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Comparative performance and analysis of indigenous pig production systems in Cameroon: constraints and socio-economic characterization in three agro-ecological zones

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ABSTRACT

A socio-economic characterization of the indigenous pig farming systems, performance analysis, and constraints were carried out in three agro-ecological areas of Cameroon such as Sudano-Sahelian (SSA), Western highland (WHA) and Humid forest with bimodal rainfall Areas (HBA). A questionnaire was administered to 157 farmers. The data were analyzed using the descriptive statistics procedure. The results showed that pig farming was mainly practised by men over forty year old (79.1%), with a low level of technical supervision and having reached the level of primary education (44.6%). The production systems in HBA and SSA are mostly extensive whereas in WHA these systems were mostly semi-intensive. The piggeries were made with wooden pens (61.1%). The farms were more prone to feed shortages in the SSA and WHA. The animals were mostly fed once (45.8%) or twice (38.9%) a day. Animals were largely unvaccinated (40.8%) and not dewormed (59.9%). The SSA farming system was the least efficient in terms of gross added value per sow per year (GVA /sow/year = 398 USD) while the WHA and HBA (GVA/ sow/year in the WHA = 1305 USD and GVA /sow/year in the HBA= 1210 USD). This characterization is important for future improvements in livestock management, especially with the indigenous pig farming system in Cameroon.

Keywords: Cameroon, breeding, management, productivity, swine**.**

INTRODUCTION

All animals, breeds, strains, or species that are economic, scientific, cultural, and human interest in terms of food production and agricultural products are called animal genetic resources (AnsGR) (Rege and Gibson, 2003). The role of AnsGR in safeguarding human well-being can be felt in different ways. AnsGR is an essential component of world food security because a hundred million poor people rely on their animals to provide multiple products and services (FAO, 2012). Today

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around 795 million people are underfed in the world, predominantly in developing countries, and the increased demand for animal protein is estimated at 70% by 2050 (FAOStat, 2018). Cameroon counts about 25.2 million inhabitants and pork is consumed by nearly 70% of that population (Kouam et al., 2020). This percentage represents 12% of total meat production after that from poultry (40%) and cattle (34%) (FAOSTAT, 2018). The number of pigs bred in Cameroon is estimated at 3.11 million heads. Pig's production reached about 40.000 tons in 2016 and projections for 2020 indicated an increase of about 10% (Mfewou and Lendzele, 2018). Pig products represent not only a source of proteins but also income for many farmers. Indigenous pigs play an important role to smallholder farmers in various countries (Thutwa et al., 2020). Those in Cameroon are the Bakossi, Bakweri, Bamileke, Mankon long nose and Kousseri breeds. In general, they are known for their good quality and tasty meat and are considered adapted to the local breeding systems (Motsa'a et al., 2018). They easily adapt to changes in environmental conditions and convert food waste into valuable products that complement the local economy. In addition, they have several advantages over other farmed animal species due to their large spans (Mbuthia et al., 2015). Pigs allow to transit from local to an economic resource due to their pedigrees which can be produced more quickly (Akoa, 2006).The relatively low production cost, rapid growth rate, short generation interval, and high production potential are beneficial (Djimenou et al., 2017a; Djimenou et al., 2021). However, the lack of rigor in livestock standards in terms of infrastructure, feeding, and health does not allow Africa's local resources in general and pigs especially, to express optimally their zootechnical performance (Motsa'a et al., 2018). Information on Cameroon indigenous pig's population of some agro-ecological zones, status, production characteristics, and economic uses need to be updated. The objective of this study was to carry out a comparative analysis of indigenous pig farming performance, constraints, and socio-economic characteristics from three different agro-ecological zones of Cameroon.

Materials and methods

Description of the study zones

This study was carried out in three Cameroonian agro-ecological zones, defined based on the climatic conditions, geographical positions, and altimetric features (Figure 1). The Sudano-Sahelian Area (SSA) is located between 8°36" to 12°54" North latitudes and 12°30" à 15°42" east longitudes. This area is characterized by a monomodal rainfall type with variable intensity (400 to 1200 mm per year). Its surface is 100,353 km^2. The annual average temperature is 28°C, with maxima of 40 to 45°C in April. The SSA is represented, in the Far North Region, by three divisions: Diamaré, Mayo Kani, and Mayo Danay (Cheo, 2016). The Humid forest area with bimodal rainfall (HBA) is located from 2°6" to 4°54"/5°48" North latitudes and from 10°30" to 16°12" east longitudes. It is characterized by an average annual temperature of 25°C, a bimodal rainfall regime (1500 to 2500 mm/year), and relative humidity of 70 to 90%. This agro-ecological zone is represented by three divisions: Upper Sanaga, Mfoundi, and Lékié. Its surface area is 165,770 km^2. The Western highland Area (WHA) is located between 4°54" to 6°36 "North latitudes and 9°18" to 11°24 "east longitudes. The average temperature is low at 19°C, and the rainfall is heavy (1500-2000 mm/year) in a monomodal pattern. The WHA is constituted by the Bamboutous, Menoua, and Noun divisions. Its surface area is 31,192 km^2 (Djoufack, 2011). These agroecological zones are known for their high densities of production and marketing of pigs, with about 0.6 million heads in both the SSA, HBA and about 1.7 million individuals in the WHA (INS, 2015).

Farm selection

Authorization for the survey of local pig farms was obtained from the Ministry for Livestock, Fisheries, and Animal Industries. Farms were located with the help of the regional, divisional and sub-divisional delegates. Other farms were located using the snowball technique where a previously located farmer helps to spot a neighbor and so on.

Cross-sectional survey

A total of 157 volunteer farmers from the three agro-ecological areas were enrolled: 34 in the SSA, 55 in the HBA, and 68 WHA. A structured questionnaire was administered to participants; it sought information on the description of social and economic characteristics, management system, feeding, pig diseases, and reproduction management, environmental control, constraints, and the movement of pig breeds between different systems.

Calculation of livestock system performance

The technical and economic performance of each breeding system was calculated using an Excel spreadsheet. The unit of economic production taken into account in the calculation of the economic performance of a given breeding system was the sow. Several basic questions guided this step: how many times per year does a sow give birth? How many piglets does it have? How many die?

For each breeding system, the following parameters were evaluated

- gross product per sow per year = (difference between the selling price and the purchase price of the sow + value of all products sold during the reproduction cycle of a mother) / duration (per year) of the reproduction cycle.
    - *Piglet production/sow/year = number of litters/year x number of piglets born/sow*
    - *piglet mortality rate = number of live piglets/sow/year = numerical productivity at weaning.*
    - *Sold production/sow/year = number of litters/year X number of piglets born/litter X (1-piglet mortality rate) X (1-adult mortality rate before sale) = numerical production at sale.*
    - *Manure production = Amount of manure produced per year per sow X (selling price of manure + Amount of manure produced per piglet (before sale) per year) X selling price of manure* (Devienne and Wybrecht, 2002).

- Intermediate consumption = reproduction cost + feed cost + health cost + maintenance cost (building and equipment)
    - *Fattening increases intermediate consumption by 2/3 and piglets are vaccinated on average twice a year (*Cadero et al., 2017*)*

- Gross value added = Difference between the values of the gross product and intermediate consumption per sow per year.

Statistical analysis

Data collected were transferred into a numeric data format and assembled using Excel 2012. Basic statistics (frequency, mean and standard error) were calculated using Statistical Analysis System (SAS), version 9.4. Software. Differences between means were tested using the Student Newman Keuls test (Clark and SAS, 2004).

Ethical clearance

Before any interview, the objectives of the study were first explained to each respondent whose participation was voluntary and anonymous. Respondents expressed their willingness and consent to participate.

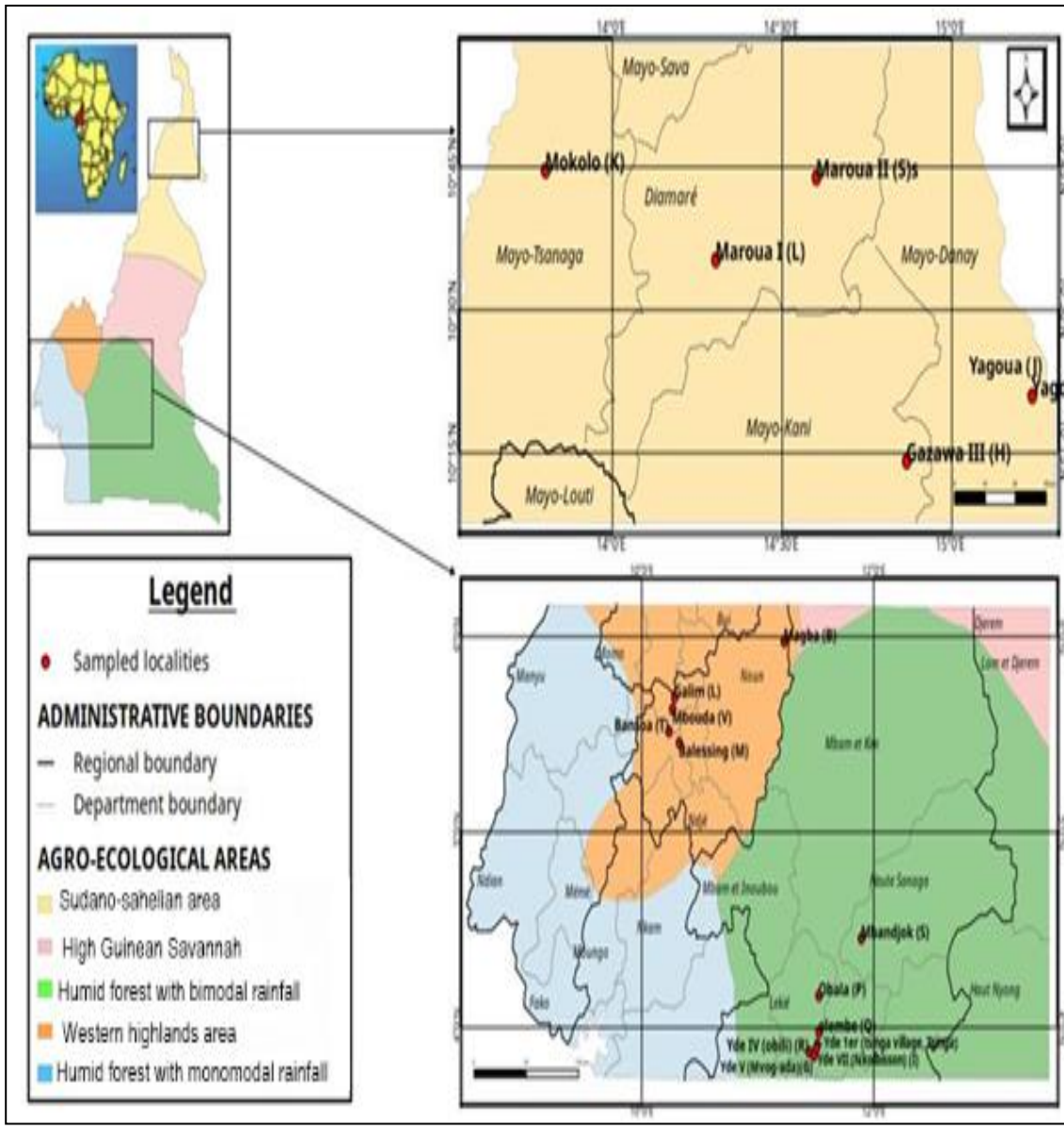

Figure 1: Map showing the three different agro-ecological zones (QGIS Development Team, 2009).

RESULTS

Description of production systems

Traditional pig farming is most widespread in the regions (53.3% in the WHA, 76.9% in the HBA, and 93.7% in the SSA).

In the WHA, the local breed "Bamileke pig" predominated and the traditional breeding was mainly semi-intensive. The average number of pigs per farm varied from 7 to 12, which partly lived in pens or were left to roam freely, mainly in rural areas. The pigs were fed on mixed and combined kitchen waste, agro by-products (spent grains, oil cake, and bran). Animals wandered around in search of a few tubers and other food products in the fields or food scraps in the refuse dongs. When they

returned to the pigsty, they received the bran from the cereals as a feed supplement. Livestock farmers in the WHA and HBA were mainly cow-calf fatteners (98.2% and 79.8% respectively); these occasionally sold piglets to other farmers. Breeders were confronted with the problems of reproduction and diseases due to the uncontrolled nature of this type of farming. The SSA was characterized by two types of traditional pig farming. On the one hand, a permanent divagation, a system in which production units generally had 5 to 6 pigs, human and financial investments of farmers were derisory. The animals roamed all year round to feed and drink water by themselves. They were local breeds and destined exclusively for sale. On the other hand, the semi-stabling system was the most common type of farming (93.7%) and characterized by a rudimentary shelter, limited and irregular distribution of agricultural by-products (12.5%), and kitchen wastes (87.5%). Pigs spend the day out of the compound. On average about 12 pigs per farm were reared in this type of farming. Animals were of the local breed still called "pigs of the SSA" in 94.11% of the farms despite some crossbreeding with exotic breeds (Large White, Landrace). Rearing conditions were rudimentary, without respect for housing and hygiene standards; animals were affected by the spread of African swine fever (71.4%) in the rainy season. Food and sanitary coverage were either approximate or non-existent. Livestock farmers were breeder-fatteners (76.7%) or fatteners (23.3%). The latter bought young pigs from farrows on the farm or in markets when prices were low.

Socio-economic profile of the livestock owners

The Table 1 shows that livestock farmers were mainly men (79.1%) over forty years old; most of the respondents were farmers (56.7%) and had a primary school education (44.6%). However, it appeared that while respondents (52.7% in the HBA and 38.2% in the SSA) did not have a chance to go to school, all of those in WHA had at least primary school education. These results reflect the low level of training in pig farmers. Only 3.6%; 26.5% and 33.8% actors were trained in the HBA, SSA, and WHA respectively.

Breeding system and feed management

The main livestock system, particularly in rural areas, was the traditional extensive type (57.97%), although an alternative model seemed to be emerging through the semi-intensive system (40.7%), which was more oriented towards marketing. Only the WHA showed an intensive industrial model in livestock management; it represented 1.27% of the farms surveyed. Most of the piggeries were built with wooden pens (61.1%) with concrete floors. However, a considerable percentage of piggeries (32.5%) were built with iron sheet pens, and few pigs housed (6.4%) with mud-brick in SSA. Figure 2 illustrates some housing systems found in three agro-ecological study zones (Table 2)

The farms were more prone to feed shortages in the SSA and WHA. This constituted a major constraint in the development of the practice. However, it should be noticed that animal feed was mainly made up of agro-industrial feed supplements (62.4%), household and kitchen waste (24.2%) and in some cases locally purchased feed (13.4%). The animals were mostly fed once (45.8%) or twice (38.9%) a day.

Diseases and treatments

From the farms surveyed, it appeared that the animals were largely unvaccinated (40.8%) and not undewormed (59.9%), which makes them vulnerable to diseases and infections of all kinds, such as African swine fever (19.1%), salmonella diarrhoea (25.5%) and others (31.2%), as well as mouth and stomach infections (24.2%) (Table 3).

Economic performance

Zoo-economic parameters

The average age at childbearing for sows was around six months (5.92 months) in the HBA and (5.84 months) the WHA while in the SSA this age is delayed to almost seven months. On average, these animals had a

double litter per year until the end of their career, which generally occurred after 4 years. The number of pigs per farrowing was higher in the WHA (9.53 pigs) and HBA (8.23 pigs) than in the SSA (7.31 pigs). The mortality rate of young animals until the sale was relatively low (less than 17% in the WHA and HBA) and reached 19.25% in SSA; the age at sale was 8.12 months for the SSA, and a little earlier in the WHA (7.06 months) and the HBA (6.92 months), although these data didn't vary significantly.

The selling price of piglets fluctuated around 54.16 USD with disparities between the northern and southern zones. The average price of an adult pig was 112.94 USD in the SSA, 153.03 USD in the WHA, and 154.85 USD in the HBA. These prices followed the same logic when buying a sow at the beginning of her career and at the time of culling: they were higher in the WHA and the HBA than in the SSA.

Finally, in addition, to live pigs, pig farming also produces droppings that were sold and used in the fields by farmers. This was a significant source of income (Table 4).

Intermediate costs

Intermediate inputs were mainly the cost of feed supplements and veterinary care, which were passed on to both young and adult pigs each year. The costs of feed supplements were around 24.30 USD per sow and 6.87 USD per piglet. Veterinary care costs amount to USD 9.82 per sow and 3.96 USD per piglet (Table 5).

The gross product

The calculation of the gross product makes it possible to highlight the value produced per sow over its entire career and to relate it to the year for greater precision. Thus, the gross product over the whole career of a sow (Table 6) was less important in the SSA (1961.21 USD) than in the HBA (4763.58 USD) and in the WHA where it was the highest (5933.69 USD). Over the year, a sow produced USD 557.89 in the SSA, USD 1179.59 in the HBA, and USD 1487.14 in the WHA

Intermediate consumption

Intermediate consumption was also more important in the HBA and WHA than in the SSA (Table 7). Over the entire career of a sow, they represented about 774.09 USD in the HBA, 722.79 USD in the WHA and only 555.32 USD in the SSA. They were around USD 179.41 per year per sow.

Gross value added (GVA)

The gross value added represents the wealth created per sow over its entire career. This estimate was reported on a yearly basis for greater precision. Thus, over its career and over the year, a sow earned much more in the WHA and HBA than in the SSA (Table 8). On average, a sow earned 3541.85 USD over it career and 1033.04 USD per year.

Table 1: Socio-economic profile of traditional pig farmers in the different agro-ecological areas.

Variables	Agro-ecological areas(N)			Total no. (%)
	HBA	SSA	WHA	
Age (years)				
20 – 29	2	2	4	8(5.1%)
30 - 39	15	17	6	38(24.2%)
≥40	38	15	58	111(70.7%)
Sex				
Female	17	10	20	47(29.9%)
Male	38	24	48	110(70.1%)

Profession				
Public workers	13	0	4	17(10.8%)
Farmers	15	21	53	89(56.7%)
Traders	8	11	0	19(12.1%)
Others	19	2	11	32(20.4%)
Educational status				
No school	29	13	0	42(26.8%)
Primary school	11	2	57	70(44.6%)
Secondary School	11	17	8	36(22.9%)
University	4	2	3	9(5.7%)
Trained farmers				
No	53	25	45	123(78.3%)
Yes	2	9	23	34(21.7%)

Table 2: Breeding and feed management.

Variables	**Agro-ecological areas**			**Total no. (%)**
	HBA	**SSA**	**WHA**	
Breeding system				
Extensive	42	31	18	91 (57.97%)
semi –intensive	13	3	48	64 (40.7%)
Intensive	0	0	2	2 (1.27%)
Type of building material				
wooden pens	25	24	47	96 (61.1%)
iron sheet pens	30	10	11	51 (32.5%)
mud brick walls	0	10	0	10 (6.4 %)
Feed scarcity				
No	0	2	9	11 (7.0%)
Yes	55	32	59	146 (93%)
Feeding practice				
Kitchen waste	23	2	13	38 (24.2%)
Commercial feed	4	9	8	21(13.4%)
Agro-by-product	28	23	47	98 (62.4%)
Feeding frecency/day				
Once	46	17	9	72 (45.9%)
Twice	4	17	40	61 (38.9%)
Thrice	5	0	19	24 (15.3%)

Figure 2: Types of piggeries in the three agro-ecological zones: a) old iron sheet pens in HBA and c) constructs with mud bricks in SSA were semi-extensive; b,e) wooden pens in WHA; d,f) extensive pig farming system in HBA and SSA.

Table 3: Disease and treatment in pig farming.

Constraints	Agro-ecological areas			Total no. (%)
	HBA	SSA	WHA	
Diseases				
African Swine Fever (ASF)	2	0	28	30(19.1%)
Foot and mouth diseases (FMD)	19	0	19	38(24.2%)
Diarrhea (*Salmonella, E. coli*)	21	11	8	40(25.5%)
Other diseases	13	23	13	49(31.2%)
Prophylaxis				
None	39	15	10	64(40.8%)
Deworming	10	11	42	63(40.1%)
Vaccination	6	8	16	30(19.1%)

Table 4: Zoo-economic parameters of traditional pig farms.

Variables	Agro-ecological areas			All
	SSA	WHA	HBA	
Breeding age (months)	6.75 ± 1.06 [a]	5.84 ± 0.60 [b]	5.92 ± 0.74 [b]	5.72 ± 0.67
Age at (end of procreation) (months)	41.68 ± 3.43 [b]	47.93 ± 2.62 [a]	48.46 ± 2.87 [a]	45.80 ± 2.92
Number of litters per year	1.87 ± 0.71 [a]	1.93 ± 0.66 [a]	1.84 ± 0.61 [a]	1.90 ± 0.67
Number of piglets per litter	7.31 ± 2.02 [b]	9.53 ± 2.38 [a]	8. 23 ± 2.45 [a]	8.17± 2.25
Piglet mortality rate from piglet stage to sale (%)	19.25[a]	15.46[b]	14.25[b]	16.83
Age at sale (months)	8.12 ± 3.38 [a]	7.06 ± 2.01 [a]	6.92 ± 3.42 [a]	7.70 ± 2.76
Selling price of piglets (USD / unit)	47.83±9.44 [b]	56.06±11.83 [a]	58.48±11.09 [a]	54.16± 10.48
Selling price of adult pigs (USD)	112.94±16.91 [b]	153.03±18.96 [a]	154.85±19.13 [a]	140.56± 17.28

NB: 1 USD=547…FCFA Values (mean ± SEM of pig of the same agro-ecological area) with the same letter in the same line are not significantly different.

Table 5: Intermediate costs.

Variables	Agro-ecological areas			Total
	SSA	WHA	HBA	
Annual feed cost supplements for the sow (USD)	22.7 ± 4.15 [b]	20.07 ± 4.20 [b]	28.01±8.1 [a]	24.30±4,29
Annual Feed supplements cost per piglet (USD)	6.9±2.43 [a]	5.91±2.38 [a]	7.56±3.53 [a]	6.87±2.80
Annual veterinary care cost for the sow (USD)	9.95±3.66 [a]	7.19±2.73 [b]	11.38±4.46 [a]	9.82±3.57
Annual Veterinary care cost per piglet (USD)	3.68±0.53 [a]	2.83±0.29 [a]	3.63±0.55 [a]	3,96±0.43

Values (mean ± SEM of pig of the same agro-ecological area) with the same letter in the same line are not significantly different.

Table 6: Gross product per pig farm surveyed.

Variables	Agro-ecological areas			Total
	SSA	WHA	HBA	
Number of piglets/sow/year	12,26±2,02[b]	16,96±2,80[a]	13,97±2,30[b]	14,4±2,37
Number of young /sow/year	9,89±1,86[b]	14,34±2,79[a]	11,11±2,1[a]	12,2±2,29
Number of piglets sold/ sow/ year	4,94±0,92[b]	7,17±1,40[a]	5,55±1,08[a]	6,18±1,15
Number of piglets sold in a sow's reproduction cycle	17,14±4,26[b]	28,64±7,25[a]	22,41±5,67[a]	23,14±5,75
Sow manure/quarry product (USD)	107,56±25,55[b]	176,02±42,20[a]	154,57±37,05[a]	147,39±35,01
Manure product/piglets (pre-marketing) / sow reproduction cycle (USD)	13,33±3,78[b]	23,94±6,88[a]	22,27±6,40[a]	20,07±5,70
Difference between the sale price and the purchase price of a sow (USD)	69,64 ± 22,65[a]	78,71±25,70[a]	39,61±12,93b	62,9±20,46
Monetary value of piglets in a sow's reproduction cycle (USD)	81,64±65,61[b]	1605,63±1005,71[a]	1310,63±1060,10[a]	1005,71±808,28

Monetary value of young adults on the reproduction cycle of a sow (USD)	1935,87±732,90[b]	4382,81±1660,94[a]	3470,28±1315,12[a]	3266,22±1236,57
Gross product on a sow's quarry (USD)	1961,21±946,87[b]	5933,69±2870,68[a]	4763,58±2304,59[a]	4228,15±2041
Gross product/sow/year (USD)	557,89±245,51[b]	1487,14±654,96[a]	1179,59±519,511[a]	1075,69±473,39

Values (mean ± SEM of pig of the same agro-ecological area) with the same letter in the same line are not significantly different.

Table 7: Intermediate consumption per traditional pig farm surveyed.

	Agro-ecological areas			
Variables	**SSA**	**WHA**	**HBA**	**Total**
Cost of feed for the sow on her reproduction cycle, (USD)	78,79±12,79[b]	80,09±13,00[b]	113,14±18,37[a]	92,21±14,97
Cost of feed for piglets sold over the sow's reproduction cycle, (USD)	118,36±17,47[b]	169,28±25[a]	169,48±25,01[a]	153,6±22,67
Feed costs for fattened piglets over the sow's reproduction cycle, (USD)	197,26±30,00[b]	282,13±42,90[a]	282,46±42,95[a]	248,52±37,79
Cost of sow veterinary care (USD)	34,52±5,83[b]	28,72±4,85[b]	45,95±7,76[a]	37,69±6,36
Cost of veterinary care for piglets sold at the sow quarry (USD)	126,38±13,00[b]	162,57±16,72[a]	163,02±16,77[a]	157,3±16,18
Total cost of intermediate consumption in the sow's quarry (USD)	555,32±69,43[b]	722,79±90,37[a]	774,09±96,80[a]	686,44±85,83
Total cost of intermediate consumption per sow per year (USD)	160,03±10,45[b]	181,15±11,84[a]	191,68±12,52[a]	179,41±11,72

Values (mean ± SEM of pig of the same agro-ecological area) with the same letter in the same line are not significantly different.

Table 8: Gross added value per indigenous pig farm surveyed.

	Agro-ecological areas			
Variable	**SSA**	**WHA**	**HBA**	**Total**
GAV of a sow over the duration of her reproduction cycle (USD)	1405,89±563,52[b]	5210,89±2088,70[a]	3989,51±1599,13[a]	3541,85±1419,69
GAV/sow /year (USD)	397,85±147,21[b]	1305,98±483,25[a]	1209,9±447,70[a]	1033,04±382,26

Values (mean ± SEM of pig of the same agro-ecological area) with the same letter in the same line are not significantly different.

DISCUSSION

Based on the results from this study, the majority of traditional pig farmers in the three agro-ecological zones were men. A similar observation was also reported in Cameroon Ndébi et al. (2009) a decade before. Additionally, the majority of respondents were averagely forty years old. This age can be explained either by the activity itself, (which requires a certain amount of initial financial capital that is often not available to younger age) or by the fact that the peri-urban location or even the rural activity involves more elderly people. The limited number of women in this

sector is probably due to the harshness of this type of farming fundamentally different from small animal and poultry farming which is more accommodating (Mbuthia et al., 2015; Djimenou et al., 2017b; Motsa'a et al., 2018).

Most of these livestock keepers with at least a primary level of education were predominantly engaged in agriculture which represented their main source of income. This finding corroborated observations of Akilimali et al. (2017), who characterized smallholder pig production systems in three agro-ecological zones in South Kivu (Democratic Republic of Congo) and of Fualefac et al. (2014) who showed that 86% of pig farmers in northern Cameroon were able to read and write. This characteristic should allow farmers to better manage livestock systems and improve performance. Unfortunately, in this work, most of these farmers were neither supervised nor trained in livestock husbandry practices; this was a major constraint to the development of the different farming systems as Akoa Etoa (2019) reported previously. Moreover, the lack of training facilities for the selection of appropriate techniques in the systems studied forces most livestock farmers to acquire their knowledge through experience.

Breeding systems were essentially extensive in HBA and SSA, while in WHA, the semi-intensive system was practised. These results support the findings of Ndebi et al (2009) who indicated that pig production systems were highly (85.2%) semi-intensive in the North region and mostly (84.3%) cloistering in the West region. It is known that free-ranging encourages high incidences of random and uncontrolled mating (Motsa'a et al., 2018). Under such circumstances, pigs from different households can mate with little or no monitoring; this contributes to inbreeding (Mbuthia et al., 2015). In the local breeding system, herd management was also based on the: extensive, semi-intensive, and intensive modes. Even though extensive breeding was generally dominant, especially in the rural environment, these three breeding systems were often governed by the calendar of agricultural activities. The majority of herders were forced to practice permanent or seasonal confinement due to the damage caused by wandering, difficulty in controlling the animals, conflicts between herders and farmers, the rapid spread of disease, etc. (Agbokounou et al., 2016; Youssao et al., 2008a).

In agro-ecological areas, pigs were housed of installs made up of various materials such as wood, iron sheets, mud-brick walls. Motsa'a et al (2018) also reported that indigenous pig houses in the monomodal rainfall area of Cameroon were built using locally available materials. It is recommended that pigs should be housed in facilities that have ample protection against environmental risks, stress, good sanitation, and hygienic conditions, sufficient space, minimum feed wastage which are as cheap as possible (Mbuthia et al., 2015) This is to protect them from adverse temperatures (hypothermia and hyperthermia), wind, wet floors, and diseases. It has been noticed that where pigs are left to free-range and only penned during the rainy season, herd composition changes significantly during the periods of confinement due to high farrowing incidence (Djimenou et al., 2017a).

Farm prone feed shortage and animals were fed mostly once, with agro-by-product, principally in WHA. Feed cost constitutes a serious obstacle to the achievement of these objectives, as it represents 70% of total investments (Dieumou and Tandzon, 2017). Pig farming systems of considered agro-ecological areas with feed scarcity remind a great constraint. Feeding indigenous pigs with kitchen waste is a common practice in Africa (Yassou et al., 2009, Mbuthia et al., 2015; Dieumou and Tandzon. 2017; Djimenou et al. 2017a; Mfewou and Lendzele. 2018; Motsa'a et al., 2018; Kouam et al., 2020; Thutwa et al., 2020; Tassou et al., 2021). The use of unconventional feed resources in traditional pig farming was also reported by Dieumou and Tandzon (2017) who worked on Feed Management in Pig Production and an Attempt for Improvement: A Case Study of Babadjou Locality in the Western Region of Cameroon.

Absence and/or non-observance of the technical, hygienic, and prophylaxis program adapted to the local breed weakens the performance of local pig breeding. Although they have a high capacity and tolerance to harsh climates (Djimenou et al., 2017a). The wastes are likely to carry the ASF virus from the remains of a contaminated pig because the virus can survive for months in protein-rich materials (FAO, 2012). The wastes are also likely to carry other viruses (rotavirus, coronavirus, and swine influenza viruses), bacteria (*Erysipelothrix rhusiopathiae*, Salmonella spp, *Escherichia coli*), and parasites (Cryptosporidium spp., coccidia, helminths). Kitchen wastes are serious hazards in pig farming in the country in general because feeding pigs with kitchen waste is a common practice countrywide. Farmers need to be sensitized to the danger of such a practice (Kouam et al., 2020).

Concerning the evaluation of economic performance and, in particular, the gross added value of each agro-ecological zone surveyed, it appears that the traditional systems of the WHA area was economically better than those of the HBA and SSA as already reported by Etoa et al., (2019). Therefore, it seems more economically opportune to carry out this activity in the WHA and HBA rather than in the SSA of Cameroon which suffers from more marked functional difficulties (food shortages, unhealthy housing, almost non-existent sanitary coverage and proliferation of diseases, uncontrolled reproduction and increased inbreeding rates, difficulty in obtaining improved breeds, etc.). The WHA compared to the two other areas has the highest gross product and gross added value. The performance of this agro-ecological area based on reproduction parameters, numerical productivity by weight, and economics: almost two (1.93 ± 0.66) litters on average per year, 9.53 ± 2.38 piglets per litter, a mortality rate of around 15.46%, and more than 14 pigs sold per sow. of which around half are previously fattened, which gives more value to the production. The best breeders have specific characteristics and profiles. They are trained and supervised in pig farming (35.5% of breeders in the West for a general average of 21.4% in all areas).

In addition to these technical aspects, which reduce fixed costs and increase the gross product, performances can also be explained by the traditional feed, which is quite widespread in the southern commodity chain system. The WHA and HBA unlike the SSA are important agricultural areas where pig feeding is facilitated by the wide availability of agricultural products and by-products, such as cassava, banana, maize grains, yam, sweet potato, etc., which are also available in the WHA and HBA (Akoa, 2006). Often practicing mixed feeding, livestock owners also benefit from the strong local presence of feed mills and local private companies specializing in the production of complete feeds. Examples include EPA (Elevage Promotion Afrique). NAAPCAM (Nouvel Appui Agropastoral du Cameroun), SPC-Agrocam (Société des Provenderies du Cameroun), etc. (Akoa, 2006). These results are in line with the work of Kiki et al (2018) based their study on southern Benin which shown that the improvement of productivity of local breed pigs requires better feeding. This is generally mixed (traditional and supplementary feed).

Ndébi et al. (2009) through the study of margins in the pork marketing channels in Cameroon already presented the system of the Great South as the most efficient with profit margins practically identical between the WHA and HBA. However, the difference was at the level of the type of pork marketed, whether fresh meat, standing pork, or braised pork. According to these authors, the trade margin on live pigs is much more volatile and lower than that of fresh meat and braised pork due to the structuring of transaction costs and the profit margin generated to the benefit of the trader at the farmer's expense.

Conclusion

This study compared Cameroonian indigenous pig farming, production systems and its constraints and socio-economic characteristics from three agro-ecological

areas. These activities are mainly practiced by men in their forties and over, with a lower level of education and no training in pig's production. The constraints identified can be overcome through improved management, health care, and extension support coupled with genetic improvement to provide quality breeding animals by the ministry of livestock production and animal industry. These zootechnical performances in connection with the management of reproduction and the supervision of the breeders make the highland areas the most economically successful in terms of pig breeding. It is therefore important that public and private management structures consider raising awareness and training farmers in the management of pig farms in these environments to promote increased reproduction better rearing techniques, the development of professionalization of pig farms, and the development of policies to this effect. The technical challenges support is to succeed in making each system evolve according to its possibilities. Improving the general structure of pig production by upgrading the farms is also necessary. The promotion of the economic benefit of pig farming should guide research and production improvement through institutional strengthening to ensure the promotion of sustainable growth of the different farming systems.

COMPETING INTERESTS

The authors of this manuscript have no competing interests.

AUTHORS' CONTRIBUTIONS

OSMG and PFM designed the study. Data collection, analysis, and the first draft of the manuscript: OSMG, DPVM; review and editing: VPM, KAE, CFBB, and PFM. All authors read and approved the manuscript.

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