



Phenotypic and Morphometric Characterization of Local, Improved and Pietrain Stress-Negative Pigs and the Products of their Crossbreeding in Benin

CONSTANT BORIS BANKOLE¹, IGNACE OGOUDANAN DOTCHE^{1*}, SERGE GBÈNAGNON AHOUNOU¹, MAHAMADOU DAHOUDA², ISSAKA YOUSAO ABDOU KARIM¹, MARCEL SENOU²

¹Laboratory of Animal Biotechnology and Meat Technology, University of Abomey-Calavi, Polytechnic School of Abomey-Calavi, 01BP2009, Cotonou, Benin; ²Department of Animal Production, Faculty of Agronomic Science, University of Abomey-Calavi, 01 BP 526, Cotonou, Benin.

Abstract | The introduction of Pietrain breed into pig farming in Benin has resulted in a notable shift in the racial composition of the pigs being raised. The objective of this study was to describe the morphological and phenotypic characteristics of local, improved, and Pietrain pigs, as well as the products of their crossbreeding. A sample of 178 pigs, aged 8 months, were included in the study. The pigs were divided into the following categories: 48 improved pigs, 24 local pigs, 16 Pietrain pigs, 40 pigs F1 crosses between the Pietrain and the improved, and 50 pigs crossed F1 between the Pietrain and the local pig. The data on morphometric measurements (body length, head length, ear length, pelvis length, pelvic width, chest girth, height at withers, the length of the tail, shoulder width and circumference of hock) were taken on the animals using a Animal Weigh Tape. The phenotype data (snout appearance, coat pattern, coat color, head profile, ear type, ear orientation, skin appearance, hair type and back line) were subsequently recorded following an observation of the animals. These data were subjected to analysis, and the impact of genetic type and sex on morphometric measurements was evaluated using Fisher's F-test. The Chi-squared test was employed to determine the impact of breed on phenotype data. The morphometric measurements were found to be lowest in local pigs and their crosses with Pietrain, highest in improved pigs, and intermediate in Pietrain and their crosses with improved pigs. There was a significant difference in coat color between the genetic types ($p < 0.001$). The prevalence of black coat was significantly higher ($p < 0.05$) in local pig (100 %) and their crossbred (95 %), whereas white coat was more prevalent in improved pig (91.7 %) and their crossbred (90 %). Local and improved pigs exhibited a greater prevalence of long, thin snout (60 to 62.5 %), whereas the snout was shorter and cylindrical in Pietrain (100 %) and their crossbred (100 %) ($p < 0.05$). The findings indicate that local, improved, Pietrain, and crossbred pigs can be distinguished morphometrically and phenotypically.

Keywords | Pig breed, Phenotype, Body measurements, Crossbreeding, Pietrain, Benin

Received | September 09, 2024; **Accepted** | October 26, 2024; **Published** | December 30, 2024

***Correspondence** | Ignace Ogoudanan Dotche, Laboratory of Animal Biotechnology and Meat Technology, University of Abomey-Calavi, Polytechnic School of Abomey-Calavi, 01BP, Benin; **Email:** dotcheign@gmail.com

Citation | Bankole CB, Dotché IO, Ahounou SG, Dahouda M, Youssao Abdou Karim I, Senou M (2025). Phenotypic and morphometric characterization of local, improved and pietrain stress-negative pigs and the products of their crossbreeding in benin. Adv. Anim. Vet. Sci. 13(1): 146-156.

DOI | <https://dx.doi.org/10.17582/journal.aavs/2025/13.1.146.156>

ISSN (Online) | 2307-8316; **ISSN (Print)** | 2309-3331



Copyright: 2025 by the authors. Licensee ResearchersLinks Ltd, England, UK.

This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

Pig farming represents a significant source of income for the population of Benin and contributes to national food security (Djimenou *et al.*, 2017; Dotché *et al.*, 2021). The estimated population of reared pigs is 910,477 (FAOSTAT, 2024), comprising a variety of genotypes. The animals have been classified into three primary genotypes: local, improved, and crossbred (Youssao *et al.*, 2018).

The local pig is a diminutive stature. The mean birth weight of the pigs in question is 531–658 g, with a mean age at puberty of 221–245 days (Dotché *et al.*, 2020a). The number of piglets born in a litter varies between five and eight. The meat quality of the local breed is noteworthy, and the animals exhibit excellent resistance to disease and stress (Agbokounou *et al.*, 2016a).

The term “improved pigs” is used to describe a variety of exotic breeds, as well as the offspring resulting from various crossbreeding involving these original breeds (Youssao *et al.*, 2018). This is the consequence of unregulated crossbreeding by breeders. The potential breeds involved in these crosses and matings include Large White and Landrace, followed by animals crossbred from these different genetic types (Dotché *et al.*, 2018; Youssao *et al.*, 2018). The coat is predominantly white, with a variety of patterns. The head profile is concave, with a short, cylindrical snout (Youssao *et al.*, 2018). The improved pigs are large animals, most often reared in confined settings (Dotché *et al.*, 2018; Kiki *et al.*, 2018). The mean birth weight is 1100 g, with a mean litter size of 9 piglets (Dotché *et al.*, 2020b). These animals exhibit accelerated growth and demonstrate reduced disease resistance (Dotché *et al.*, 2020b).

Local pigs are typically reared in a more free-range manner within the traditional system due to their comparatively poor performance, which ultimately renders them less profitable on improved farms (Agbokounou *et al.*, 2016b; Djimenou *et al.*, 2017). Improved pigs are reared in “improved” farms due to their superior performance compared to local pigs (Dotché *et al.*, 2020b). From a quality perspective, the meat of local pigs is more highly valued by consumers than that of improved pigs, largely due to its lower fat content.

To enhance the productivity of local pigs, farmers have adopted a crossbreeding strategy involving the integration of local breeds with improved pigs exhibiting superior genetic traits (Dotché *et al.*, 2019). The crossbreeds allow for the creation of subjects that exhibit superior zootechnical performance compared to the local breed and greater disease resistance than breeds of improved genotypes (Dotché *et al.*, 2019). One disadvantage of these crossbreeds is that their meat contains a considerable amount of fat, which limits its consumption. To reduce the fat content of cross-

bred meat, the Pietrain breed was introduced as a replacement for the improved breeds in the crossbreeding scheme. The Pietrain is a pig breed of Belgian origin, distinguished by its high yield of lean meat and capacity to enhance carcasses destined for lean pork markets (Leroy and Verleyen, 2000; Youssao *et al.*, 2002). Moreover, this breed has been employed in crossbreeding with the improved genotype breed, yielding highly favorable outcomes in terms of production performance and meat quality (Bankolé, 2019). Pietrain is choice by Beninese farmers for crossbreeding with locally pigs reared, as it has been shown to improve performance.

The improvement work carried out on local breeds has resulted in a change in the racial configuration of pigs reared, and it is essential to characterize them phenotypically for better management of pig resources in Benin. By characterizing these breeds, it will be possible to select animals with characteristics that are similar to those of the improved breed. The aim of this study was to characterize phenotypically pigs resulting from crossbreeding between local breeds and breeds improved with Pietrain, and to compare them with parent breeds with a view to enhancing their value.

MATERIALS AND METHODS

STUDY AREA

The study was conducted at the piggery of the Animal Production Department of the Faculty of Agronomic Sciences and at the piggery of the Animal Biotechnology and Meat Technology Laboratory of the Animal Production and Health Department of the Polytechnic School of Abomey-Calavi, both of which are situated within the University of Abomey-Calavi.

ANIMAL MATERIALS AND BREEDING METHODS

The study was conducted at the research station. The animal material is composed of subjects from various matings conducted to enhance the growth performance of local and improved Benin pigs through crossbreeding with Pietrain stress-negative pigs. Data were collected at eight months of age on 178 pigs, including 48 improved pigs (36 females and 12 males), 24 local pigs (8 females and 16 males), and 16 Pietrain pigs (10 females and 6 males). A total of 40 F1 crossbred pigs were produced by crossing the Negative Stress Pietrain boar with an improved sow (20 males and 20 females). Additionally, 50 F1 crossbred pigs were produced by crossing the Negative Stress Pietrain boar with a local sow (26 males and 24 females). The age of eight months is equivalent to the age at which pigs are introduced into the reproductive cycle in Benin (Dotché *et al.*, 2018). The Pietrains utilized in this study were imported from Belgium. The parents of the local pigs were procured from private farms in the commune of Ifangni, Benin. The crossbreeding

was conducted on-site at the University of Abomey-Calavi. The local, Pietrain, and crossbred pigs were reared under identical conditions.

The reproducers were housed in well-constructed, solid buildings with solid feeders and troughs, which were maintained in a clean and hygienic condition. Each sow raised both male and female piglets in the same pen until they were weaned at six weeks of age. Subsequently, at the age of five months, the male and female piglets were relocated to separate pens.

The weaned pigs were fed a diet with a high protein content (20% protein, 3,000 kcal/kg) during the initial growth phase, from weaning to 2.5 months of age. The diet was provided ad libitum until the conclusion of the aforementioned period. Subsequently, the animals were provided with a growth-finish feed twice a day, spanning the period from 2.5 months to 8 months of age. The feed consisted of the following ingredients: corn, wheat bran, rice bran, soybean meal, palm kernel meal, shell, salt, premix, and lysine. The feed provided 2,500 kilocalories per kilogram of metabolizable energy and contained 16% protein. Water was provided in an unrestricted (ad libitum) manner.

DATA COLLECTION

The phenotypic traits and morphometric measurements taken were selected in accordance with the instructions set forth by the [FAO \(2012\)](#).

MORPHOMETRIC MEASUREMENTS: The body measurements were obtained using a Animal Weigh Tape. The data collection process was conducted in accordance with the procedures outlined by [Youssao et al. \(2018\)](#). The animals were maintained in a standing position on all fours throughout the duration of the measurements. The aforementioned measurements were conducted by the same operator on all animals. The body measurements were: body length (horizontal distance from the point of the shoulder to the pin bone), head length (distance between snout and forehead of pig), ear length (distance between the tip of the ear and the base), pelvis length (distance from hip tip to buttock tip), pelvic width (distance between the extreme lateral points of the hook bone of the pelvis), chest girth (largest circumference of the body immediately behind the shoulder), height at withers (vertical distance between the ground and the point of wither), the length of the tail (distance between the base and the end of the tail), shoulder width (horizontal distance between the points of the left and right shoulder blades) and circumference of hock.

PHENOTYPIC PARAMETERS: In the case of phenotypic traits, the pigs were described on the basis of direct observation. The qualitative phenotypic characteristics described were related to hair (straight, shorts, long, dense, sparse), snout

appearance (long and thin, short and cylindrical) coat pattern (uniform, magpie, spotted), coat color, head profile (concave, straight), ear type (semi-lop, droopy, prick), ear orientation (forward, backwards, upwards), skin appearance (smooth, wrinkled), hair type (straight, curly) and back line (straight, saddle). These parameters were described for each pig in the study.

STATISTICAL ANALYSIS

The analyses were conducted in accordance with the guidelines set forth by the [FAO \(2012\)](#) for the phenotypic characterization of animal genetic resources. The data were analyzed using R software, version 4.3.2 (2023-10-31 ucrt) and SAS (Statistical Analysis System, Cary, NC, USA, 2006). In order to ascertain whether the quantitative variables (morphometric measurements) in question exhibited a normal distribution, the SAS Proc Univariate procedure was initially employed. A linear fixed-effects model was fitted to the body measurement data, including the fixed effects of genetic type and sex. The interaction between genetic type and sex was incorporated into the ANOVA model. The significance of each effect was determined using the Fisher F-test with the AovSum function in the FactoMineR library ([Cornillon et al., 2018](#)). Adjusted averages are presented in [Tables 1 and 2](#). In the event of a significant genetic type effect, a Student's t-test was employed to facilitate a comparison between two breeds. The mathematical model is as follows:

$$Y_{ijk} = \mu + T_i + S_j + TS_{ij} + \varepsilon_{ijk}$$

Where;

Y_{ijk} : the measure of pig k, genetic type i and sex j;

μ : the value of the overall mean;

T_i : fixed effect of genetic type i (local pigs, Pietrain Stress Negative, crossbreeding between Pietrain and local pigs);

S_j : fixed effect of sex j (male and female);

TS_{ij} : interaction between genetic type i and sex j of the animal;

ε_{ijk} : random residual effect.

Subsequently, the R's factoextra library was employed for principal component analysis (PCA) on the measurements. The PCA analysis facilitated the visualization of the breed structure and genetic diversity resulting from the various crossbreeding operations.

In order to test the effect of the genetic type on the qualitative variables, a chi-squared test was employed, utilizing the chisq.test function within the R statistical software. Subsequently, the CA function from the FactoMineR library was employed to conduct a factorial correspondence analysis on a contingency table that cross the individuals in rows (the distinct genotypes) and the variables in columns.

Table 1: Effect of genetic type on morphometric characteristics (measured in cm) of local, improved and Pietrain pigs and the products of their crossbreeding.

Variable	Improved (N=48)		Local (N=24)		PixIm (N=40)		PixLo (N=50)		Pietrain (N=16)		F-Test
	Average	SE	Average	SE	Average	SE	Average	SE	Average	SE	
Body length	69.8a	0.6	47.9c	0.8	60.5b	0.6	44.4d	0.5	60.1b	1	***
Head length	28.2a	0.2	24.2c	0.3	25.6b	0.2	22.4d	0.2	23.6c	0.3	***
Ear length	20.4a	0.2	11.5d	0.3	18.4b	0.2	13.3d	0.2	15.7c	0.3	***
Pelvis length	20.5b	0.3	16.4c	0.4	23a	0.3	17.8c	0.2	21.6ab	0.5	***
Tail length	28a	0.3	21.2cd	0.5	24.6b	0.3	19.9d	0.3	22.7c	0.5	***
Pelvic width	16.2a	0.2	10.8c	0.3	11.4c	0.2	9.1c	0.2	13b	0.3	***
Height at withers	65.4a	0.5	51.1c	0.7	59.3b	0.5	47.8d	0.4	58.5b	0.8	***
Chest girth	86.1a	0.7	67.5c	0.9	77.7b	0.7	63.3d	0.6	76.8b	1.1	***
Hock circumference	14a	0.1	9.8c	0.2	13.2b	0.1	10.3c	0.1	13.1b	0.2	***
Neck circumference	64.5a	0.7	46.4c	0.8	56.5b	0.6	45.1c	0.7	57.9b	1	***
Shoulder width	13.9a	0.2	9.6c	0.3	11.6b	0.2	9c	0.2	13.4a	0.3	***
Snout circumference	32.6a	0.3	23.8c	0.4	29.2b	0.3	23.4c	0.2	28.8b	0.4	***
Number of teats	14.3a	0.3	10c	0.7	15a	0.5	12.5b	0.4	14.8a	0.6	***

ES: standard error; *****:** $p < 0.001$; **a,b,c:** means on the same line followed by different letters, differ significantly at the 5% threshold; **PixIm:** improved female x Pietrain negative stress male; **PixLo:** local female x Pietrain negative stress male.

Table 2: Interaction between genetic type and sex on morphometric characteristics (measured in cm) of local, improved and Pietrain pigs and the products of their crosses.

Variable	Improved		Local		PixIm		PixLo		Pietrain		Root MSE	Test de F
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female		
Body length	69.8a	69.7a	45.6d	50.2c	61.6b	59.3b	44.4d	44.3d	58b	62.2b	3.9	**
Head length	28.3a	28.1a	24.1c	24.2c	26.3b	24.9c	22.5d	22.3d	23.2cd	23.9c	1.3	*
Ear length	21a	19.9b	11.5f	11.5f	19.2b	17.6c	13.2e	13.4e	15.2d	16.3d	1.2	***
Pelvis length	20.6c	20.4c	15.9e	17be	22.9a	23a	17.8d	17.7d	20.9bc	22.2ab	1.8	*
Tail length	27.1b	28.8a	21.3de	20.9ef	25.8c	23.4d	19.7f	20f	22.2de	23.1d	2.1	***
Pelvic width	16.4a	15.9a	10.2d	11.2cd	11.3c	11.5c	9.3e	8.9e	12.7bc	13.3b	1.3	*
Height at withers	66.4a	64.4a	50.7e	51.5e	60.7b	57.8cd	47.6f	48f	56.9d	60.2bc	3.2	**
Chest girth	86a	86.1a	63.8e	71.2d	76.1c	79.4b	63.2e	63.3e	74.2cd	79.5b	4.3	***
Hock circumference	14.3a	13.6b	9.9e	9.6e	13.6b	12.7c	10.5d	10.1e	12.8c	13.4bc	0.7	*
Neck circumference	66a	63.1b	44.2e	48.5e	58.3c	54.6d	46.1e	44e	55.2cd	60.6bc	4	***
Shoulder width	14.5a	13.3b	8.3e	10.9d	11.9cd	11.2c	8.7e	9.3e	13.2ab	13.7ab	1.2	***
Snout circumference	32.9a	32.3a	24.6d	23.1de	30b	28.5c	24d	22.7e	28.7bc	28.9bc	1.7	*

:** $p < 0.05$; *:** $p < 0.01$; **a,b,c:** means on the same line followed by different letters, differ significantly at the 5% threshold; **PixIm:** improved female x Pietrain negative stress male; **PixLo:** local female x Pietrain negative stress male.

RESULTS

MORPHOMETRIC PARAMETERS OF LOCAL, IMPROVED AND PIETRAIN STRESS-NEGATIVE PIGS AND THE PRODUCTS OF THEIR CROSSBREEDING

The morphometric measurements differed significantly according to the genetic type ($p < 0.001$). The lowest measurements were observed in local pigs and their crossbred with Pietrain, while improved pigs exhibited the highest measurements. Pietrain and their crossbred with improved

pigs demonstrated intermediate measurements (Table 1). Local pigs and their crossbreeds with Pietrain exhibited morphological similarities for the majority of morphometric measurements, except the head length, body length, height at withers, and the chest girth. The local pigs exhibited higher values for all four parameters ($p < 0.05$). Moreover, Pietrains and their crossbred with the improved breed exhibited similarities in most morphometric measurements, except the head length, ear length, and the tail length. The crossbred exhibited higher values for all three parameters ($p < 0.05$).

The mean body length of local breed females (50.2 cm) was significantly ($p < 0.05$) longer than that of males (45.6 cm). The ear length, head length, and snout circumference of males crossed F1 improved pig x Pietrain were observed to be greater ($p < 0.05$) than those of females. Similarly, the improved breed's ear length and snout circumference were observed to be longer in crossbreds between the local breed and Pietrain. As with ear and head length, male crossbreds (improved pig x Pietrain) exhibited significantly higher neck circumferences (58.3 cm) than females (54.6 cm). A similar observation was made with regard to the improved genotype. Withers height exhibited sexual dimorphism in the Piétrain breed and F1s (improved pig x Piétrain), with females displaying the greatest values. Of the four genetic types under study, three demonstrated sex-dependent variations in thoracic perimeter, with females exhibiting significantly higher measurements than males. The upper shoulder value was significantly higher ($p < 0.05$) in males of the improved breed (14.5 cm) than in females (13.3 cm). In contrast, the opposite was observed in the local breed. With regard to the limbs, males of both the improved breed and the product of crossbreeding with the Piétrain exhibited a significantly greater hock circumference than females.

pigs are situated in axis 1, local pigs in axis 2, and Pietrain and Pietrain x improved crossbred pigs in axis 3. The variables associated with the axis are height at withers, thoracic perimeter, girth of jowl, neck circumference, snout circumference, and scapulo-ischial length. The variables head length and pelvic length are most accurately represented on axis 2, while ear length, hip width, and shoulder width are more closely associated with axis 3. In comparison, local pigs and F1 crossbreds (local female x Pietrain male) exhibited morphometric measurements that were relatively similar. In contrast, Pietrains and F1 crossbreds (improved female x Pietrain male) exhibited comparable morphometric measurements. The improved pigs, represented on Axis 1, exhibited morphometric measurements that were largely aligned with those of the Pietrains and F1 crossbreds (improved female x Pietrain male). However, they diverged significantly from the local pig and F1 crossbred groups (local female x Pietrain male).

PHENOTYPIC PARAMETERS OF LOCAL, IMPROVED AND PIETRAIN STRESS-NEGATIVE PIGS AND THE PRODUCTS OF THEIR CROSSBREEDING

There was a significant difference in coat color between the different genetic types ($p < 0.001$). The prevalence of black was significantly higher ($p < 0.05$) in local pigs (100 %) and Pietrain x local crossbred (92%), whereas white was more common in improved pigs (91.7 %) and Pietrain x improved crossbred pigs (90 %) (Table 3). Finally, the black spotted coat was observed to be more prevalent in Pietrains. The snout of local (60 %) and improved (62.5 %) pigs was observed to be longer and thinner ($p < 0.05$), while in Pietrains (100 %), Pietrain x local crossbred (100 %) and Pietrain x improved crossbred (100%), it was noted to be shorter and cylindrical. The same results were observed with regard to the appearance of the hair, which was markedly longer and denser in local (100 %) and improved (75 %) pigs, but shorter and sparser in Pietrains (100%) and their crossbred with Local, Improved pigs. The improved pigs exhibited a greater proportion of concave heads (66,7%) and droopy ears ($p < 0.05$) compared to the other genetic types, which displayed straight, short heads (80 to 100 %) and prick ears (90 to 100 %) (Table 3).

The results of the factorial correspondence analysis were interpreted across three axes ($\chi^2 = 408.85$; $p < 0.0001$). The three factorial axes collectively contributed 97.2% to the total inertia, with 70.27% attributable to axis 1, 17.33% to axis 2, and 9.59% to axis 3 (Figure 2). The CA revealed that Pietrain exhibited a white coat with black, sparse hair and forward ears. The improved pigs exhibited a concave head, long, dense hair, saddleback, long, thin snout, wrinkled skin, and droopy ears. The local pigs were distinguished by a uniform black coat, upward ears, and dense hair. F1 crossbreds (improved female x Pietrain male) exhibited a distinctive set of characteristics, including a short head, a

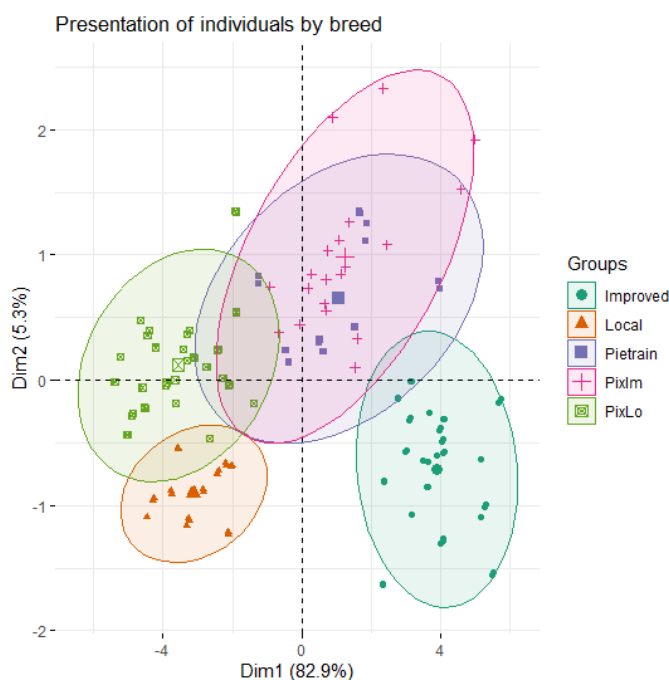


Figure 1: Principal component analysis of morphometric measurements of different pig genotypes.

Principal component analysis of morphometric measurements was employed to differentiate the five genetic types, as illustrated in Figure 1. The majority of variables were represented on axis 1, which explained 82.9% of the variation observed, while axis 2 accounted for only 5.3% of the variation and axis 3 for 3.2%. In terms of contribution to axis composition, improved and Pietrain x local crossbred

short, cylindrical snout, smooth skin, and short, sparse hair. Finally, F1 crossbreeds (local female x Pietrain male) were distinguished by a number of distinctive physical characteristics, including a straight head, a short cylindrical snout, short hair, a straight back line, and erect ears.

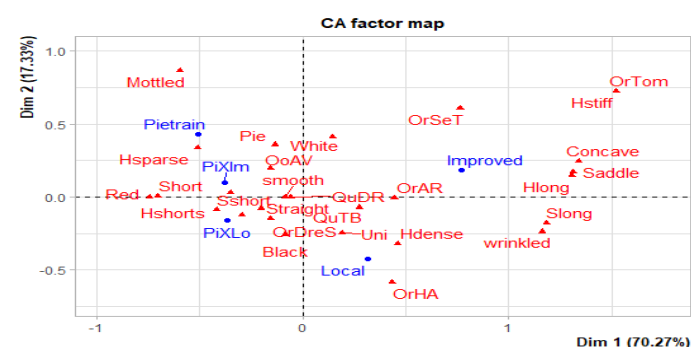


Figure 2: Spatial distribution of phenotypic traits in improved, local, Pietrain, PiXIm (improved female x negative stress Pietrain male) and PiXLo (local female x negative stress Pietrain male) pigs; **Hstiff:** straight hair; **Hshort:** short hair; **Hlong:** long hair; **Hdense:** dense hair; **Hsparse:** sparse hair; **Slong:** long, thin snout; **Sshort:** short, cylindrical snout; **Uni:** Uniform coat pattern; **Pie:** piebald coat pattern; **Mottled:** spotted coat pattern; **White:** white coat; **Black:** black coat; **Red:** Red coat; **Concave:** concave head profile; **Straight:** straight head profile; **Short:** short head profile; **OrSeT:** semi-drooping ear; **OrTom:** drooping ear; **OrDreS:** upright ear; **OoAV:** forward-facing ear; **OrAR:** rear-facing ear; **OrHA:** upward-facing ear; **Smooth:** smooth skin; **Wrinkled:** wrinkled skin; **QuDR:** straight tail; **QuTB:** corkscrew tail; **Straight:** straight topline; **Ensil:** enseled topline.

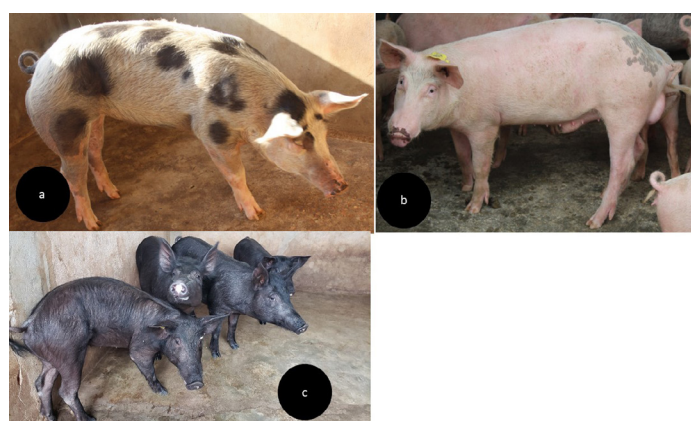


Figure 3: Pietrain (a); improved (b) and local (c) pigs.

DESCRIPTION OF EACH BREED ACCORDING TO PHENOTYPIC AND MORPHOMETRIC PARAMETERS

IMPROVED PIG: The improved pig was, in general, distinguished by a concave profile head (66.7 %), which was observed in 66.67% of the specimens, with an average length of 28.2 ± 0.2 cm. The majority of pigs (62.5%) exhibited a long, thin snout (62.5 %), with an average circumference of 32.6 ± 0.3 cm. The ears were observed to measure 20.4 cm

in length and were found to be generally pointed forward (58.3%) (Table 1). Additionally, a lesser proportion of the subjects exhibited ears that were drooping or semi-lop, pointing backwards or upwards (Table 3). The majority of pigs exhibited a predominantly white coat (91.7%) (Figure 3b). The hair was long and dense, with a smooth surface. The majority of the subjects exhibited a predominantly straight tail (54.1%), rather than a corkscrew-shaped tail (45.8%), with an average length of 28 ± 0.3 cm. The mean height at withers was 65.4 ± 0.5 cm, and the mean body length was 69.8 ± 0.6 cm. With regard to the morphology of the back, 58.3 % of the pigs exhibited a straight back, while 41.7% displayed a saddle-shaped back. The mean length of the pelvis was 20.5 ± 0.3 cm, with a mean width of 16.2 ± 0.2 cm for the hips. The mean chest circumference was 86.1 ± 0.7 cm, while the mean distance from the shoulder width was 13.9 ± 0.2 cm. The mean circumference of the hock and neck was 14 ± 0.1 cm and 64.5 ± 0.7 cm, respectively.

LOCAL PIGS: The local pigs were of a diminutive stature and exhibited a predominantly uniform black coat color (Figure 3c). Their height at the withers was recorded at 51.1 ± 0.7 cm. The head was generally straight, with an average length of 24.2 ± 0.3 cm. The snout was long and thin, with an average circumference of 23.8 ± 0.4 cm, and the ears were 11.5 ± 0.3 cm long and oriented upwards. The predominant characteristics of the skin were smoothness (73.3%), while the hair was observed to be short (60%) and dense (100 %) (Table 3). The backline of the animal was predominantly straight, with mean measurements at the with at the shoulder, the width at the hips, and the length of the pelvis recorded as 9.6 ± 0.3 cm, 10.8 ± 0.3 cm, and 16.4 ± 0.4 cm, respectively. The mean of body length was 47.9 ± 0.8 cm, while the mean of the chest girth was 67.5 ± 0.9 cm. The mean neck circumference was 46.4 ± 0.8 cm, while the mean snout circumference was 23.8 ± 0.4 cm (Table 1). The tail was observed to be straight, with an average length of 21.2 ± 0.5 cm. The mean number of teats was 10 ± 0.7 .

STRESS-NEGATIVE PIETRAIN: The Pietrain is a breed of medium-sized pig with a notably muscular physique (Figure 3a). The animal stood at a height of 58.53 ± 0.8 cm at the withers and exhibited a distinctive piebald-black coat. The head was characterized by a straight and short profile, with erect, forward-pointing ears. Additionally, the snout was observed to be of a short, cylindrical nature (Table 3). The mean values for the head length and snout circumference were 23.6 ± 0.3 cm and 28.8 ± 0.4 cm, respectively. The mean length of the ears was 15.75 ± 0.3 cm. The hair was short and sparse, covering a smooth skin surface. The Pietrain exhibited a broad, straight back, with average measurements of 13.4 ± 0.3 cm for the width at the shoulder, 13 ± 0.3 cm for the width at the hips, and 21.6 ± 0.5 cm for the length of the pelvis (Table 1). The mean values for chest girth and body length were 76.8 ± 1.1 cm

Table 3: Effect of genetic type on phenotypic characteristics of local, improved and Pietrain pigs and the products of their crosses.

Variable	Improved (N=48)		Local (N=24)		PixIm (N=40)		PixLo (N=50)		Pietrain (N=16)		Chi ²
	%	CI	%	CI	%	CI	%	CI	%	CI	
Hair											
Straight	25a	12.3	0b	0	0b	0	0b	0	0b	0	**
Shorts	20.8c	11.5	60b	19.6	100a	0	100a	0	100a	0	***
Long	79.2a	11.5	40b	19.6	0c	0	0c	0	0c	0	***
Dense	75b	12.3	100a	0	35b	14.8	44b	13.8	0c	0	***
Sparse	20.8c	11.5	0c	0	65ab	14.8	56b	13.8	100a	0	***
Snout											
Long and thin	62.5a	13.7	60a	19.6	0b	0	0b	0	0b	0	***
Short and cylindrical	37.5b	13.7	40b	19.6	100a	0	100a	0	100a	0	***
Coat colour patterns											
Uniform	66.7a	13.3	73.3a	17.7	55a	15.4	68a	12.9	0b	0	***
Magpie	25b	12.3	26.7b	17.7	25b	13.4	20b	11.1	100a	0	***
Spotted	8.3b	7.8	0b	0	20b	12.4	12b	9.0	100a	0	***
Coat color											
White	91.7a	7.8	26.7b	17.7	90a	9.3	32b	12.9	100a	0	***
Black	41.7b	13.9	100a	0	35b	14.8	92a	7.5	100a	0	***
Dark red	0a	0	0a	0	10a	9.3	8a	7.5	0a	0	NS
Light red	0a	0	0a	0	15a	11.1	4a	5.4	0a	0	NS
Head profile											
Concave	66.7a	13.3	20b	16	0c	0	0c	0	0c	0	***
Straight	33.3b	13.3	80a	16	100a	0	100a	0	100a	0	***
Ear type											
Semi-lop	16.7a	10.6	0b	0	10ab	9.3	0b	0	0b	0	*
Droopy	29.2a	12.9	0b	0	0b	0	0b	0	0b	0	***
Prick	54.1b	14.1	100a	0	90a	9.3	100a	0	100a	0	***
Ear orientation											
Forward	58.3b	13.9	26.7b	17.7	80a	12.4	72a	12.4	100a	0	**
Backwards	12.5a	9.4	13.3a	13.6	15a	11.1	0a	0.0	0a	0	NS
Upwards	29.2b	12.9	60a	19.6	5c	6.8	28b	12.4	0c	0	**
Skin											
Smooth	75b	12.3	73.3b	17.7	100a	0	100a	0	100a	0	**
Wrinkled	25a	12.3	26.7a	17.7	0b	0	0b	0	0b	0	**
Tail type											
Straight	54.2b	14.1	73.3ab	17.7	70ab	14.2	64ab	13.3	100a	0	NS
Curly	45.8a	14.1	26.7a	17.7	30a	14.2	36a	13.3	0b	0	NS
Back line											
Straight	58.3b	13.9	80ab	16.0	100a	0	100a	0	100a	0	***
Saddle	41.7a	13.9	20a	16.0	0b	0	0b	0	0b	0	***

N: Number; **CI:** Confidence interval; **NS:** Not significant; *: p<0.05; **: p<0.01; ***: p<0.001; percentages of the same line followed by different letters differ significantly at the 5% threshold; **PixIm:** improved female x Pietrain negative stress male; **PixLo:** local female x Pietrain negative stress male.

and 60.1 ± 1 cm, respectively, while the mean values for the hock and neck circumference were 13.1 ± 0.2 cm and 57.9 ± 1 cm, respectively. The tail was 22.7 ± 0.5 cm in length. The mean number of teats was 14.8 ± 0.6.

F1 HYBRID (IMPROVED FEMALE X PIETRAIN MALE): The pigs resulting from crossbreeding between Pietrain boars and improved sows were observed to exhibit predominantly uniform (55%) and less spotted (20%) or magpie (25%) coat patterns (Table 3). Pigs with uniform patterns (55%) were typically white (Figure 4b), whereas those with spotted or magpie coats exhibited magpie-black, white spotted with black, or, in a minor proportion, russet with black spots. The skin was observed to be smooth and covered with short, sparse hair. All crossbreeds exhibited a short, straight head measuring 25.6 ± 0.2 cm in length, with ears positioned erect and forward, measuring 18.4 ± 0.2 cm in length. The snout was of a short, cylindrical configuration. The mean height at the withers was 59.3 ± 0.5 cm, while the mean chest girth was 77.7 ± 0.7 cm. The mean values of tail length, pelvic length, and pelvic width were 24.6 ± 0.3 cm, 23 ± 0.3 cm, and 11.4 ± 0.2 cm, respectively (Table 1). The mean values for the measurements of the neck, snout, and hock were 56.5 ± 0.6 cm, 29.2 ± 0.3 cm, and 13.2 ± 0.1 cm, respectively. The backline and tail profile were straight. Additionally, 30% of the subjects exhibited a curly tail. The mean tail length of male (25.8 ± 1.8 cm) was found to be significantly greater ($p < 0.05$) than that of females (23.4 ± 2.4 cm) (Table 2). The same results were obtained for neck circumference. The mean ear length of males (19.2 ± 0.99 cm) was found to be significantly longer ($p < 0.05$) than that of females (17.6 ± 1.4 cm).

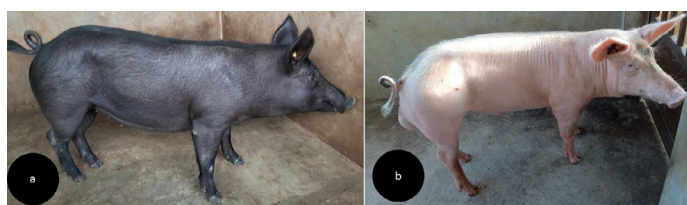


Figure 4: Pietrain-local sow crossbred pig (a); Pietrain-improved (b).

F1 HYBRIDS (LOCAL FEMALE X PIETRAIN MALE): The average height at the withers and body length of F1 crossbred pigs between Pietrain boars and local sows was 47.8 ± 0.4 cm and 44.4 ± 0.5 cm, respectively (Table 1). The predominant coat color was black (92%), and the coat was more uniform (68%) (Figure 4a). The head was typically straight in profile (100%), with an average length of 22.4 ± 0.2 cm. The ears were observed to be forward (72%) and 13.3 ± 0.2 cm in length. The snout, with an average circumference of 23.4 ± 0.2 cm, was of a short, cylindrical shape. The hair was observed to be significantly sparser (56%) than dense (44%) on a smooth skin surface (Table 3). The tail was predominantly straight (64%) and 19.9 cm in length. All pigs exhibited a straight back line (100%), with an average shoulder width of 9 ± 0.2 cm, hip width of 9.1 ± 0.2 cm, and pelvis length of 17.8 ± 0.2 cm. The mean snout and hock circumferences were 45.1 ± 0.7 cm and 10.3 ± 0.1 cm, respectively. The mean number of teats was 12.5 ± 0.4 (Table 1).

DISCUSSION

The study on the phenotypic and morphometric characterization of local, improved, Pietrain pigs and the products of their crossbreeding permitted the discrimination of these genetic groups. In terms of phenotype the characteristics of the local and improved pigs in the present study were found to be consistent with those of local and improved pigs in Benin (Djimenou *et al.*, 2018; Youssao *et al.*, 2018). Similar results were also observed in local pigs from Nigeria, Ghana, and Togo (Adeola *et al.*, 2013; Adjei *et al.*, 2015; Alenyorege *et al.*, 2015; Somenutse *et al.*, 2019). The observed traits in the Pietrain are consistent with the description provided by Piedboeuf (2014) for this breed. This description characterizes the Pietrain as having a white coat spotted with black, a short, straight head bearing small, erect, forward-facing ears, and moderately long legs with well-developed, broad hams. The characteristics exhibited by the two crossbreeding groups (improved female x Pietrain males) and (local female x Pietrain males) were largely in line with those of the Pietrain, with the exception of the appearance of the hair. The hair was slightly denser than that of the Pietrain, and the coat was more uniform, with the crossbred offspring from the local pig displaying a much darker hue and those from the improved genetic type a much lighter one. The prevalence of black pigmentation in crossbred offspring between the local pig and the Pietrain is likely attributable to the coat color of the maternal (local) sow, which is predominantly black, and the presence of a black spot in the sire (Pietrain). This observation confirms the findings of Legault and Chardon (2000) on coat coloration in pigs, which demonstrated that F1 animals resulting from crossbreeding between sows with a black phenotype and spotted Pietrain boars were all black. This suggests that the gene coding for black color is dominant over the gene coding for spotted Pietrain color. Legault and Chardon (2000) demonstrated that all F1 hybrids resulting from crossbreeding white sows with Pietrain boars exhibited a white coat, a finding that is consistent with the results of the present study. These findings also indicate that the gene responsible for the white color is dominant over the gene that causes the spotted pigmentation observed in the Pietrain. Therefore, crossbreeding the improved, white-colored sow with the Pietrain boar resulted in a predominantly white coat coloration. From a phenotypic perspective, the resemblance between crossbreds (improved x Pietrain, local x Pietrain) and Pietrain with regard to hair type (short and sparse), snout type (short and cylindrical), profile (straight), ear type (erect), ear orientation (forward) and tail type (straight) would assist breeders in making an initial selection of crossbred reproducers that are closely aligned with Pietrain. This initial selection could be enhanced by the inclusion of data on morphometric measurements.

The influence of genetic type on the morphometric measurements documented in this study has been previously reported by Okoro *et al.* (2015). These include parameters such as ear length, tail length, chest girth, snout circumference, snout length, height at withers, and body length at birth, weaning, and 20 weeks of age in local pigs, Large White and Landrace pigs, as well as crossbred derived from them. Additionally, Youssao *et al.* (2018) observed an influence of genetic type on morphometric measurements of pigs in Benin, while Karnuah *et al.* (2018) did so in Liberia. The genetic types in question included local pigs, exotic pigs (Large White, Landrace, and Hampshire), and those of crossbred. In comparison to the improved and Pietrain genotypes, the local pigs exhibited the lowest morphometric measurements, as documented by Youssao *et al.* (2018) in Benin in their investigation of local, improved, and crossbred genotypes. The cross between local and Piétrain pigs exhibits a close proximity to the local genotype for the majority of the measured traits. However, these two genotypes diverge in head length, ear length and number of teats, and these traits could be employed in the sorting of crossbred reproducers in order to obtain the most optimal reproducers that are closely aligned with the Piétrain phenotype. The improved pig x Piétrain crosses exhibited morphometric measurements, including basin length, height at withers, thoracic perimeter and neck circumference, that were similar to those observed in the Piétrain. These traits could be employed by farmers to identify the most suitable reproducers in proximity to the Piétrain phenotype following a crossbreeding event involving the Piétrain and an improved pig genotype. The improved breed exhibits similarities to the Piétrain with regard to criteria such as pelvis length and shoulder top, which could assist farmers in the selection of improved reproducers before crossing them with the Piétrain.

In contrast to the findings of the present study, which indicate a significant impact of sex on morphometric measurements, particularly in local pigs and improved pigs, crossbred between improved genotypes and Piétrain, Adjei *et al.* (2015) observed no effect of sex on the measurements of local Ghanaian pigs and their crossbreeds with exotic breeds. The absence of a sex effect in the Adjei *et al.* (2015) study may be attributed to the diversity in breeding practices observed across the study's various locations. Indeed, the study of Adjei *et al.* (2015) was conducted in multiple regions with diverse farmers. In light of the aforementioned considerations, it is plausible that males and females are not reared under identical conditions. Consequently, the elimination of the sex effect observed in females and males may be attributed to this variability in rearing practices. As in the present study, the sex effect has been demonstrated in body measurements of local pigs in Burkina Faso (Tapsoba *et al.*, 2023) and crossbred and local pigs in Nigeria (Oluwole and Omitogun, 2015). The effect of sex is ad-

vantageous for the local female in parameters such as chest girth and shoulder width, which are skeletal and muscular development regions in farm animals (Youssao *et al.*, 2018). This demonstrates significant body development in females to enable them to withstand reproduction, despite the fact that the age of the animals used corresponds to the age at which pigs start reproduction in Benin (Dotché *et al.*, 2018). In the other breeds, no significant differences between the sexes were observed for these parameters simultaneously. However, the trends indicate an advantage for females compared to males.

CONCLUSIONS

The study employed a phenotypic characterization approach to identify and differentiate five distinct genetic types of pigs: local, improved, Piétrain, and the products resulting from their crossbreeding. The lowest measurements were observed in local pigs and F1 crossbreds (local female x Piétrain male), while the highest were seen in improved pigs. Intermediate measurements were exhibited by Piétrain genetic types and F1 crossbreds. Local pigs and crossbreds from the latter exhibited black coats, whereas improved pigs and crossbreds from the former displayed white coats. The coats of local and improved pigs were observed to be longer and denser, while those of Piétrains and their crossbred offspring were noted to be shorter and sparser.

ACKNOWLEDGEMENTS

The authors would like to thank the University of Abomey-Calavi for its support in carrying out this work, thanks to the project entitled "Improving the butchery skills and resilience of the local pig in Benin by crossing with the Piétrain negative stress in southern Benin.", abbreviated as Projet Piétrain, through the Competitive Research Funds Program of the University of Abomey-Calavi (PFCR3IUAC).

NOVELTY STATEMENT

This study offers insights into phenotypic and morphometric traits that could potentially be useful in distinguishing pig genotypes when selecting them for breeding. Additionally, it has provided a means of measuring the level of genetic diversification observed at the phenotype level following crossbreeding between local pigs and Piétrain in Benin.

AUTHOR'S CONTRIBUTIONS

C B Bankolé, I O Dotché, I A K Youssao, M Senou conceived the study design. C B Bankolé, I O Dotché and S

Ahounou collected the data. I O Dotché, D Mahamadou, M Senou and I A K Youssao analyzed the data. C B Bankolé and I O Dotché wrote the manuscript. M Senou, D Mahamadou and I A K Youssao corrected the manuscript. All authors read and approved the final manuscript.

FUNDING

The work was financed by the Competitive Research Funds Program of the University of Abomey-Calavi (PFCR3IU-AC) through the Pietrain project.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

REFERENCES

- Adeola AC, Oseni SO, Omitogun OG (2013). Morphological characterization of indigenous and crossbred pigs in rural and peri-urban areas of southwestern Nigeria. *Open J. Anim. Sci.*, 3: 230-235. <https://doi.org/10.4236/ojas.2013.33034>
- Adjei OD, Osei-Amponsah R, Ahunu BK (2015). Morphological characterization of local pigs in Ghana. *Bull. Anim. Health Prod. Afr.*, 63, 299-304.
- Agbokounou MA, Ahounou GS, Youssao AKI, Mensah GA, Koutinhoun GB, Hornick J-L (2016a). Ethnologie et potentialités du porc local d'Afrique. *J. Anim. Plant Sci.*, 29 : 4665-4677.
- Agbokounou MA, Ahounou GS, Youssao AKI, Mensah GA, Koutinhoun GB, Hornick J-L (2016b). Caractéristiques de l'élevage du porc local d'Afrique. *J. Anim. Plant Sci.*, 30 : 4701-4713.
- Alenyorege B, Kodjo AK, Addah W (2015). Phenotypic Characteristics of the Ashanti Black Pig under intensive rearing. *Vet. Sci.*, 5: 22-27.
- Bankolé K (2019). Perception des éleveurs sur les croisements entre les races exotiques et les races locales porcines. *Memoire de Master en Normes et Contrôle de Qualité des Produits Agro-Alimentaires, EPAC/UAC*, 63 p.
- Cornillon P-A, Guyader A, Husson F, Jégou N, Josse J, Klutchnikoff N, Matzner-Lober E, Rouvière L, Thieurmél B (2018). 'R pour la statistique et la science des données.' Presses Universitaires de Rennes: Rennes, 415p
- Djimenou D, Adoukonou-Sagbadja H, Chrysostome CAAM, Koudandé OD (2018). Caractérisation phénotypique des porcs locaux (*Sus scrofa domestica*) au Sud du Bénin. *J. Anim. Plant Sci.*, 37L: 5956-5975.
- Djimenou D, Adoukonou-Sagbadja H, Koudandé DO, Chrysostome C, Hounzangbe-Adote SM, Agbangla C (2017). Socio-demographic characteristics of pig producers and structure of pig herd in South of Benin. *Int. J. Biol. Chem. Sci.*, 11: 2177-2193. <https://doi.org/10.4314/ijbcs.v11i5.19>
- Dotché IO, Ahounou GS, Salifou CFA, Biobou R, Kiki P, Govoeyi B, Antoine-Moussiaux N, Dehoux J-P, Mensah AG, Farougou S, Thilmant P, Youssao Abdou Karim I, Koutinhoun GB (2018). Selection and culling criteria for breeding boars and sows in pig farms from Oueme and Plateau departments in Benin. *Rev. Elev. Med. Vet. Pays Trop.*, 71: 47-57. <https://doi.org/10.19182/remvt.31224>
- Dotché IO, Idohou S, Dahouda M, Kiki P, Govoeyi B, Antoine-Moussiaux N, Youssao AKI (2019). Crossbreeding and consanguinity management in pig farms in the departments of Ouémé and Plateau in Benin. *Vet. World*, 12: 1816-1825. <https://doi.org/10.14202/vetworld.2019.1816-1825>
- Dotché IO, Bonou GA, Dahouda M, Antoine-Moussiaux N, Dehoux JP, Mensah GA, Farougou S, Thilmant P, Karim IYA, Koutinhoun BG (2020a). Reproductive performances of local pigs in West African countries: A review. *J. Adv. Vet. Res.*, 10:49-55.
- Dotché OI, Bankolé B, Dahouda M, Biobou R, Bonou GA, Antoine-Moussiaux N, Dehoux J-P, Thilmant P, Mensah GA, Koutinhoun GB, Youssao AKI (2020b). Comparison of reproductive performances of local and improved pigs reared in south Benin. *Trop. Anim. Health Prod.*, 52(2): 687-698. <https://doi.org/10.1007/s11250-019-02058-y>
- Dotché IO, Seydou KB, Ahouanse AGG, Tohoum E, Bankolé BC, Youssao Abdou Karim I (2021). Comment concevoir la biosécurité des élevages porcins des milieux lacustres du sud Bénin pour réduire le risque de maintien et de dissémination de la peste porcine africaine ? *Cah Agric.*, 30: 32. <https://doi.org/10.1051/cagri/2021018>
- FAO (2012). Phenotypic characterization of animal genetic resources. *FAO Anim. Prod. Health Guidelines No. 11*. Rome, 142 p.
- FAOSTAT (2024). Cultures et produits animaux. <https://www.fao.org/faostat/fr/#data/QCL>
- Karnuah AB, Osei-Amponsah R, Dunga G, Wennah A, Wiles WT, Boettcher P (2018). Phenotypic characterization of pigs and their production system in Liberia. *Int. J. Livestock Prod.*, 9: 175-183. d
- Kiki P, Dahouda M, Toléba SS, Ahounou GS, Dotché IO, Govoeyi B, Antoine-Moussiaux N, Mensah AG, Farougou S, Youssao AKI, Dehoux J-P (2018). Pig feeding management and pig farming constraints in Southern Benin. *R Rev. Elev. Med. Vet. Pays Trop.*, 71: 67-74. <https://doi.org/10.19182/remvt.31223>
- Legault C, Chardon P (2000). Génétique de la coloration de la robe chez le porc. *Journées Rech. Porc. En. Fr.*, 32: 385-395.
- Leroy PL, Verleyen V (2000). Performance of the Piétrain ReHal, the new stress negative Piétrain line. *Qual. Meat Fat Pigs Affect. Genet. Nutr.*, 161-164. (Proceeding of the joint session of the European Association for Animal Production Commission on Pig Production, Animal Genetics and Animal Nutrition, Zürich, Switzerland) https://doi.org/10.3920/9789086865048_025
- Okoro VMO, Ogundu UE, Udedibie ABI, Okoro CL, Ukwu HO, Ibe SN (2015). Effect of genotype, sex and parity on growth traits of diallel crossed Nigerian indigenous and exotic pigs. *Nig. J. Anim. Prod.*, 42: 30-41. <https://doi.org/10.51791/njap.v42i1.959>
- Oluwole OO, Omitogun GO (2015). Phenotypic evaluation of nigerian indigenous pigs (NIP), its hybrid and backcross for litter and reproductive traits during dry and wet season. *Int. J. Innov. Agric. Biol. Res.*, 3 : 11-18.
- Piedboeuf M (2014). awé-Service porcin: le Piétrain.
- Somenutse KG, Aziadekey MK, Kulo AE (2019). Characterization of local pig in Togo and prediction by barymetry of its live weight. *Livest. Res. Rural Dev.*, 31:.
- Tapsoba SA, Akounda B, Traoré FG, Sawadogo ES, Yougbaré B, Pindé S, Sanou M, Tamboura H, Soudre A, Bayala B, Traore A (2023). Morphological characterization of Burkina Faso

local pig. Rev. Burkinabè Rech. Sci. Nat. Appliquées, 42 : 135-150.
 Youssao AKI, Verleyen V, Michaux C, Clinquart A, Leroy PL (2002). Composition de la carcasse, qualité de la viande et exploitation du Piétrain stress négatif. Ann. Méd. Vét., 146 : 329-338.

Youssao AKI, Dotché IO, Toléba SS, Kassa K, Ahounou GS, Salifou CFA, Dahouda M, Antoine Moussiaux ND, Mensah AG (2018). Phenotypic characterization of pig genetic resources in the departments of Oueme and Plateau in Benin. Rev. Elev Med. Vet. Pays Trop., 71: 59-65. <https://doi.org/10.19182/remvt.31219>