

5. Recommendation

- Goat breeding programme should be urgently established to make breeding bucks available to goat rearing communities. This is to minimize the effect of inbreeding in the goat population in the country.

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6. Author Contribution Statement

Dr. Abdulrahman Sesay, Dr. Sanpha Kallon and Student(Brima Turay) carried out the experiment, analyzed the data and wrote the manuscript : Dr. Abdul Rahman Sesay and Dr. Sanpha Kallon, and Dr. Vector Patrick Bagla designed the study, planned the experiment protocol, supervised the findings of this work and corrected the manuscript; Dr. Sanpha Kallon contributed to the supervision of the findings. All authors discussed the results and contributed to the final manuscript

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