



Phenotypic Characterization Of West African Dwarf (WAD) Goats In Ebonyi State, Southeast Nigeria.

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ABSTRACT

The objective of this study was to phenotypically characterize goats in Ebonyi State, Southeast Nigeria, based on some measured traits. Records were taken on a total of 372 goats (151 males and 221 females) kept by traditional farmers, covering six out of thirteen Local Government Areas (LGAs), two from each of the three senatorial districts of the State. In each LGA, 15 farmers were randomly selected, and measurements were taken of a random sample of 2-5 goats depending on the flock size. Categorical traits scored were coat type and texture, coat colour, presence or absence of horn, horn type and orientation, presence or absence of wattle, presence or absence of supernumerary teat, sex and age of each animal, which were also recorded. Body weight and linear body measurements were recorded for each animal. Categorical traits were analyzed using simple percentages. Linear body measurements were correlated with body weight and with each other. Regression equations for prediction of body weight from linear body measurements were estimated for sex and age of the goats. The categorical traits of goats studied conform to the breed characteristics of the WAD goats. The predominant coat colour of the goats was all black/predominantly black (43.55%). The coat type was stiff, short, and straight type. There were no incidences of polledness among the goat population. Only 5.9% of goats in Ebonyi State had wattles. The body measurements of the goat population in the study area were within the reported ranges for WAD goats by several authors.

Keywords: Phenotype, characterization, sex, goats, traits

INTRODUCTION

Goats are among the most important livestock species in developing countries because of their adaptability, low maintenance requirements, short generation interval, and ability to thrive under diverse environmental conditions (FAO, 2019; Melesse *et al.*, 2021). In Nigeria, goats constitute a major component of the livestock subsector and play a critical role in food security, poverty alleviation, income generation, and socio-cultural activities, particularly among rural households (Yakubu *et al.*, 2019; Adebambo *et al.*, 2024). With an estimated population exceeding 88 million heads, Nigeria possesses one of the largest goat populations in Africa, dominated by indigenous breeds such as the West African Dwarf, Red Sokoto, and Sahel goats (FAOSTAT, 2023; Adebambo *et al.*, 2024). These indigenous goats contribute substantially to the supply of animal protein through meat production while also providing skins, manure, savings, and insurance against economic shocks for smallholder farmers (Banerjee *et al.*, 2020; Berihulay *et al.*, 2019). The sustainability of goat production in tropical environments is largely attributed to the unique adaptive characteristics possessed by indigenous genetic resources. Nigerian indigenous goats are known for their tolerance to heat stress, resistance to endemic diseases and parasites, ability to utilize poor-quality feed resources, and capacity to survive under extensive management systems (Mdladla *et al.*, 2017; Talebi *et al.*, 2020; Adebambo *et al.*, 2024). These adaptive traits have evolved through years of natural and artificial selection, making indigenous goat populations valuable

reservoirs of genetic diversity for present and future breeding programmes (Mrode *et al.*, 2019; FAO, 2019).

Characterization of animal genetic resources is an essential prerequisite for their sustainable utilization, improvement, and conservation (FAO, 2019; Gamaniel and Gwaza, 2017). Phenotypic characterization, which involves the assessment of qualitative and quantitative traits such as coat colour, horn characteristics, ear orientation, body dimensions, and body conformation, remains the first step in breed identification and classification (Muchenje *et al.*, 2017; Hagan *et al.*, 2021). Information generated from phenotypic characterization provides baseline data for understanding within- and between-population variation, identifying unique genetic resources, and establishing breeding objectives aimed at improving productivity without compromising adaptability (Mdladla *et al.*, 2017; Berihulay *et al.*, 2019; Ojango *et al.*, 2019). In recent years, increasing attention has been directed toward the characterization and conservation of indigenous livestock genetic resources due to concerns about genetic erosion arising from indiscriminate crossbreeding, changing production systems, urbanization, and climate change (FAO, 2019; Mrode *et al.*, 2019; Adebambo *et al.*, 2024). The loss of locally adapted genotypes represents a significant threat to livestock biodiversity and may reduce the capacity of production systems to respond to emerging environmental and market challenges (Melesse *et al.*, 2021; Talebi *et al.*, 2020). Consequently, accurate documentation of indigenous goat populations has become a priority in many developing countries, including Nigeria (Yakubu *et al.*, 2019; Ojango *et al.*, 2019).

Ebonyi State, located in southeastern Nigeria, is characterized by a predominantly agrarian economy where goat production forms an integral part of mixed crop-livestock farming systems. Goats in the state are reared mainly under extensive and semi-intensive management systems and contribute significantly to household nutrition and income generation. Despite their importance, information on the phenotypic diversity and population structure of goats in Ebonyi State remains limited compared with reports from other regions of Nigeria (Yakubu *et al.*, 2019; Adebambo *et al.*, 2024). The paucity of detailed characterization data constrains the identification of distinct populations and limits opportunities for the development of evidence-based breeding and conservation programmes. Furthermore, increasing movement of animals across regions, uncontrolled mating practices, and changing management systems may facilitate genetic admixture and gradual loss of unique adaptive traits within local goat populations (Berihulay *et al.*, 2019; Mrode *et al.*, 2019). Given the economic significance of goats and the growing concern over the conservation of animal genetic resources, there is a need to document and evaluate the phenotypic characteristics of goats reared in Ebonyi State. Such information will contribute to the establishment of baseline data for breed improvement, conservation planning, and sustainable utilization of indigenous goat genetic resources. The findings will also support national and global efforts aimed at safeguarding livestock biodiversity while enhancing productivity, resilience, and food security in smallholder production systems (FAO, 2019; Ojango *et al.*, 2019; Adebambo *et al.*, 2024).

MATERIALS AND METHODS

Study Area

The study was conducted in Ebonyi State, located in the southeastern geopolitical zone of Nigeria (latitude 5°40'–6°45'N; longitude 7°30'–8°30'E). The state is characterised by a humid tropical climate with a bimodal rainfall pattern, high relative humidity, and mean annual temperatures ranging from 26 to 32°C.

There are thirteen Local Government Areas (LGAs) in the State. The State is also divided into three senatorial zones, namely: Ebonyi North, comprising Abakaliki, Ebonyi, Ishielu, Ohaukwu and Izzi LGAs; Ebonyi Central, made up of Ikwo, Ezza North and Ezza South LGAs; and Ebonyi South, made up of Afikpo North, Afikpo South, Ivo, Ohaozara and Onicha LGAs.

Agriculture is the dominant occupation of the rural population, with the cultivation of rice, yam, cassava, maize, and legumes being widely practiced. Livestock production is also an important component of the farming system, with goats, sheep, poultry, pigs, and cattle commonly reared under extensive and semi-intensive management systems. The widespread distribution of goats across the state and their importance to rural livelihoods make Ebonyi State a suitable location for studies on the phenotypic characterization of indigenous goat genetic resources (FAO, 2019; NIPC, 2025).

Data Collection

Data were collected from 372 randomly selected indigenous goats sampled across six Local Government Areas (LGAs) of Ebonyi State, Nigeria. Two LGAs were randomly selected from each of the three senatorial districts, giving a total of six LGAs. Within each selected LGA, approximately 15 goat farmers were randomly chosen, and between two and five goats were sampled per flock depending on flock size. During data collection, animals were properly restrained, and measurements were recorded with the assistance of trained personnel.

The age of each goat was determined using dentition according to the procedure described by Makita et al. (1992). Animals with eight milk incisors were classified as yearlings, while the eruption of two, four, six, and eight permanent incisors corresponded to age ranges of 1-2, 2-3, 3-4, and 4-5 years, respectively. Animals older than five years were identified based on the degree of tooth wear. For subsequent analyses, goats were further grouped into two age classes: kids (<15 months; milk-teeth stage) and adults (≥15 months; permanent incisor stage), following Makita *et al.* (1992).

Phenotypic characterization was carried out using both quantitative and qualitative traits following the guidelines of the Food and Agriculture Organization (FAO, 2012) and recent livestock characterization studies (Hagan et al., 2021; Yakubu et al., 2019). Quantitative traits measured included body length (BL), heart girth (HG), height at withers (HAW), and hip width (HW). Measurements were taken using a flexible measuring tape and a metre rule while animals were standing on a flat surface in a normal posture. Pregnant does were excluded from measurement to minimize variation associated with physiological changes during gestation.

Qualitative traits were assessed through visual observation and included coat colour, coat type, coat texture, horn presence, horn shape, horn orientation, ear orientation, presence or absence of wattles, presence or absence of beard, and sex of the animal. These traits were recorded to evaluate phenotypic diversity and facilitate the characterization of indigenous goat genetic resources in the study area.

Data Analysis

Descriptive statistics (means, standard deviations, ranges) were computed for all quantitative traits stratified by sex. Pearson correlation coefficients among body weight and linear body measurements were computed and evaluated for significance at $p < 0.01$. Data were analysed using SPSS version 26.0 (IBM Corp., 2020).

Results and Discussion

Coat Type and Hair Characteristics

All goats examined in this study exhibited a uniformly short, stiff, and straight hair coat. In sexually mature males, this characteristic was particularly pronounced along the dorsal mane extending from the neck to the tail region. The predominance of short hair coats among goats in Ebonyi State is indicative of adaptation to the humid tropical environment. Coat characteristics are important adaptive traits because they influence heat exchange, thermoregulation, and overall animal performance. Indigenous goat populations in tropical

environments typically possess short hair coats that facilitate heat dissipation and reduce thermal stress. Similar observations have been reported in Nigerian and West African indigenous goats, where coat type has been identified as an important component of environmental adaptation and resilience (Daramola and Adeloye, 2009, Yakubu *et al.*, 2019; Melesse *et al.*, 2021; Adebambo *et al.*, 2024). This coat morphology reduces the insulating barrier between the skin and the ambient environment, thereby enabling more efficient sensible heat loss, a mechanism especially relevant in environments with elevated temperature-humidity indices (Gupta & Mondal, 2021).

Mean body hair length was 2.97 ± 0.61 cm in males ($n = 151$), 3.00 ± 0.63 cm in females ($n = 221$), and 2.98 ± 0.62 cm in the combined population. Brisket hair length in males averaged 9.90 ± 1.03 cm. The consistency of coat type across the sampled population is indicative of a shared adaptive phenotype rather than deliberate artificial selection, consistent with the observation that coat attributes in traditional goat populations reflect long-term natural selection under local ecological pressures (Abioja *et al.*, 2022; Sesay *et al.*, 2022). Coat type, as an adaptive morphological feature, may indirectly influence body weight through its role in thermal balance and, consequently, in nutrient partitioning toward productive processes.

Coat Colour Distribution

Coat colour is among the most taxonomically informative and farmer-recognized qualitative traits in goat populations (Oseni *et al.*, 2017). In the present study, coat colours were highly variable, encompassing all-black, all-brown, all-white, and various bicolour and mixed phenotypic classes (Table 1). The pattern of pigmentation across individuals was irregular, with both spotted and speckled animals observed. No significant sex difference in coat colour frequency was detected, which is consistent with the autosomal inheritance patterns governing coat colour in goats.

The extensive variation in coat colour demonstrates the existence of substantial phenotypic diversity within the goat population of Ebonyi State. Such diversity is characteristic of indigenous populations maintained under traditional management systems where mating is largely uncontrolled, and selection is based primarily on adaptation and survival rather than breed standards. Similar findings have been reported for West African Dwarf goat populations across southern Nigeria and other parts of West Africa (Yakubu *et al.*, 2019; Hagan *et al.*, 2021).

All-black or predominantly black animals constituted the most prevalent colour class (43.55%), followed by all-brown or predominantly brown (28.23%). All-white or predominantly white animals accounted for 11.02%, while the remaining proportions comprised bicolour (black and white: 5.91%; brown and white: 4.84%; black and brown: 3.76%) and mixed colour (2.69%) phenotypes (Table 1). The predominance of black coat colour in this population corroborates findings reported for WAD goats in southwestern Nigeria (Odubote, 1994; Oseni *et al.*, 2006) and is consistent with broader documentation of WAD goat populations in Ghana, where dark pigmentation was most frequently recorded (Ofori *et al.*, 2021).

The prevalence of black coat colour has significant physiological implications in tropical environments. Darker coat pigmentation increases the absorption of solar radiation, elevating the heat load on animals and potentially impairing metabolic efficiency (Hashem *et al.*, 2023; Gerken, 2024). Recent experimental evidence demonstrates that black-coated WAD goats exhibit significantly higher rectal temperatures, respiratory rates, and impaired haematological parameters compared to lighter-coated conspecifics under equivalent thermal challenge conditions (Adedeji, 2022).

The wide variability in coat colour distribution observed in the Ebonyi State population strongly suggests the absence of systematic selection pressure and a prevalence of indiscriminate mating within the traditional production system. This is consistent with the assessment of WAD goat populations elsewhere in Nigeria, where coat colour polymorphism

has been interpreted as indicative of an outbred, traditionally managed gene pool (Okoro *et al.*, 2023).

Incidence of Wattles

Wattles are paired integumental appendages arising from the ventral neck region, whose occurrence in goats is controlled by a dominant autosomal gene (Kefelegn *et al.*, 2019). In the current study, wattle incidence was low and exclusively of the bilateral type, with a combined incidence of 5.9% across both sexes (Table 1). Specifically, 5.96% of males (9/151) and 5.88% of females (13/221) carried bilateral wattles, with mean wattle lengths of 2.52 ± 0.19 cm and 2.60 ± 0.16 cm, respectively. The absence of a significant sex difference in wattle occurrence is consistent with the autosomal dominant mode of inheritance of this trait. The low wattle prevalence observed in the present study is consistent with earlier reports for WAD goats in Nigeria (Odubote, 1994) and aligns with observations in Tswana goats, where wattles were similarly reported as an occasional phenotypic feature (Nsoso *et al.*, 2004). However, the current estimate differs considerably from those reported for WAD goats in southwestern Nigeria, where incidence rates of up to 63% have been documented (Oseni *et al.*, 2006). Such discrepancies likely reflect genuine population-level genetic variation between geographically separated flocks, differences in sampling strategy, and the potential influence of uncharacterized environmental or founder effects in each population. Phenotypic characterization studies across multiple WAD goat populations in West Africa confirm that wattle incidence varies substantially by geographic origin, reinforcing the view that the WAD goat encompasses a genetically heterogeneous assemblage of local ecotypes rather than a single homogeneous breed (Okoro *et al.*, 2023; Sesay *et al.*, 2022).

Table 1: Distribution of coat colour phenotypes and wattle incidence among WAD goats in Ebonyi State, southeastern Nigeria.

Coat colour	No. of Animals	Percentages	Mean $\pm$ SEM (cm)
All black/predominantly black	162	43.55	-
All brown/predominantly brown	105	28.23	-
All white/predominantly white	41	11.02	-
Black and white	22	5.91	-
Black and brown	14	3.76	-
Black and white	18	4.84	-
Mixed Colours	10	2.69	-
Total	372	100	-
Incidence of Wattle			
Male	9 (n=151)	5.96	2.52 $\pm$ 0.19
Female	13 (n=221)	5.88	2.60 $\pm$ 0.16
Combined sexes	22 (n=372)	5.90	2.57 $\pm$ 0.12

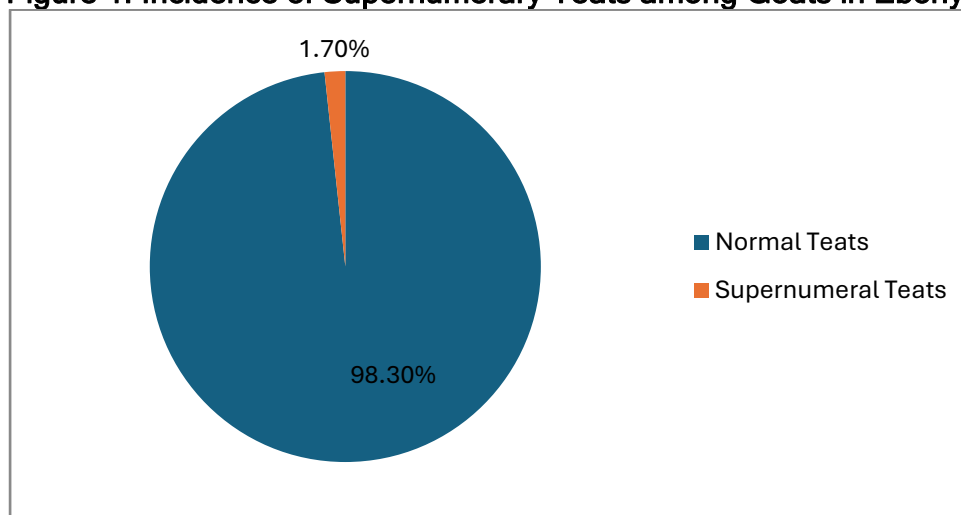
Supernumerary Teat Incidence

Figure 1 shows the incidence of supernumerary teats on the goats examined. Of the 221 adult female goats examined, 98.3% (218 animals) possessed the normal bilateral teat configuration. Only three animals (1.7%) exhibited supernumerary teats, in each case comprising two additional accessory teats. This low incidence suggests either that the trait arises sporadically from somatic mutation or that selective disadvantage within the population constrains its frequency. The present finding is broadly consistent with the characteristically low supernumerary teat incidence documented in other WAD goat populations (Odubote, 1994; Amao *et al.*, 2003).

Presence of supernumerary teats may constitute a functional liability in mechanized milking operations and can complicate udder health management. Although some traditional farmers associate the presence of extra teats with enhanced reproductive performance or prolificacy, this belief remains anecdotal and has not been substantiated empirically. Breeding

programmes targeting genetic improvement of milk production in WAD goats should consider the inclusion of teat conformation as a selection criterion, particularly where the application of milking equipment is anticipated (Amao *et al.*, 2003). Given the very low prevalence of supernumerary teats in the current population, however, this trait does not represent an immediate management concern under traditional extensive husbandry.

Figure 1. Incidence of Supernumerary Teats among Goats in Ebonyi State



Horn Morphology

All 372 animals in the study were horned; no polled individuals were identified. This finding is consistent with earlier characterisation studies of WAD goats across West Africa, in which universal hornedness was reported (Odubote, 1994; Sesay *et al.*, 2022). The complete absence of polledness in the study population is notable from a genetic standpoint. Polledness in domestic goats is genetically linked to the polled intersex syndrome (PIS), a condition caused by a chromosomal rearrangement on BTA1 that disrupts the expression of the PISRT1 and FOXL2 regulatory sequences (Pailhoux *et al.*, 2020; Borthwick *et al.*, 2022). The dominant allele for polledness, when homozygous in genetic females, results in intersexuality and reproductive failure, thereby imposing a strong selective disadvantage in traditional breeding systems in which reproductive fitness is the primary selection criterion.

Horn shape and orientation varied significantly between sexes (Table 2). Males exhibited predominantly curved horns (62.9%) relative to the straight type (37.1%), whereas females were predominantly straight-horned (76.5%). With respect to horn orientation, the back-and-in/out orientation was more common in males (51.7%), while the back-and-straight orientation predominated among females (65.2%). The mean adult horn length was 5.19 ± 1.30 cm, with a range of 4-12 cm. These sex-specific differences in horn morphology are consistent with the secondary sexual character functions of horns in goats, particularly their role in intra-sexual competition and dominance hierarchies in males (Ofori *et al.*, 2021).

Table 2: Horn shape and orientation distribution (%) by sex in WAD goats sampled in Ebonyi State, southeastern Nigeria.

	Male (n=151)	Female (n=221)	Combined (n=371)
Shape of horn (%)			
Straight	37.1	76.5	60.5
Curved	62.9	23.5	39.5
Orientation of horn (%)			
Back and straight	35.1	65.2	53.0
Back and in or out	51.7	21.5	34.9
Others	13.2	11.3	12.1

Linear Body Measurements and Body Weight

Mean body weight and linear measurements disaggregated by sex and for the combined population are presented in Table 3. Male goats were marginally heavier (16.60 kg) than females (16.00 kg), with a combined mean BW of 16.10 kg. Mean BL, HG, HAW, and HW for the combined sexes were 70.00 cm, 58.00 cm, 45.00 cm, and 62.00 cm, respectively. The slightly greater BW recorded in males is consistent with the sexually dimorphic growth trajectories characteristic of the WAD goat breed (Okoro *et al.*, 2023). Notably, HW was marginally greater in females (63.00 cm) than in males (62.00 cm), a difference attributable to the obstetric demands of pregnancy and parturition, which necessitate a broader pelvic cavity in does.

The morphometric profile of the Ebonyi State WAD goat population broadly conforms to the breed standards documented in the literature. The reported breed characteristics describe mature WAD goats as achondroplastic animals with withers heights of 30-50 cm and live weights between 18-25 kg for adults (Ofori *et al.*, 2021; Sesay *et al.*, 2022). The values recorded in the present study fall within these reported ranges, confirming the breed affiliation of the sampled population. The slightly lower BW compared to published breed standards may reflect the predominantly extensive management system and associated nutritional limitations typical of the study area, as nutritional plane is a well-established environmental modulator of growth performance in small ruminants (Dige *et al.*, 2022).

Body weight and linear measurements increased progressively with age across the population, consistent with the ontogenetic deposition of skeletal and soft tissues during the growth trajectory. Age-dependent increases in morphometric parameters have been consistently reported for WAD goats across multiple production environments (Ofori *et al.*, 2021; Okoro *et al.*, 2023; Sesay *et al.*, 2022). The age composition of the sampled population, which included a disproportionately high representation of breeding-age males, likely contributed to the mean BW recorded.

Table 3: Descriptive statistics for body weight and linear body measurements of WAD goats in Ebonyi State, southeastern Nigeria.

Trait	Sex	n	Minimum	Maximum	Mean $\pm$ SD
Body Weight (kg)	Male	151	6.10	24.00	16.60 $\pm$ 0.30
	Female	221	6.10	22.00	16.00 $\pm$ 0.20
	Kids	68	6.30	16.70	7.77 $\pm$ 0.20
	Adults	304	9.80	24.00	16.10 $\pm$ 0.16
Body Length (cm)	Male	151	51.00	84.00	69.90 $\pm$ 0.55
	Female	221	51.00	92.00	68.70 $\pm$ 0.45
	Kids	68	51.00	68.00	59.00 $\pm$ 0.41
	Adults	304	51.00	92.00	70.00 $\pm$ 0.34
Heart Girth (cm)	Male	151	42.00	74.00	59.00 $\pm$ 0.46
	Female	221	40.00	59.00	57.00 $\pm$ 0.40
	Kids	68	40.00	58.00	49.00 $\pm$ 0.53
	Adults	304	45.00	70.00	58.00 $\pm$ 0.30
Height at Withers (cm)	Male	151	34.00	52.00	45.60 $\pm$ 0.26
	Female	221	34.00	48.00	44.80 $\pm$ 0.25
	Kids	68	34.00	43.00	39.00 $\pm$ 0.35
	Adults	304	34.00	57.00	45.00 $\pm$ 0.16
Hip Width (cm)	Male	151	43.00	74.00	62.00 $\pm$ 0.52
	Female	221	44.00	80.00	63.00 $\pm$ 0.46
	Kids	68	42.00	64.00	52.00 $\pm$ 0.50
	Adults	304	46.00	80.00	62.00 $\pm$ 0.32

Correlations Among Body Weight and Linear Measurements

Body weight was significantly and positively correlated ($p < 0.01$) with all recorded linear body measurements in both sexes. Among males, the highest correlations were observed between BW and HG, and between BW and BL, reflecting the greater contribution of thoracic and trunk dimensions to overall body mass in bucks of breeding age. Among females, correlations between BW and HW, and between BW and HAW, were relatively elevated compared with males, a pattern that is physiologically consistent with the pelvic and hindlimb structural investments required to support pregnancy and parturition.

The strong intercorrelations among linear measurements themselves were also statistically significant ($p < 0.01$), indicating coordinated skeletal growth across body regions. These results are in agreement with findings from other WAD goat characterization studies that have demonstrated high phenotypic correlations among morphometric traits, often attributed to pleiotropic genetic regulation of skeletal development (Dige *et al.*, 2022; Ofori *et al.*, 2021). The significant positive correlations among BW, BL, HG, and HAW demonstrate that animals with longer bodies, wider heart girths, and greater withers heights tend to attain higher body weights, supporting the use of these traits as indirect selection criteria in breeding programmes designed to improve productivity.

The practical implications of these correlations for livestock improvement are substantial. In resource-limited production environments where calibrated weighing equipment is unavailable, HG and BL measurements obtained with a simple flexible tape can serve as reliable predictors of live weight (Dige *et al.*, 2022; Ofori *et al.*, 2021). The development of locally validated weight-estimation equations for WAD goats in southeastern Nigeria, incorporating BL and HG as primary predictors, is therefore recommended as a priority for future research supporting smallholder livestock development programmes in the region.

Table 4: Correlation between traits of WAD goats in Ebonyi State

Trait	Category	BL	HG	HAW	HW
BW	Male	0.884**	0.954**	0.764**	0.875**
	Female	0.871**	0.933**	0.768**	0.885**
BL	Male		0.897**	0.693*	0.873**
	Female		0.867**	0.771**	0.918**
HG	Male			0.747**	0.906**
	Female			0.724**	0.898**
HAW	Male				0.744**
	Female				0.747**

BW=Body Weight, BL=Body Length. HG=Heart Girth, HAW=Height at Withers. HW=Hip Width, **= $P < 0.01$

Conclusion

This study provides a comprehensive morphological profile of the WAD goat population in Ebonyi State, southeastern Nigeria, encompassing both qualitative breed descriptors and quantitative production-relevant measurements. The population was characterized by uniform short, stiff coat type, a predominance of black or dark-coloured coat phenotypes, low wattle and supernumerary teat incidence, universal hornedness with sexually dimorphic horn morphology, and body measurements consistent with WAD breed standards. The significant and positive correlation between body weight and linear measurements, particularly heart girth and body length, supports the use of morphometric parameters as practical indirect selection tools. The predominance of black coat colour in the population warrants further investigation into the thermoregulatory and productive consequences of coat pigmentation under prevailing tropical conditions. These findings contribute to the national inventory of

WAD goat AnGR and provide a scientific basis for the design of community-based breed improvement programmes in southeastern Nigeria.

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