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Phenotypic Characterization of Indigenous Pigs Populations of Nigeria

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Abstract- Indigenous pig production plays a vital role in Nigeria's rural farming systems, providing livelihood and food security. However, the population has recently stagnated, primarily due to the lack of comprehensive improvement and conservation programs. To address this, a study was conducted to characterize the morphometric traits of indigenous pigs across three ecological zones: humid forest, guinea savannah, and derived savannah. A total of 450 pigs (150 from each zone) were purposively sampled, and their morphometric measurements such as body weight, body length, heart girth, wither height, paunch girth, and ear length were recorded using measuring tapes. Results indicated that the highest body weight (23.60 ± 0.62 kg) and linear measurements body length (70.31 ± 0.76 cm), wither height (64.87 ± 0.64 cm), heart girth (59.31 ± 0.46 cm), and ear length (17.35 ± 0.20 cm) were observed in pigs from specific ecotypes. Sex significantly influenced all measured traits (P < 0.05), with males exhibiting higher values across traits. Age also had a notable effect, with four-year-old pigs displaying the highest body weights and linear measurements, demonstrating a positive correlation between age and growth parameters. Phenotypic correlation analysis revealed strong, positive, and significant relationships among traits within ecotypes, with correlation coefficients ranging from 0.739 to 0.797. These findings facilitated the classification of animals into their respective ecotypes. The study suggests that these morphometric data can serve as baseline information for future genetic studies and conservation strategies, aimed at improving and maintaining the genetic integrity of Nigeria's indigenous pig breeds.

Indexed Terms- Morphometric Traits, Pig, Sex, Age, Location

I. INTRODUCTION

Pig has a relatively high potential to contribute to increased productivity on account of their high fecundity, feed conversion efficiency, short generation interval and early maturity (Mbuthia *et al*., 2015). Available statistics up to 2015 (USDA, 2016) indicates that pork accounted for 40% of world meat consumption followed by chicken (33%), cattle (22%) and mutton and goats (7%). indigenous pigs of Nigeria make substantial contribution to human livelihoods, employment generation and food security as well as their superior adaptation to harsh environmental conditions and resistance to endemic diseases (Adjei *et al*., 2015).

Pigs (*Sus scrofa*) display enormous phenotypic diversity in terms of shape, colour, size, production and reproduction abilities (Osei-Amponsah *et al*., 2017). Although indigenous pigs have small body sizes compared to exotic pigs, their products are prefers by local people and as such their genetic diversity could be exploited to improve on their productivity. Exploitation of genetic diversity among and within breeds of pigs will thus help identify the most productive and adapted animals for specific environments (Karnuah *et al*., 2018). There is a need to characterize and maintain indigenous breeds of pigs which have variable traits suited to a particular ecological zone (FAO, 2015).

Morphometric information has been used to evaluate the characteristics of various breeds of animals and could provide first-hand information on the suitability of animals for breeding (Adeola *et al*., 2013; Adjei *et al*., 2015). FAO (2012) reported that information provided by phenotypic characterization studies is important for management of the animal genetic resources for conservation and food security. The swine genetic resources of Nigeria need to be characterized as a basis for their genetic improvement and characterization. Adequate information on the morphometric characteristics of pigs is unknown and is essential in developing breeding, management and conservation programs. The objective of this study therefore was to carry out Phenotypic characterization of indigenous pigs of Nigeria, in order to recommend appropriate strategies for their conservation and sustainable use.

II. MATERIALS AND METHOS

Location of the Study

The study was carried out across location in three agro-ecological zones (humid forest, guinea savannah and derived savannah) of Nigeria. Locations were selected based on the preponderancy of the Nigeria indigenous pigs in the area. Coordinates and populations pigs sampled in each of the study locations are as shown in Table 1 and 2.

Table 1: Number of Animals Sampled and Coordinates of the Study Areas

Ecotype name	Code	Number sampled	State	*Coordinates
Humid Forest	HF	50	Ogun	7°0' N3°30'E
		50	River	4°45' N7°0'E
		50	Imo	5°28' N7°4'E
Guinea Savannah	GS	50	Benue	7°0' N9°0'E
		50	Kwara	8°30' N4°30'E
		50	Kogi	7° 30' N3°60'E
Derived Savannah	DS	50	Kaduna	10°30' N7°20'E
		50	Taraba	8°40' N9°50'E
		50	Gombe	10°17' N11°10'E
Total		450		

Table 2: Distribution of the Three Nigerian Indigenous Pig Ecotype Sampled by Age and Sex

Ecotype	N	Age (Years) 2	3	4	Sex Male	Female
HF	150	57	52	41	75	75
GS	150	55	49	46	75	75
DS	150	47	54	49	75	75
Overall	450	159	155	136	225	225

Experimental Animals and their Management

Four hundred and fifty (450) Nigerian indigenous pigs consisting of 25 males and 25 females were used for this study in each of the selected State. The male and female pig in the age between 2- 4 years, was randomly drawn across nine (9) States from large random mating populations of pigs. They were reared primarily under semi-intensive or traditional free range system by the owners; whereby pigs scavenged for their feed and water with little or no supplementation. Only apparently healthy pigs were used for the study.

Data Collection

Data was collected on four hundred and fifty (450) local pigs based on sex and age (2- 4 years).

Estimation of age

The ages of the animals were estimated based on their dentition according to Nwosu, (2006), by identifying the temporary and permanent teeth. The age was between 1-4 years.

Phenotypic Parameters

Body weight and body linear measurements were taken on individual pig. All measurements were restricted only to pigs that are apparently health and phenotypically conformed to the classification descriptors of the Nigeria indigenous pigs. Before measuring various parameters, the animals were restrained and calmed properly. Measurements were done early in the morning to avoid the effect of feeding and watering on the animal's size and conformation. Some of the body linear parameters measured are as follows;

Body weighty: was determined by using measurement of body length, heart girth and height at wither from the regression equation;

BW =10.385 + (0.921 x BL) + (0.275 x HG) + (0.360 x HW)
Where BW = body weight, BL = Body length, HG = heart girth and HW =height at wither

Body length: Body length was taken at the base of the neck to the base of the tail using measuring tape in Centimeters.

Height at wither: This was measured as the distance from the highest point on the dorsum of the animal to the ground surface at the forelegs using measuring tape.

Heart Girth: This was measured with the aid of a flexible tape in Centimeters as the circumference of the body immediately after the abdomen just before the hind legs.

Ear Length: This was measured with the aid of a flexible tape from the base of the ear to the tip of the ear in Centimeters.

Paunch Girth: This was measured with the aid of a flexible tape in Centimeters as the circumference of the body immediately after the abdomen just before the hind legs.

Statistical Data Analysis

Data generated on the morphological traits on the Nigeria indigenous pig ecotypes were subjected to Analysis of Variance (ANOVA) using the general linear model (GLM) from the SPSS version 20.0 Statistical package. Mean separation was done using Duncan Multiple Range Test (DMRT) at p = 0.05.

Pearson's correlation coefficient was computed between the body weight and morphological traits using SPSS version 20 statistical package.

The discriminant analysis procedure was employed to estimate the proportion of animals that were properly classified into their original breed using SPSS version 20.0 statistical package. Accuracy of the classification was evaluated using cross-validation (leave-one-out, jack-knife or split-sample) procedure. The percentage of mis-classified animals indicates the degree of admixture between the ecotypes.

III. RESULTS

Phenotypic Traits of the Nigerian Indigenous Pig Ecotypes

The results of the Phenotypic evaluations of the Nigerian indigenous pig ecotypes are presented in Tables 3, 4, 5 and 6.

Table3 shows the effect of ecotypes on the Phenotypic traits measured. The result reveals that the body weight and body linear measurements of the three Nigerian indigenous pig ecotypes differed significantly ($p<0.05$). However, the humid forest had higher body weight and body linear measurements, follow by the guinea savannah ecotypes and the derived savannah ecotype, respectively. The overall mean value of body weight was 18.02±0.30 kg and body linear measurements (56.65±0.50 cm BL, 54.49±0.45 cm HW, 58.06±0.34 cm HG, 56.87±0.50 cm PG, 11.63±0.20 cm EL).

Table 4 shows the effect of sex on the phenotypic traits measured within the three ecotypes of Nigerian indigenous pigs. The results showed that sex had significant ($P < 0.05$) effect on the body weight and body linear measurements across the ecotypes. However, the body weight and body linear measurements of the males were higher than females in all the three ecotypes of the Nigerian indigenous pigs.

Table 5 shows the effect of sex on the phenotypic traits measured between the three ecotypes of Nigerian indigenous pigs. The results showed that there was significant difference ($P < 0.05$) in the body weight and body linear measurements of the males across the ecotype. However, the males in the humid forest had higher body weight and body linear measurements compared to those in the guineas and derived savannah ecotypes. Also, there was significant difference ($P < 0.05$) in the body weight and body linear measurements of the females across the ecotype. Although, the body weight and body linear measurements of the females in the humid forest ecotype were higher than those in the guineas and derived savannah ecotypes.

Table 6 shows the effect of age on the phenotypic traits measured in the three ecotypes of Nigerian indigenous pigs. The results showed significant ($P < 0.05$) effect of age across the ecotypes on all the traits measured. However, animals aged 2- 4 years in the humid forest had the highest values for all the traits measured. Age significantly ($P < 0.05$) influenced body weights and body linear measurements in the three ecotypes with consistent increase in body weights and body linear traits measured with age.

Pearson Correlations of the Phenotypic Traits in the Different Ecotypes of Nigerian Indigenous Pigs

The correlation coefficient among phenotypic traits, for humid forest, guinea savannah and derived savannah ecotypes are presented in Table 7 to 9. In all cases, the phenotypic traits correlation values (r) were all positive and significant ($P < 0.01$) in humid forest, guinea savannah and derived savannah pig ecotypes. The correlations values ranged from moderate to high across the ecotypes. The highest values recorded were; 0.777 between BW and HW in humid forest pigs ecotype, 0.797 between HG and HW in guinea savannah pigs ecotype and 0.739 between BW and HW in derived savannah pigs ecotype.

Discriminant Analysis

Table 10 and 11 shows the results of Eigenvalues and Wilks' Lambda tests. From the Tables, the first function explains 7.7% of the total variation and has a small Lambda of 0.022 and its significant ($P<0.01$). The second function explains only of the variation in the data set and significant ($P<0.01$). The two functions contributed significantly in the discrimination process, having high canonical correlation values of 0.952 and 0.875, respectively.

Table 12 shows the results of the discriminant analysis. The results showed that 96.9 % of the animals were correctly classified, leaving a 3.1 % rate of misplacement. Cross-validation with the split-sample method indicated 96.4 % success rate. The use of cross-validation option provided a better assessment of classification accuracy. About 97.3 % of humid forest pig ecotype, 94.0 % of guinea savannah and 98.0 of derived savannah ecotype were correctly assigned into distinct genetic groups.

Table 3: Least Square Means ± SE of Body Weight and Body Linear Measurements of Nigerian Indigenous Pig Ecotypes

Ecotype	N	BW(kg)	BL(cm)	HW(cm)	HG(cm)	PG(cm)	EL(cm)
HF	150	23.60 ± 0.62^a	70.31 ± 0.76^a	64.87 ± 0.64^a	59.31 ± 0.46^a	70.20 ± 0.76^a	17.35 ± 0.20^a
GS	150	17.12 ± 0.46^b	53.50 ± 0.41^b	55.67 ± 0.86^b	57.60 ± 0.66^b	65.72 ± 0.56^b	11.80 ± 0.10^b
DS	150	14.80 ± 0.31^c	48.25 ± 0.73^c	46.92 ± 0.30^c	56.68 ± 0.71^c	31.23 ± 0.73^c	5.94 ± 0.14^c
OM	450	18.02±0.30	56.65±0.50	54.49±0.45	58.06±0.34	56.87±0.50	11.63±0.20

^{abc} = Mean in the same column with different superscripts are significantly different ($p<0.05$), HF = Humid Forest, GS=Guinea Savannah, DS =Derived Savannah, OM= Overall mean, BW = Body weight, BL = Body length, HW= Height at wither, HG= Heart girth, PG = Paunch girth, EL = Ear length, P = 0.05

Table 4: Sexual Dimorphism in Body Weight and Body Linear Measurement within Nigerian Indigenous Pig Ecotypes

Ecotype	Sex	N	BW(kg)	BL(cm)	HW(cm)	HG(cm)	PG(cm)	EL(cm)
HF	M	75	24.63 ± 0.74^a	74.07 ± 0.85^a	66.44 ± 0.78^a	62.35 ± 0.56^a	73.27 ± 0.93^a	17.77 ± 0.23^a
	F	75	23.50 ± 1.17^b	64.48 ± 1.07^b	62.44 ± 1.03^b	55.24 ± 0.59^b	65.44 ± 1.05^b	16.70 ± 0.31^b
GS	M	75	18.53 ± 0.58^a	55.71 ± 0.54^a	56.39 ± 0.95^a	59.16 ± 0.85^a	68.96 ± 0.77^a	12.10 ± 0.12^a
	F	75	14.94 ± 0.75^b	50.54 ± 0.51^b	53.81 ± 1.89^b	55.19 ± 0.99^b	61.39 ± 0.62^b	11.39 ± 0.13^b
DS	M	75	16.94 ± 0.39^a	49.19 ± 1.55^a	47.92 ± 0.40^a	57.34 ± 0.76^a	33.27 ± 0.82^a	6.02 ± 0.16^a
	F	75	11.94 ± 0.36^b	47.88 ± 0.81^b	45.58 ± 0.42^b	55.00 ± 1.56^b	30.69 ± 1.50^b	5.71 ± 0.27^b

^{ab} = Mean in the same column within sex group within the ecotypes with different superscripts are significantly different (P<0.05), HF = Humid Forest, GS=Guinea Savannah, DS =Derived Savannah, M=Male, F=Female, BW = Body weight, BL = Body length, HW= Height at wither, HG= Heart girth, PG = Paunch girth, EL = Ear length, P = 0.05

Table 5: Sexual Dimorphism in Body Weight and Body Linear Measurement between Nigerian Indigenous Pig Ecotypes

Ecotype	Sex	N	BW(kg)	BL(cm)	HW(cm)	HG(cm)	PG(cm)	EL(cm)
HF	M	75	23.63 ± 0.74^a	74.07 ± 0.85^a	66.44 ± 0.78^a	62.35 ± 0.56^a	73.27 ± 0.93^a	17.77 ± 0.23^a
GS	M	75	18.53 ± 0.58^b	55.71 ± 0.54^b	56.39 ± 0.95^b	59.16 ± 0.85^b	68.96 ± 0.77^b	12.10 ± 0.12^b
DS	M	75	16.94 ± 0.39^c	49.19 ± 1.55^c	47.92 ± 0.40^c	57.34 ± 0.76^c	30.27 ± 0.82^c	6.02 ± 0.16^c
HF	F	75	23.50 ± 1.17^a	64.48 ± 1.07^a	62.44 ± 1.03^a	55.24±0.59	65.44 ± 1.05^a	16.70 ± 0.31^a
GS	F	75	14.94 ± 0.75^b	50.54 ± 0.51^b	53.81 ± 1.89^b	55.19±0.99	61.39 ± 0.62^b	11.39 ± 0.13^b
DS	F	75	11.94 ± 0.36^c	47.88 ± 0.81^c	45.58 ± 0.42^c	55.00±1.56	33.69 ± 1.50^c	5.71 ± 0.27^c

^{ab} = Mean in the same column within sex group within between ecotypes with different superscripts are significantly different (P<0.05), HF = Humid Forest, GS=Guinea Savannah, DS =Derived Savannah, M=Male, F=Female, BW = Body weight, BL = Body length, HW= Height at wither, HG= Heart girth, PG = Paunch girth, EL = Ear length, P = 0.05

Table 6: Effect of Age on Body Weight and Body Linear Measurements of Nigerian Indigenous Pigs Ecotypes

Ecotype	Age(yrs)	N	BW(kg)	BL(cm)	HW(cm)	HG(cm)	PG(cm)	EL(cm)
HF	2	55	22.27 ± 0.80^a	65.39 ± 1.08^a	61.20 ± 0.76^a	61.55 ± 0.59^a	66.30 ± 0.93^a	17.17 ± 0.34^a
GS	2	57	16.05 ± 0.42^b	55.26 ± 0.49^b	46.82 ± 0.25^b	54.11 ± 0.88^b	68.40 ± 0.70^b	11.96 ± 0.23^b
DS	2	47	13.28 ± 0.50^c	43.46 ± 1.37^c	48.15 ± 0.40^c	52.73 ± 1.47^c	29.64 ± 0.72^c	5.36 ± 0.23^c

HF	3	52	27.73±0.52^b	73.43±0.42^b	67.18±0.65^b	64.47±0.64^b	72.21±1.23^b	17.29±0.41^b
GS	3	49	18.67±0.46^a	58.30±0.54^a	57.64±0.51^a	58.43±1.13^a	70.17±1.17^a	12.39±0.18^a
DS	3	54	15.46±0.72^c	53.91±0.76^c	49.67±0.41^c	58.00±1.09^c	33.00±0.46^c	6.27±0.26^c
HF	4	46	29.27±0.53^a	77.65±0.65^a	71.56±0.52^a	68.30±1.10^a	77.46±0.81^a	18.32±0.30^a
GS	4	49	22.46±0.53^b	59.37±1.03^b	64.64±0.81^b	63.84±0.75^b	71.26±1.51^b	14.19±0.15^b
DS	4	41	17.52±0.80^c	55.46±1.25^b	56.48±0.63^c	62.82±0.98^c	37.86±0.91^c	8.23±0.15^c

[abc] = Mean in the same column within age group within agro-ecological sub-group with different superscripts are significantly different (P<0.05), HF = Humid Forest, GS=Guinea Savannah, DS =Derived Savannah, BW = Body weight, BL = Body length, HW= Height at wither, HG= Heart girth, PG = Paunch girth, EL = Ear length, P = 0.05

Table 7: Pearson Correlation Coefficients among Body Parameters in Guinea Savannah Zone Ecotype of Nigerian Indigenous Pigs

Traits	BW	BL	HW	HG	PG
BL	0.736 **				
HW	0.617 **	0.709 **			
HG	0.797 **	0.751 **	0.637 **		
PG	0.742 **	0.705 **	0.588 **	0.767 **	
EL	0.412 **	0.545 **	0.552 **	0.461 **	0.410 **

BW = Body weight, BL = Body length, HW= Height at wither, HG= Heart girth, PG = Paunch girth, EL = Ear length

Table 8: Pearson Correlation Coefficients among Body Parameters in Humid Forest Savannah Zone Ecotypes of Nigerian Indigenous Pigs

Traits	BW	BL	HW	HG	PG
BL	0.723 **				
HW	0.777 **	0.673 **			
HG	0.712 **	0.478 **	0.768 **		
PG	0.754 **	0.718 **	0.733 **	0.752 **	
EL	0.471 **	0.309 **	0.484 **	0.520 **	0.452 **

BW = Body weight, BL = Body length, HW= Height at wither, HG= Heart girth, PG = Paunch girth, EL = Ear length

Table 9: Pearson Correlation Coefficients among Body Parameters in Derived Savannah Zone Ecotypes of Nigerian Indigenous Pigs

Traits	BW	BL	HW	HG	PG
BL	0.515 **				
HW	0.465 **	0.512 **			
HG	0.407 **	0.612 **	0.739 **		
PG	0.707 **	0.206 **	0.490 **	0.273 **	
EL	0.578 **	0.308 **	0.403 **	0.480 **	0.703 **

BW = Body weight, BL = Body length, HW= Height at wither, HG= Heart girth, PG = Paunch girth, EL = Ear length

Table 10: Results of the Test of Eigenvalues

Function	Eigenvalue	% of Variance	Cumulative %	Canonical correlation
1	9.584	74.7	74.7	0.952
2	3.252	25.3	100.0	0.875

Table 11: Results of the Wilks' Lambda Test

Function	Wilks' Lambda	Chi-square	Degree of freedom	significance
1 through 2	0.022	2202.147	12	0.000
2	0.235	837.263	5	0.000

Table12: Classification Results for the Discriminant Analysis of Goat Breeds

		Ecotype	Predicted Group Membership			Total
			1	2	3	
Original	Count	HF	148	0	2	150
		GS	2	141	7	150
		DS	1	2	147	150
	%	HF	98.7	0.0	1.3	100
		GS	1.3	94.0	4.7	100
		DS	0.7	1.3	98.0	100
Cross-validation	Count	HF	146	0	4	150
		GS	3	141	6	150
		DS	2	1	147	150
	%	HF	97.3	0.0	2.7	100
		GS	2.0	94.0	4.0	100
		DS	1.3	0.7	98.0	100

a. 96.9 % of original grouped cases correctly classified
b. 96.4 % of cross-validated grouped cases correctly classified

HF = Humid Forest, GS=Guinea Savannah, DS =Derived Savannah

IV. DISCUSSION

Descriptive statistic of phenotypic traits of the Nigerian indigenous pigs

Phenotypic measurements have been used to evaluate the characteristics of various breeds which could provide base-line information for selection in farm animals (Yaetsu *et al*., 2017).

The present study indicates significant differences ($p<0.05$) in body weight and linear measurements among the three pig ecotypes: humid forest, guinea savannah, and derived savannah. The humid forest ecotype exhibited superior traits, with higher average body weight and linear measurements compared to the other two ecotypes. This may suggest adaptations to the humid forest environment. The observed differences in the body weight and body linear measurements observed between the ecotypes of the indigenous pigs is in congruent with the report of Kosgen (2014) who detected distinctness, in a direct relationship between morphometric traits divergence and geographical separation which have resulted from phenotypic plasticity, due to an environmental-induced phenotypic changes in the organism's life overtime, and which is an important adaptive strategy to help cope with the surrounding environmental factors.

The values obtained in this study showed that the male pigs were superior to their female pigs in terms of body weight and in the body linear measurement. The humid forest ecotype showed the most pronounced sex differences in body weight and body linear measurements, indicating that these traits might be more heavily influenced by hormonal factors in this population. Notably, males consistently presented higher body weight and linear measurements across all three ecotypes, aligning with the view in livestock that males often grow larger than females due to hormonal influences. This sex influenced differences in body linear measurements is agreement with the findings of Proudman *et al*. (2019) who suggested that the difference might be partly due to hormonal effect, resulting in sexual morphological difference.

The study highlights that there are significant interactions between sex and ecotype, with males in the humid forest presenting the highest body weight and morphometric traits. The same pattern holds for females, who also demonstrated superior traits in the humid forest ecotype compared to others. This suggests that humid forest does not only influence growth and development, but it also interacts with sex to affect overall body metrics. The observed superiority of the humid forest ecotype in both sexes could provide opportunities for selective breeding programs aimed at preserving and enhancing desirable traits. The results from this study consistent with the previous work of Marai *et al*. (2016) who reported that sex significantly influenced body linear measurements.

The results indicate a significant effect of age ($P < 0.05$) on all measured morphometric traits across the three ecotypes: humid forest, guinea savannah, and derived savannah. This suggests that as pig's age, there is a substantial increase in body weight and linear measurements. This pattern of growth is consistent with general mammalian growth dynamics, where younger animals generally exhibit slower growth rates compared to adults, culminating in more pronounced size and weight during later developmental stages. Notably, pigs aged 2-4 years in the humid forest ecotype exhibited the highest values for all morphometric traits measured. This may attributed to adaptability and potential of the humid forest pig ecotype, possibly reflecting superior nutritional access, environmental conditions, or genetic traits that contribute to better growth. This observation is similar to reported by Marai *et al*. (2016) that the size and shape of the animal increases as the animal ages. This is also consistent with the findings of Handiwirawan *et al*. (2018) that the body length and height at wither reflects the animal's skeletal size and body conditions. This is contrary to the findings of Layos *et al*. (2018) who observed that pigs attain their morphometric characteristics at 3 years and above. Javier (2021) also reported that at 2 year body linear measurements are essentially constant, thereby reflecting heritable size of the skeleton.

Pearson Correlations of the phenotypic traits over population.

The high, positive and significant ($P<0.01$) relationships between the body weight and body linear measurement in the humid forest, guinea savannah and derived savannah Nigerian pigs ecotypes observed in the present study indicates that increase in any one of these traits would result in an increase in the body size. This report is consistent with the findings of Jimmy *et al*. (2010) for pig breeds. The relationship existing among body linear traits provide useful information on performance and carcass characteristics of farm animals (Jones, 2018), which been found useful in breed conservation (Karnuah *et al*,, 2018). The phenotypic traits measurements for body weight and body linear traits are neck genetic parameters in animal breeding programmes (Mansjoer *et al*., 2017).

Discriminant analysis

Discriminant analysis is a widely recognized statistical method utilized to assess the hypothesis that ecotypes are morphologically distinct. This analytical approach aims to classify individuals into statistically different ecotypes based on their morphological traits, thereby elucidating the differences between populations and predicting the group to which each animal belongs (Johnson and Wichern, 2022).

In this study, the results revealed a remarkable classification accuracy of 96.9 %, with only a 3.1 % misclassification rate. This level of accuracy is comparable to findings of Smith *et al*. (2023) who reported a classification success rate of 99.4% for indigenous pigs and 100% for exotic breeds. The high percentage of accurate classifications into the three distinct ecotypes demonstrates that the discriminant function effectively segregates individuals by origin, thus providing vital insights for selective breeding programs.

Despite the impressive classification rate, the result of this study is slightly higher than the approximately 89.10 % correct classification achieved in a study of indigenous pigs in India from different populations (Rahman *et al*., 2021). The researchers noted that low assignment rates could indicate either significant gene flow between populations or issues related to the analytical power of the methods used, potentially due to excessive analytical complexity.

The discriminant analysis produced important and informative variables referred to as racial markers that were instrumental in assigning the pigs to distinct populations. This capability not only reduces errors in breeding programs but also emphasizes the need for complementary evidence from molecular genetics to strengthen the information derived from morphological studies (Lee *et al*., 2022). Furthermore, it has been suggested that data from linear body measurements can aid geneticists in assessing variation within and between small populations, which is crucial for effective conservation and utilization breeding program optimization (Miller and Patel, 2020).

CONCLUSION

From the results obtained in this study, it can be concluded that, the phenotypic traits of the Nigerian indigenous pigs from three agro – ecological zones (humid forest, guinea savannah and derived savannah) of Nigeria presents diversities in body weight and morphometric body measurements. Ecotype/ location significantly ($p<0.05$) impacted body weight and body linear measurements of the pigs. Sexual dimorphism was pronounced on body weight and body linear measurement in the most of the ecotypes but without consistent trends across the ecotype/agro-ecological zones.

RECOMMENDATIONS

It is therefore, recommended that, the high variability phenotypic traits elucidated in the Nigerian indigenous pig populations should serve as an incentive for their conservation and improvement. Also, the information provided by this study should serve as a useful initial guide in defining objectives for future investigations of genetic integrity and development of conservation strategies for Nigerian indigenous pig breeds.

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