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Full length Research paper

Evaluation of the Reproductive Performances of local Sows in Southern Benin

Omoegiu MO[1&2*], Adoligbé MC[2], Tobada P[2], Amagnidé GA[1], Osei-Amponsah R[3], Edénakpo KA[1] and Koudandé OD[1]

[1]National Agricultural Research Institute of Benin (INRAB), Benin.
[2]University of Abomey-Calavi (UAC), Benin.
[3]Department of Animal Science, School of Agriculture, College of Basic and Applied Sciences, University of Ghana,P. O. Box, LG 226, Legon, Accra, Ghana.

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Native sows contribute to a large extent to food security and poverty alleviation in Benin. However, their reproductive performances particularly under extensive systems are poorly understood. The objective of this study was to fill this knowledge gap by selecting 284 multiparous sows based on hair colour and some reproductive parameters. The results showed that native sows of Southern Benin can be clustered into three groups with group 3 showing the best reproductive performances - highest average litter size (10.31 piglets), live-born piglets (10.31 piglets), number of functional teats (10.94) and shorter average farrowing interval (6 months). The analysis of sows' performances based on their origin revealed that sows from agro-ecological Zone 8 have the highest number of live-born piglets and the lowest age at first mating and first farrowing. The analysis of sows' performances via to hair colour showed that those with black hair have the biggest litter size and the highest number of live-born piglets. This study showed that Benin's native sows have good reproductive ability with enough variation to allow for their selection and conservation for sustainable use for protein food security and wealth creation.

Keywords: conservation, litter size, local pigs, selection, teat number.

INTRODUCTION

Demand in animal protein in sub-Saharan Africa has increased with population growth, urbanization, changes in eating habits and rising living standards (Djimènou, 2019).In Benin, the average annual animal protein consumption estimated at 12 kg per capita which is below FAO's recommendation (20 kg per capita)(FAO, 2015). This gap remains persistent despite substantial meat imports which exceed the annual local meat production, estimated at 187.627 tonnes in 2015 (Dognon et al., 2018).

Therefore, promoting the rearing of animals with a short reproductive-cycle such as pig may contribute to significantly reducing the gap between supply and demand for animal protein in Benin. Native pigs are more prolific than sheep and cattle and have a better ability to survive in harsh conditions (Djimènou, 2019).

Pork is one of the most widely consumed meats in Southern Benin because of its organoleptic qualities, especially its flavour (Djimènou et al., 2020,). The same authors reported that native pigs and their by-products, apart from its use as food, plays a very important role in culture, religion, traditional medicine and occultism in Benin. Moreover, the adaptability of native pig is proven on several levels. Indeed, in terms of health, the native pig is endowed with a high resistance or tolerance to various diseases contrary to exotic breeds that are highly susceptible to them (Randriamahefa, 2002). It develops a high tolerance to trypanosomiasis, ascariasis and can survive several epidemics (Adjei et al., 2015; Osei-Amponsah et al., 2017; Ayizanga et al., 2018, Aryee et al., 2019). Thus, the development of native pigs farming is necessary and requires a sound knowledge of the reproductive parameters of native sows. To date, few studies have been contacted on native sows (Figure 1) in Benin which were on animals reared in improved breeding system (Koutinhouin et al., 2009; Youssao et al., 2009a,b). Data on the reproductive

Corresponding author E-mail: Omoegiumo@gmail.com

performances of local sows reared under extensive farming conditions in Benin remains scanty. However, a good knowledge of the reproductive ability of animal resources in the system there are commonly reared in is essential for their genetic improvement and sustainable use. Hence, this study aims at assessing the best reproductive traits of the native sow breed as a prerequisite for the implementation of the native pig improvement program in Benin.

Figure 1: A native African sow and its litter

METHODOLOGY

Sampling and Data Collection

Pig farmers were selected from 3 of the eight agro-ecological zones in Benin, based on the extent of pig farming in the respective areas. (Djimènou et al., 2018). These include (i) zone 6, (ii) zone 7 and (iii) zone 8(Figure 2). Data were collected on 284 multiparous sows from farmers who had a breeding monitoring sheet. The data collected included sow hair colour, litter size(LS), number of live-born piglets(LBP), number of functional teats(TN), age at first mating(AM), age at first farrowing(AF), interval between farrowings(FI), number of dead-born piglets(DB) and number of piglets dead before weaning(DW).

Statistical Analysis

Selected sows were clustered based on their reproductive performances using hierarchical *clustering* on principal components (*HCPC*) analysis and the individual reproductive parameters of the sows using *Facto Mine R* (Le et al., 2008).The obtained clusters were described by one factor (cluster) Poisson models and Student-Newman-Keuls (SNK) mean structuring tests (Crawley, 2013) using *agricolae* (de Mendiburu, 2017). Two *stepwise* canonical discriminant analyses were performed to cluster selected sows according to their area of origin, hair colour and reproductive parameters by *kla R* (Weihs et al., 2005).Two further canonical discriminant analyses were then performed to evaluate the discrimination of (i) sow provenances (ZAE) and (ii) sow robes based on pre-selected reproductive parameters by *candisc* (Friendly and Fox, 2017). All these analyses were performed in the R statistical environment version 3.4.1 (R Core Team, 2017.

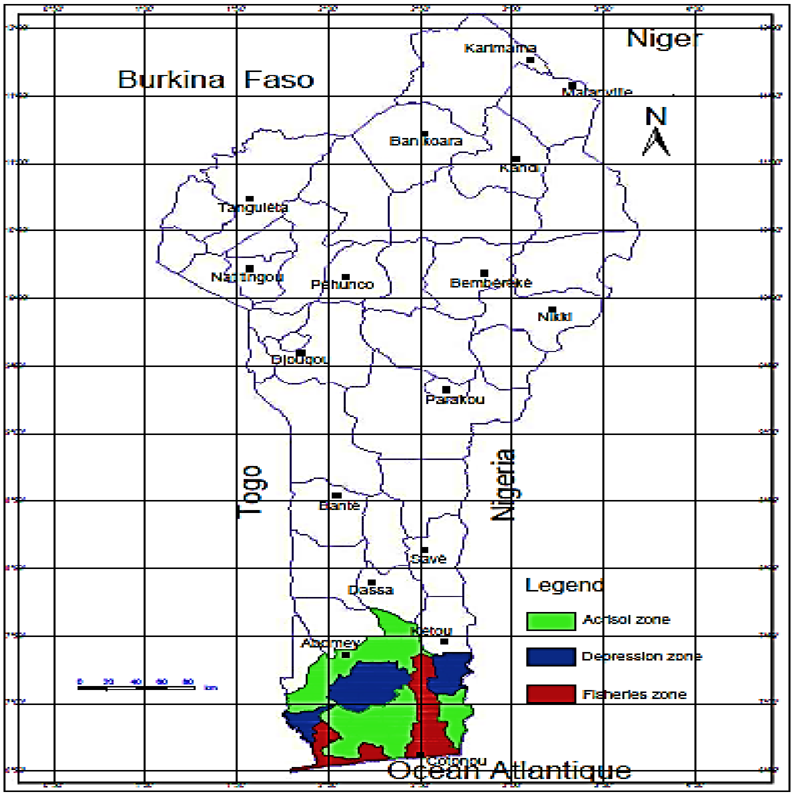

Figure 2: Areas study

RESULTS

Discrimination of Sows According to Reproductive Performance

The results of the Hierarchical Principal Component Classification (HCPC) showed that the selected sows can be distributed into 3groups including[Cluster 1:30 sows (10.56%); Cluster 2:107 sows (37.68%) and Cluster 3:147 sows (51.76%) respectively] (Figure 3).

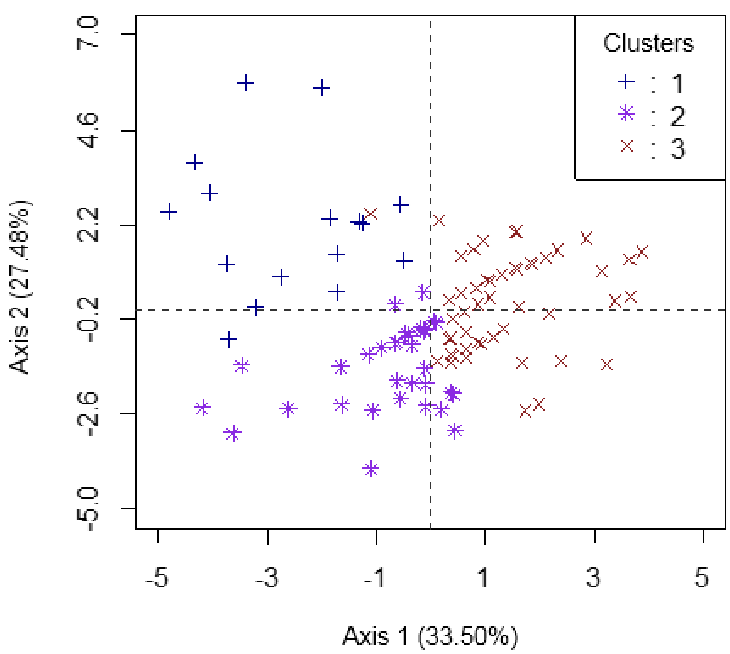

Figure 3: Distribution of the Three Sow Clusters into the 1 & 2 Axes HCPC System

As shown in Table 1, reproductive performance varied significantly ($p \leq 0.05$) between clusters ($p \leq 0.05$)with sows in Cluster 3 having the best values for LS, LB and TN while sows in Cluster 2 have the best value for AM, AFF, FI and BD. Sows in Cluster 1 have the worse value for all parameters except for DW.

Table 1: Characteristics of Sow Clusters

Cluster	Reproductive Parameters							
	LS	**LBP**	**TN**	**AM (months)**	**AF (months)**	**FII**	**DB**	**DW**
1	7.67[b#] (2.06)	7.33[b] (1.69)	10.87[a] (1.46)	9.23[a] (2.13)	13.23[a] (2.13)	7.03[a] (0.85)	0.33[a] (1.27)	0.50[b] (0.78)
2	7.53[b] (1.51)	7.50[b] (1.55)	9.70[b] (0.79)	5.76[b] (0.70)	9.72[b] (0.79)	5.99[b] (0.22)	0.04[b] (0.27)	0.35[b] (0.70)
3	10.37[a] (1.22)	10.31[a] (1.25)	10.94[a] (1.04)	5.79[b] (0.75)	9.76[b] (0.86)	6.00[b] (0.17)	0.05[b] (0.33)	1.03[a] (0.92)
Overall	9.01 (2.01)	8.94 (2.01)	10.46 (1.17)	6.14 (1.44)	10.11 (1.50)	6.11 (0.46)	0.08 (0.51)	0.72 (0.89)
p-value	0.000	0.000	0.008	0.000	0.000	0.104	0.000	0.000

LS: litter size;**LBP**: number of live-born piglets;**TN**: number of functional sow teats;**AM**: age at first mating;**AF**: age at first farrowing;**FI**: interval between two consecutive farrowings;**DB**: number of dead- bornpiglets;**DW**: number of piglets dead before weaning. The values in brackets represent the coefficients of variation. Within columns means followed by different superscripts vary significantly at the 5% threshold

Table 2:Distribution of Sows according to their Origin: Absolute Frequency and Relative Frequency (in brackets)

Agro-ecological Zone	**Cluster**		
	1	**2**	**3**
Zone 6	14 (46.67%)	42 (39.25%)	54 (36.73%)
Zone 7	14 (46.67%)	37 (34.58%)	25 (17.01%)
Zone 8	2 (6.66%)	28 (26.17%)	68 (46.26%)
Overall	30 (10.56%)	107 (37.68%)	147 (51.76%)

Table 3:Hair Colour Distribution within Clusters: Absolute Frequency and Relative Frequency (between brackets)

Sow Hair Colour	**Cluster**		
	1	**2**	**3**
White	5 (16.67%)	18 (16.83%)	33 (22.45%)
Black	8 (26.67%)	24 (22.43%)	51 (34.69%)
Black with white shoulder belt	2 (6.67%)	18 (16.82%)	14 (9.52%)
Black with white belt on the side	7 (23.33%)	16 (14.95%)	15 (10.20%)
Black with white spots	5 (16.66%)	16 (14.95%)	17 (11.57%)
Magpie	3 (10.00%)	15 (14.02%)	17 (11.57%)

The distribution of sows according to their origin (Table 2) revealed that Cluster 1 was dominated by sows from agro-ecological Zones 6 and 7 while Cluster 3 is dominated by sows from agro-ecological Zones 8 and 6 (Table 2). Though the majority of sows in Cluster 2 are from Zone 6, there is also a significant number of sows from Zone8 and Zone 7 that fall into this group. Regarding hair colour, black was dominant in all clusters (Table 3).

Discrimination of Agro-ecological Zones according to the Reproductive Performances of Sows

The results of the stepwise canonical analysis on the reproductive parameters of the sows (Table 4) showed that the number of LBP, the M and the AF were the reproductive parameters that discriminate agro-ecological zones.

Table 4. Discriminant Stepwise Analysis on the Reproductive Parameters of Sows.

Number of Step	Variable	F	Pr>F	Wilk's Lambda	Pr>Lambda
1	LBP	15.02	0.000	0.903	0.000
2	AM	6.36	0.002	0.864	0.000
3	AF	2.17	0.116	0.851	0.000

LBP: number of live-born piglets; **AM**:age at first mating;**AF**:age at first farrowing.

Table 5 presents the results of the inferential tests and the mean characteristics of the sows for the discriminating variables according to the agro-ecological zones. It showed a concordance of the results of the inferential tests and the stepwise canonical discriminant analysis, confirming the discriminating power of the agro-ecological zones on LBP, AM and AF ($p < 0.05$).

The average of the reproductive parameters of the sows (Table 5) indicate that heir AM and AF in agro-ecological Zone 8 were lower (one month less on average) than values obtained in agro-ecological Zones 6 and 7. On the other hand, LBP was higher in agro-ecological Zone 8 than in Zones 6 and 7 by one and two units respectively. It's worth to mention that sows in agro-ecological Zone 7 have the highest AM and AF and the lowest LBP.

Table 5:Variation of Discriminating Reproductive Parameters of Sows according to Agro-ecological Zones

Agro-ecological Zone	AM	AF	LBP
Zone 6	6.24^{a} (1.63)	10.15^{b} (1.76)	8.99^{b} (1.97)
Zone 7	6.59^{a} (1.61)	10.59^{a} (1.61)	8.00^{c} (2.16)
Zone 8	5.67^{b} (0.79)	9.68^{c} (0.79)	9.60^{a} (1.62)
Overall	6.14 (1.44)	10.11 (1.50)	8.94 (2.00)
Prob	**0.000**	**0.000**	**0.001**

LBP: number of live-born piglets; **AM**: **a**ge at first mating;**AF**:**a**ge at first farrowing.

Within columns means followed by different superscripts vary significantly at the 5% threshold. Prob:=probability of significance.

The canonical discriminant analysis performed on the reproductive parameters of the sows according to the three agro-ecological zones investigated (Table 6) indicated that Canonical Axis 1 includes all three reproductive parameters. Thus, AM and AF negatively correlated with this axis, showed that the sows in Zone 7 have high values for these two parameters. In contrast, the sows in Zone 8 had high values for the number of live-born piglets (Figure 4).

Hair Colour Discrimination of Sows Based on their Reproductive Performances

The results of the stepwise discriminant analysis of the reproductive parameters and hair colour of sows (Table 7) showed that LBP and LS were the parameters which discriminated the hair colour of sows on the basis of Wilk's Lambda statistics and associated probability value.

Table 8 presents the results of Poisson's regressions and the trends of the discriminant reproductive parameters according to the sow's hair colour. The analysis of the reproductive parameters revealed that globally there are two clusters of sows: the first cluster is composed by black, white and magpie hair and the second cluster consists of black and white spots, black with a white belt on the flank and black with a white belt on the shoulder hair. Irrespective of the

Table 6: Canonical Discriminant Analysis of the Reproductive Parameters of Sows according to Agro-ecological Zones

Variables	Canonical Axes	
	1	**2**
Sows' Reproductive Parameters		
AM	**-0.690**	0.298
AF	**-0.651**	0.058
LBP	**0.845**	0.311
Agro-ecological Zones		
Zone 6	-0.033	0.172
Zone 7	**-0.542**	-0.123
Zone 8	**0.458**	-0.098

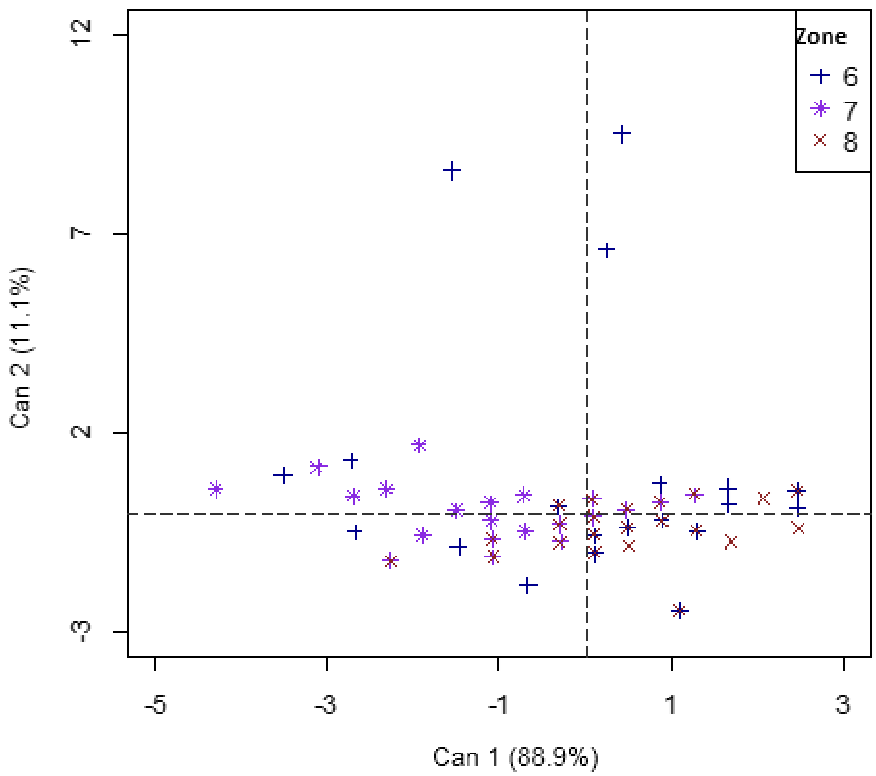

Figure 4: Discrimination of Local Sows according to Reproductive Parameters Using Agro-ecological Zones in the Axes System

Table 7: Discriminant Step-by-step Analysis of the Reproductive Parameters of Sows according to Hair Colour.

Number of Step	Variables	F	Pr>F	Wilk's Lambda	Pr>Lambda
1	LBP	0,017	0,952	0,017	0,010
2	LS	0,100	0,921	0,011	0,016

LS: Litter size;**LBP**: number of live-born piglets.

reproductive parameter considered, the first sow cluster shows the best performance.

Within columns means followed by different superscripts vary significantly at the 5% threshold.

Table 8: Reproductive Characteristics of Sows according to Dress Colour (i.e., standard deviations (between brackets) and Probability of Significance (Prob.)

Dress Colour	**LBP**	**LS**
Black	9.34^{a} (0.27)	9.41^{a} (0.21)
White	9.29^{a} (0.34)	9.38^{a} (0.27)
Magpie	9.14^{a} (0.28)	9.14^{a} (0.33)
Black with white spots	8.45^{b} (0.21)	8.71^{b} (0.38)
Black with white belt on the side	8.42^{b} (0.37)	8.45^{bc} (0.28)
Black with white shoulder belt	8.29^{b} (0.33)	8.29^{c} (0.34)
Overall	8.94 (2.01)	9.01 (2.01)
Prob.	0.015	0.016

LS: litter size;**LBP**: number of live-born piglets.

DISCUSSION

The present study, on the basis of a selected number of reproductive parameters (litter size, live born piglets and age at first mating) reveals the existence of three clusters among the native sow breed in Southern Benin. The LS varies significantly between clusters and can reach up to 10 piglets on average. This value is above those reported in most previous studies carried out in Benin and other sub-Saharan African countries. This variation could be due to the variation in breeding practices, feeding, environment and genetic types (Ranjit et al., 2015).In Benin, the reported average litter size of the native sow in traditional breeding system was 5.74 piglets (Atodjinou and Dotcho, 2006). In improved system, recorded values fell between 6.31 and 8.8piglets (Koutinhouin et al. 2009, Youssao et al., 2009a, b; Agbokounou et al., 2016, Dotché et al., 2020). Likewise, d'Orgeval (1997) reported closer value in Nigeria (6.7) and Cameroon (7.8) respectively. The average LS obtained in this study (9.1) is close to value recorded from exotic breeds reared in improved breeding system in Southern Benin(9.7) (Youssao et al., 2009a) but also in their original environment (9-10.5) (Nowak et al., 2020).What implies that the native sow can performed better if management practices are improved as stated by Djimènou (2019) and that exotic breeds are less productive in tropical environment compare as recognized by Naves et al.(2011). The number of average LBP in the present study was higher than 5.3 recorded with native sows of Bangladesh (Motaleb et al., 2014).The Prolificacy of native sows in Southern Benin was a criterion for the national breeding program aiming at increasing the numerical productivity of local sows in Benin. It was noticed that sows with the highest number of teats have the highest litter size. Thus, the number of functional teats could be used as indicator of the sows being prolific.

The AM (6 months) was similar to that recorded in improved pig breeding system (Youssao et al., 2009a, b) and lower than that recorded in traditional breeding system (9 months) (Dotché et al., 2018) in Benin and then than that recorded in Bangladesh native pigs(7.5 months) (Motaleb et al., 2014).Thus, the present study showed that the genetic potential of the native sows in terms of sexual maturity is not fully utilized yet in Benin.

The AF (10.11 months on average) and the FI(6 months) obtained were similar to recorded values of 10.43 months and 6.09 months respectively in Bangladesh native sows (Ritchil et al.,2014). Moreover, the age at first farrowing observed was less than 11.88 months in local pigs in Ouémé and Plateau departments in Benin (Dotché et al., 2020) and 12.5 months in Indian pigs (Singh et al., 2020). In contrast, the age at first farrowing in present study was higher than that (9.1 months) in Nigerian pigs (Abah et al., 2019).Based on their farrowing interval, native sows can far row twice a year, which demonstrates the profitability of pig farming compared to sheep, goat and cattle farming. The mortality rate from birth to weaning (8% in average) was 2.5 times lower than the rate reported in large-white pigs bred in intensive systems (Youssao et al., 2009a). Overall, the observed differences can be explained by various reasons. Firstly, as reported in the methodology, data were collected from farmers which had a certain rigour in the breeding management (confinement system, arranging and keeping the sow breeding management sheet up to date). Thus, these breeders had an organized breeding practice (choice of begetter based on performance), a diet that meets the maintenance and production needs of animals. Pigs, especially local pigs, are omnivores whose digestion physiology is very well adapted to the valorization of fodder and food resources that are poor in nutritional value (Djimènou et al., 2017). So, the availability in sufficient quantities of kitchen and crop residues, domestic processing by-products and green fodder are sufficient to feed pigs in traditional breeding and obtain better results. In addition, the sows that have served to the data collection were multiparous (two farrowing minimum), whereas more the number of farrowing increases, more the litter size is higher. As long as the animals are not in divagation system, they are protected from predation, bad weather such as heat, road accidents, rain and diseases. All these conditions are factors that promote productivity and reproductive parameters in sows in present study.

This difference confirmed the ability of native pigs to live and survive in harsh conditions. The heterogeneous distribution of sows within agro-ecological zones for all traits is in agreement with the previous results of the phenotypic characterization of native pigs (Djimènou et al., 2018). However, the discriminant analysis identified three sow reproductive parameters (LS, AM and AF) which differ significantly across zones. Thus, local sows in Benin have a good reproductive ability that can be improved for their conservation and sustainable use for protein self-sufficiency and wealth creation in Benin.

CONCLUSION

This study reported on the reproductive performances of native sows reared in extensive farming systems in Southern Benin. The existence of great variations in some reproductive parameters such as litter size, at-birth viability of piglets, age at first mating, is a good asset for selecting individuals with higher performances in order to improve productivity at herd level. Additionally, to ensure a sustainable management of native sows, it is important to utilise molecular genetic characterization tools such as marker-assisted selection and SNP genotyping to improve accuracy of selection and hasten their genetic improvement for protein food security.

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