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Smallholder pig production systems along a periurban-rural gradient in the Western provinces of the Democratic Republic of the Congo

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Abstract

In the Democratic Republic of the Congo (DRC), pigs are raised almost exclusively by smallholders either in periurban areas of major cities such as Kinshasa or in rural villages. Unfortunately, little information is available regarding pig production in the Western part of the DRC, wherefore a survey was carried out to characterize and compare 319 pig production systems in their management and feeding strategies, along a periurban - rural gradient in Western provinces of the DRC. Pig breeding was the main source of income (43 %) and half of respondents were active in mixed pig and crop production, mainly vegetable garden. Depending on the location, smallholders owned on average 18 pigs, including four sows. Piglet mortality rate varied from 9.5 to 21.8 % while average weaned age ranged between 2.2 and 2.8 months. The major causes of mortality reported by the farmers were African swine fever 98 %, swine erysipelas (60 %), erysipelas trypanosomiasis (31 %), swine worm infection (17 %), and diarrhoea (12 %). The majority of the pigs were reared in pens without free roaming and fed essentially with locally available by-products and forage plants whose nature varied according with the location of the farm. The pig production systems depended on the local environment; particularly in terms of workforces, herd structure and characteristics, production parameters, pig building materials, selling price and in feed resources. It can be concluded that an improvement of Congolese pig production systems should consider (1) a reduction of inbreeding, (2) an improvement in biosafety to reduce the incidence of African swine fever and the spread of other diseases, and (3) an improvement in feeding practices.

Keywords: pig rearing, smallholder farming, feeding strategies, health

1 Introduction

Raising pigs plays an important role in many tropical countries. Smallholder farming systems improve livelihood and food security for the poorest people (Dixon *et al.*, 2001; Keoboualapheth & Mikled, 2003; Kumaresan *et al.*, 2007). In addition to providing protein for human consumption, pigs are often one of the main sources of cash income in rural areas and provide manure for cropping (An *et al.*, 2004).

In the Democratic Republic of the Congo (DRC), pigs are raised almost exclusively by smallholders either in periurban areas of major cities such as Kinshasa or in rural villages. Industrial pig production is barely developed (CAVTK, 2003). According to different reports it appears that there is an increasing number of small and medium size semi-intensive pig-keeping enterprises at

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the expense of intensive pig farms in and around towns and cities (CAVTK, 2003; NEPAD & FAO, 2006). This situation is probably related to the political situation. The lack of employment caused by the wars of 1996-1998, the steady insecurity in the eastern part of the country and the injustice in the distribution of national wealth have encouraged the practice of informal activities including pig breeding. This informal economy in general, and pig production in particular promotes greater self-sufficiency and provides a greater food security to urban households (Mougeot, 2000) and increases incomes. Nonetheless, pig farms are under the influence of variables laying constraints or offering opportunities that vary according to the location of the farm. This is likely to yield variability in the production systems that will possibly reflect in differing needs regarding development programs. For instance, periurban sites in Kinshasa have an easier access to profitable markets, commercial concentrates and agro-industrial by-products while rural producers do not have all of these three aforementioned advantages. However, pig farmer in rural sites have the opportunity to obtain agricultural products such as cassava and maize at an affordable price. The absence of profitable market is due to people's poverty, suitable means of transformation and the high costs of product transportation to Kinshasa and its approximately eight millions of potential customers. Taking actions in order to make the pig rearing activity more efficient and sustainable requires the availability of data on its management in order to address the major constraints laid on pig smallholders. Unfortunately, little information is available regarding pig production in the Western part of the DRC, wherefore this study aims at characterizing and comparing smallholder pig production systems along a periurban - rural gradient of the Kinshasa and the Bas-Congo province. More specifically, this work focuses on feed resources, feeding management, breeding system, productivity and sanitary issues of pig production systems by considering differences in resources and constraints on local scale.

2 Materials and methods

A survey was conducted in four periurban municipalities of Kinshasa and in four rural areas in the Bas-Congo Province. The four periurban municipalities were N'djili (N'djili), Kimbanseke (Kimba), Mont-Ngafula (Mont), and N'sele (N'sele) (4° 19′ 19″ S, 15° 19′ 16″ E). N'djili and Kimbanseke are located to the southeast of Kinshasa, N'sele to the east and Mont-Ngafula to southwest. These four municipalities cover an area of 11.4, 273.8, 358.9 and 273.8 km^2, with 29123, 2495, 630 and 176 inhabitant per km^2 respectively for N'djili, Kimbanseke, Mont-Ngafula and N'sele. Except for N'djili, all sites are considered as periurban municipalities characterised by intense agriculture and husbandry and related activities including firewood exploitation and harvest of caterpillars, nuts, exotic fruits, mushrooms, raffia and palm wine, ferns and others (Biloso Moyene, 2008). N'djili is located more in the middle of the city. However, the presence of an agricultural perimeter with lower population density along the N'djili river favoured the installation of numerous small pig farms. The four rural areas that were surveyed in the Bas-Congo Province were Kasangulu (Kasang, 4° 43′ 24″ S, 15° 17′ 23″ E), Kisantu (Kisan, 5° 7′ 25″ S, 15° 5′ 46″ E), Mbanza-Ngungu (Mbanza, 5° 20′ 23″ S, 14° 50′ 14″ E) and Boma (Boma, 5° 46′ 40″ S, 13° 6′ 32″ E). All eight sites were selected because they were known for having a high density of pig farms. They have almost the same climate, characterised by a rainy season of eight months from mid-September to mid-May with a drop in rainfall between December and February and a dry season of four months extending from mid-May to mid-September. The average annual temperature is 25 °C and the relative humidity is 79 % (Department of Land Affairs, Environment, Nature Conservation, Fisheries and Forestry MAFECNPF, 1999).

2.1 Survey organisation

The present study involved surveys and direct on site observations from July 13 to September 13 2010. Only smallholders showing over 1.5 years of experience in pig production were considered. A total of 319 farmers were interviewed, 40 smallholders in each site except Kasangulu where only 39 farmers were interviewed. Smallholders were randomly selected on the basis of a list obtained either from farmers associations or local authorities. Lists from different sources were merged per surveyed site and farmers were continuously numbered. Numbers were randomly drawn until the sample size was reached.

Four agricultural engineers were trained for the survey before going on field. They were trained to use spring scales. The questionnaire had previously been tested by surveyors in farms located in the valley of the Funa (Kinshasa). The results of this pre-survey are not included in this paper. The questionnaire was administered in a single pass. The technique of data collection consisted of questions followed by a discussion when needed for clarity in relation to breed, names of plants and their use and the common causes of death.

The questionnaire had six main sections including the characterisation of the farm organisation and household, breeding management and productivity parameters, feed resources and feeding strategies, housing conditions, health issues and marketing. Where farmers had their own records of pigs' weight, those data were used in this study. If not, when animals of both categories considered for weight data (around weaning and around first mating) were present on the farm at least three animals for each category were weighed by the farmer with spring scales provided by the surveyors to serve as reference to estimate the weight of the others pigs. The weight of an animal was accepted only when surveyors and farmer's estimations agreed. If not, that animal was also weighed. Questions regarding feeding systems were open questions in order to allow the farmer to give enough details about his system.

2.2 Survey statistical analysis

Chi-squared analyses were used to test the independence of variable between survey sites using SPSS. The MIXED procedure of SAS was performed to compare means of quantitative data between sites. Correspondence analysis of SAS was used to study the reconciliation between the sites location and the ingredients fed to the pigs.

3 Results

3.1 Farm organisation and household structure

The nucleus family was composed of 5.9 to 7.5 people on average (Table 1). Pig breeding was either a male (47 %) or a family-run business (42 %). Few pig farms were under the supervision of women (11 %). No effect of the location was found in terms of family composition ($P > 0.05$). However, workforces, mains sources of income and children's participation in the activity were dependent on the location ($P < 0.001$). In Kisantu and Kasangulu the caretaking of pigs was performed almost exclusively by men who were the head of the households, while in Mbanza-Ngungu the whole family was involved in this activity. Family members were the major contributors to the farm workforce, while hired workers were on average present in 35 % of the farms.

3.2 Level of specialisation

The level of specialisation of smallholders varied ($P < 0.001$) according to location and province. Among them, some combined cropping and pig production, others were merely breeders while the majority had formal or informal activities in addition to agriculture (Table 2). Nevertheless, pig breeding was the main source of income of most farmers, followed by cropping and other off-farm activities such as a formal job (Table 2).

Table 1: *Household structure and farm organisation of smallholder pig production systems in the Western provinces of the Democratic Republic of the Congo (% of households) (n=40 per site).*

	Kinshasa				*Bas-Congo*				*Mean percentage*
	N'sele	*N'djili*	*Kimba*	*Mont*	*Boma*	*Mbanza*	*Kasang*	*Kisan*	
Family size (χ^2, P=0.069) *									
Lowest through 5	26	24	50	29	23	16	41	35	31
6 to10	64	71	47	66	73	76	42	60	62
More than 10	10	5	3	5	5	8	17	5	7
Average size of households	7.3	6.8	5.9	6.5	6.8	7.5	6.7	6.1	
Workforces (χ^2, P=0.001)									
Family	58	62	49	58	100	61	43	85	65
Hired workers	42	38	51	42	0	39	57	15	35
Rearing and feeding (χ^2, P<0.001)									
Men	40	26	51	68	17	3	80	90	47
Women	12	6	5	11	30	8	7	5	11
All Familly	46	68	44	21	53	89	13	5	42

* P: Chi-square tests, probability between sites.

Table 2: *Farmer speciality and main source of income of smallholder pig production systems in the Democratic Republic of Congo (% of households) (n=40 per site).*

	Kinshasa				*Bas-Congo*			
	N'sele	*N'djili*	*Kimba*	*Mont*	*Boma*	*Mbanza*	*Kasang*	*Kisan*
Specialty (χ^2, P<0.001) *								
Pig production	17.5	2.6	10.3	20.5	2.6	7.3	13.8	5.1
Pig production and cropping	20.0	53.8	51.3	9.1	10.3	14.6	10.3	23.1
Pig production, cropping and others activities	62.5	43.6	38.4	70.4	87.1	78.1	75.9	71.8
Main source of income (χ^2, P=0.042)								
Pig production	39.6	45.2	44.1	47.7	48.1	47.7	38.8	31.2
Cropping	20.9	36.9	35.5	26.1	8.6	12.8	16.5	28.6
Salary, petty trade and donation	39.5	17.9	20.4	26.2	43.3	39.5	44.7	40.2
Agricultural crops (χ^2, P<0.001)								
Vegetables	88.0	96.7	100	95.5	33.3	100	82.4	59.5
Food crops	12.0	3.3	0	4.5	66.7	0	17.6	40.5

* P: Chi-square tests, probability between sites.

The types of agricultural crops were mostly vegetable crops and cassava (7 %), except in Boma ($P < 0.001$). Farmers (21 %) also owned other animal species, mainly indigenous chicken (32 %), ducks (28 %), goats (14 %) and sheep (8 %). Farms were often located near water points (stream and pond).

3.3 Herd structure and characteristics

The average number of pigs per farm was 17.9±0.9 for all 319 farms and varied from 12.4 in Boma to 25.4 in Kasangulu (Table 3). The average number of sows, litter size and weaned piglets differed between sites and varied from 2.6 to 4.6, 7.4 to 9.7 and 6.7 to 8.5, respectively. Pre-weaning mortality rates varied from 9.5 to 21.8 % between sites. The age of the piglets at weaning ranged between 2.2 and 2.8 months according to the site. Globally, piglets were weaned on an average age of 2.5 months but between 1.5 and 2 months in 70 % of the cases. At that stage, piglet's weight ranges about 7.9 and 11.7 kg. However, when post-weaning feed was lacking, the breeder may keep piglets suckling for up to 4 months. First mating occurred when the gilt was about 7.3 to 8.9 months old but male first mating depended more on its weight rather than its age. Although this parameter was not constant across the different locations that were surveyed, reform of sows was practiced early. Indeed, on average 76 % of the farmers reformed sows not later than after the third parturition. Boars were not kept for a long time either as they were sold before they reached the age of 3 years of use in 71.0 % of the farms (Table 4).

3.4 Breeds

It was difficult to identify the actual proportions of the different breeds of pigs found in the study area. According to the statements of the breeders, it would be Large White, Piétrain, local pork (large black), Landrace and hybrids resulting from local breeds crossed with exotic breeds. However, some animals considered as Large White or Piétrain did not show all the phenotypical characteristics of these breeds while others had offsprings with highly diversified phenotypical characteristics (dress color, shape of the ears and the profile of the back of the animal). The most prevalent dress colors were white, spotted black and black.

3.5 Reproductive management

Breeding systems were very similar among smallholders. They can be assimilated to a "breeder-fattener" structure. Farmers bred sows and their piglets until the fattening pigs reached the expected slaughter weight. However, they sometimes sold weaned piglets. Sometimes sows and boars were never really reformed but sold before they reached the end of their reproductive career (Table 5). The number of farmers who owned at least one boar varied from one location to the other (P<0.001). Nsele displayed to lowest rate of boar presence with 37 % while Boma the highest (88 %). In the other locations, boars were present, in 62, 65, 57, 56, 74 and 59 % of the farms, for N'djili, Kimbanseke, Mont-Ngafula, Mbanza-Ngungu, Kasangulu and Kisantu, respectively The other farmers borrowed boars to avoid

Table 3: *Reproductive performance, birth and weaning litter size of 319 smallholder pig production systems in the Western provinces of the Democratic Republic of the Congo (% of households) (n=40 per site).*

	Means								Min	Max	S.E.M	P values of sites effect
	Kinshasa				Bas-Congo							
	N'sele	N'djili	Kimba	Mont	Boma	Mbanza	Kasang	Kisan				
Number of pigs per farm	14,5 ^{a} *	14,7 ^{a}	22,2 ^{bc}	18,5 ^{ab}	12,4 ^{a}	23,2 ^{bc}	25,4 ^{c}	12,7 ^{a}	2,0	102,0	0,86	<.001
Number of sows per farm	3,1 ^{a}	3,9 ^{a}	4,5 ^{b}	4,0 ^{ab}	4,0 ^{ab}	4,6 ^{b}	5,3 ^{b}	2,6 ^{a}	1	25	0,18	<.05
Number of boars per farm	0,5 ^{a}	0,7 ^{a}	0,9 ^{ab}	0,7 ^{a}	1,1 ^{b}	0,7 ^{a}	1,2 ^{b}	0,6 ^{a}	0	4	0,04	<.001
Gilt weight at first mating (kg)	50,3 ^{b}	52,9 ^{bc}	50,7 ^{b}	52,1 ^{bc}	43,6 ^{a}	43,1 ^{a}	56.2 ^{c}	45,8	35	90	0,54	<.001
Gilt age at first mating (month)	7,3 ^{a}	8,2 ^{ab}	8,1 ^{a}	8,7 ^{b}	7,8 ^{a}	8,5 ^{b}	7,3 ^{a}	8,9 ^{b}	5	12	0.09	<.001
Boar weight at first mating (kg)	55,4	57,2	55,0	53,8	53,9	57,0	57,6	53,5	40	90	0.72	0.083
Boar age at first mating (month)	8,4 ^{ab}	8,8 ^{b}	9,1 ^{b}	8,9 ^{b}	8,8 ^{b}	11,1 ^{c}	7,5 ^{a}	9,7	6	18	0,14	<.001
Piglets born alive per litter	8,0 ^{ab}	8,7 ^{b}	8,6 ^{b}	8,7 ^{b}	7,4 ^{a}	9,6 ^{c}	9,7 ^{c}	7,6 ^{a}	4	12	0,11	<.001
Piglets weaned per litter	7,0 ^{a}	7,4 ^{a}	7,7 ^{ab}	6,8 ^{a}	6,7 ^{a}	8,0 ^{b}	8,5 ^{b}	6,7 ^{a}	3	12	0,11	<.001
Age at weaning (month)	2,3 ^{a}	2,2 ^{a}	2,2 ^{a}	2,2 ^{a}	2,8 ^{b}	2,3 ^{a}	2,2 ^{a}	2,4 ^{a}	2	4	0,03	<.001
Weight at weaning (kg)	8,6 ^{b}	7,9 ^{a}	8,6 ^{b}	9,2 ^{c}	8,0 ^{a}	9,9 ^{c}	11,7 ^{d}	8,1 ^{ab}	4	15	0,15	<.001

* In a row, means followed by a different letter differ at a significance level of 0.05

Table 4: *Phenotypical characteristics of pigs of 319 smallholder pig production systems in the Democratic Republic of Congo (% of response).*

	Kinshasa				Bas-Congo			
	N'sele	N'djili	Kimba	Mont	Boma	Mbanza	Kasang	Kisan
Dress color (χ^2, P<0.0001) *								
White	63,9	61,8	58,7	59,7	84,4	65,6	50,9	62,6
Black	6,6	18,2	17,5	9,7	0	32,8	12,3	14,2
Spotted black	31,1	27,3	23,8	33,9	15,6	1,6	36,8	24,9

* P: Chi-square tests, probability between sites

maintenance costs. Mating is then either paid in cash or by giving a female piglet at weaning. Some farmers do not charge friends or relatives for mating with their boar.

3.6 Health issues

The main disease constraints mentioned by the farmers, were African swine fever (ASF) (95 %), swine erysipelas, diarrhoea, trypanosomiasis, worm infections (Table 6) and to a lower extent various diseases such as mange, enteritis, cysticercosis, colibacillosis, respiratory disease, coccidiosis, paralysis, pneumonia and smallpox.

Globally, ASF was the most feared disease by almost 100 % of the pig smallholders. The noted diseases were identified by the farmer or by a veterinarian according to the symptoms, seldom by sample analysis in a laboratory. The majority of farmers (74 %) never called a veterinarian and there was no site difference (P=0.099). Except for the Mont-Ngafula site, most of those who did not call a veterinarian, practice self-medicine while the remaining did not take any action because of a lack of financial resources. The use of vaccine depended on the investigated site (Table 7). Some farmers declared to have vaccinated their herd against swine erysipelas (43 %). Moreover, some farmers declared that they had vaccinated their animals against ASF (53 %) and trypanosomiasis (45 %) while to our knowledge no vaccine exists against any of these two diseases.

Table 5: *Reform of sows (number of parturition) and boars (number of years use) (% of households) (n=40 per site).*

	Kinshasa				*Bas-Congo*			
	N'sele	*N'djili*	*Kimba*	*Mont*	*Boma*	*Mbanza*	*Kasang*	*Kisan*
Sows (parturition) (χ^2, P<0.001) *								
1 to 2	8,6	24,3	12,9	18,2	30	50	7,4	23,1
3	68,6	59,5	54,8	51,5	57,5	47,5	44,4	56,4
4	14,3	10,8	9,7	18,2	10	0	22,2	15,4
5	8,6	5,4	22,6	12,1	2,5	2,5	25,9	5,1
Boars (years) (χ^2, P<0.001)								
1	22.7	70.8	46.2	3,6	77,5	0	12,5	25,8
2	50.0	12.5	30.8	60,7	12,5	61,5	50,0	25,8
3	18.2	12.5	7.7	25,0	2,5	38,5	25,0	29,0
≥4	9.1	4.2	15.4	10,7	7,5	0,0	12,5	19,4

* P: Chi-square tests, probability between sites

Table 6: *Main diseases reported by pig smallholders in the Democratic Republic of Congo (% of farmer) (n=40 per site and per disease).*

	Kinshasa				*Bas-Congo*				
	N'sele	*N'djili*	*Kimba*	*Mont*	*Boma*	*Mbanza*	*Kasang*	*Kisan*	χ^2, *P* *
ASF	71	100	100	95	92	100	100	100	<0.001
Swine erysipelas	55	65	73	18	78	95	91	8	<0.001
Trypanosomiasis	45	23	42	18	41	31	52	0	<0.001
Diarrhoea	58	23	37	39	54	49	12	3	<0.001
Worm infection	18	10	15	13	35	33	9	0	<0.001

* P: Chi-square tests, probability between sites

Table 7: *Type of vaccine administered to pigs in the Democratic Republic of Congo (% of response).*

	Kinshasa				*Bas-Congo*			
	N'sele	*N'djili*	*Kimba*	*Mont*	*Boma*	*Mbanza*	*Kasang*	*Kisan*
(χ^2, P<0.0001) *								
Trypanosomiasis	64	17	60	16	7	21	23	14
Swine erysipelas	8	34	31	24	7	29	38	43
ASF	20	48	6	16	86	46	39	14
Other	8	0	2	44	0	4	0	29

* P: Chi-square tests, probability between sites

3.7 Housing system

Permanent housing was practiced among all sites (P=0.31) with very little free-roaming pigs that were found in Kasangulu and Kisantu (Table 8). Four types of materials used to build walls were identified: (i) concrete, (ii) burnt-brick, (iii) mud-brick and (iv) wood and showed significant differences between sites (P<0.001). Durable materials (cement bricks and corrugated galvanized iron) were used in almost all urban sites (Kinshasa) while Mud bricks or wood and straw were used in rural sites (Bas-Congo) (Table 8). All the farmers used almost the same housing management and had separated fattening and maternity pens.

There were site differences in presence of feeders and drinkers in pigsties. Feeders were present in only 47 % of the farms and drinkers in 89 %. Materials used as feeders/drinkers were plastic basins, open plastic containers placed in an open wooden box or in large aluminum pot. Pigs‘ drinking water depends on location and came either from tap water, wells, and rivers or from springs (Table 9).

3.8 Feeding system

Correspondence analysis revealed that the various ingredients used in pig feed depended on location (Figure 1). Dimension 1 contrasted agro-industrial by-products with cassava. Dimension 2 did not provide enough information because the feed ingredients they tend to contrast are poorly used. The approximation of Boma to urban sites was due the use of palm kernel cakes and brewers grains. Kimbanseke was isolated from the other urban sites due to the high frequency of use of rice and corn bran.

Table 8: *Pigsties building materials and feeding equipments in the Democratic Republic of Congo (n=40 per site).*

	Kinshasa				*Bas-Congo*			
	N’sele	*N’djili*	*Kimba*	*Mont*	*Boma*	*Mbanza*	*Kasang*	*Kisan*
Housing (χ^2, P=0.31) *								
Permanent	100	100	100	100	100	100	97	95
Periodic	0	0	0	0	0	0	3	5
Building materials (χ^2, P<0.001)								
Durable	8	90	80	85	38	67	7	15
Semi-durable	3	5	2	10	56	5	93	85
Wood and straw	90	5	17	5	5	29	0	0
Feeding equipments (χ^2, P<0.001)								
Feeders	69	33	41	61	77	44	17	34
Drinkers	90	95	95	90	80	68	100	94

* P: Chi-square tests, probability between sites

Table 9: *Origin of drinking water in 319 Congolese pig production systems.*

	Kinshasa				*Bas-Congo*			
	N’sele	*N’djili*	*Kimba*	*Mont*	*Boma*	*Mbanza*	*Kasang*	*Kisan*
Origin of water (χ^2, P=0.31) [1]								
Tap water	10	24	0	12	82	12	9	89
Rivers	51	5	16	26	0	73	31	5
Wells	18	63	76	26	18	2	3	5
Springs	21	8	8	37	0	12	57	0

[1] P: Chi-square tests, probability between sites

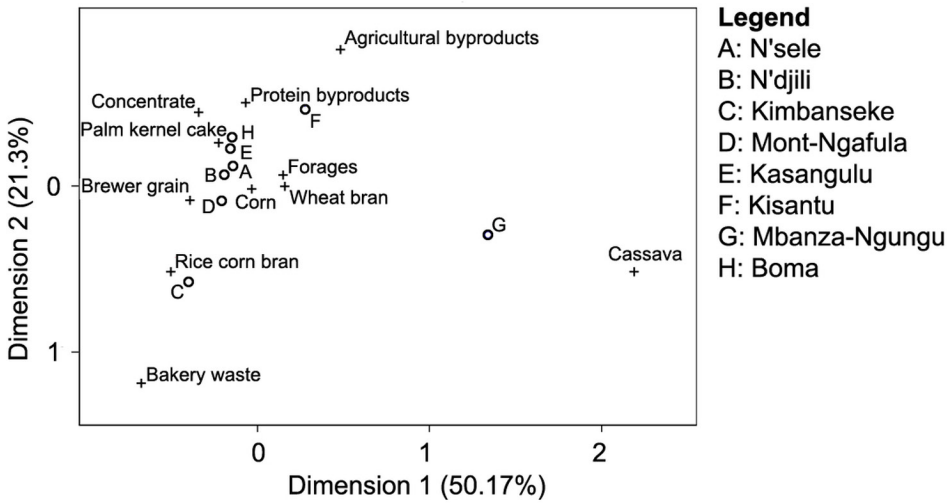

Fig. 1: *Reconciliation between sites in terms of feed ingredients in Congolese pig production systems.*

Ingredients used in pig diets varied with the location (Table 10) and only 4 % of farmers used commercial concentrate. Forage plants were fed to the pigs by almost all the farmers among all sites, with exception of Mont-Ngafula and Kasangulu where only up to 2/3 of the farmers used forage plants to feed the animals (P = 0.035).

Forty-three plant species were mentioned during the survey among which 33 could be formally identified. The most cited were vegetable crop by-products as well as *Manihot esculenta* leaves, *Ipomoea batatas* leaves, *Eichhornia crassipes*, *Psophocarpus scandens*, *Pueraria phaseoloides*, *Boerhavia diffusa*, *Musa* spp. leaves and *Carica papaya* leaves (Table 11). The used plant species varied among the study sites.

3.9 Marketing

There was no difference in origin of starting animal stocks between sites. In general, animals were purchased in the neighbourhood from other smallholders (97 %) without breeding selection, and seldom purchased from industrial pig farms (2.5 %) or religious congregations (0.5 %). The two latter generally raised improved European pig breeds. Finished pigs were sold alive or slaughtered directly for the end consumers. The average selling price depended on site (P<0.0001) and ranged from 2.00±0.2 USD in Boma to 4.12±1.0 USD in Kasangulu per kg live weight and from 3.00±0.1 USD/kg in Boma to 4.96±0.8 USD/kg in Mont-Ngafula for pork (Table 12).

Pigs were slaughtered, sold and consumed mainly for great feasts such as New Year, Christmas or Wedding parties (45 %) or when an unexpected need of money occurred (20 %). Some breeders (20 %) consumed only the fifth quarter (bowels, liver, kidney, lung, stomach sometimes the head) of the slaughtered animals while the best pieces were sold for cash income.

4 Discussion

The purpose of this study was to understand whether and how smallholder pig production systems varied in management and feeding strategies in periurban and rural areas in the Western provinces of the Democratic Republic of Congo. Although the four periurban sites were quite similar across all investigated variables, no specific variable could be found that discriminated the four periurban sites from the four urban sites due to strong differences within the four rural locations.

Regardless of the location, all family members played a role in the pig raising activity. Nonetheless, women were usually kept away from pig daily activities which differed from results of surveys conducted in Kenya (Kagira *et al.*, 2010), where women were shown to play a bigger part in pig raising activities. The low participation of women however agreed with data collected in Botswana (Nsoso *et al.*, 2006). The implication of the family workforce into pig breeding can contribute positively to a reduction in production cost and improve livelihood and hence shows the importance of this activity as a source of family income.

Table 10: *Percentage of response for the use of feed ingredients by pig producing farmers in Congo.*

	Kinshasa				*Bas-Congo*				
	N'sele	*N'djili*	*Kimba*	*Mont*	*Boma*	*Mbanza*	*Kasang*	*Kisan*	χ^2, P *
Wheat bran	100	87	85	93	9	88	82	92	<0.001
Palm kernel cake	95	87	75	64	94	10	91	79	<0.001
Brewers grain	63	82	78	66	57	5	42	5	<0.001
Corn	54	85	40	27	3	29	36	26	<0.001
Rice and corn bran	29	18	65	39	0	0	21	5	<0.001
Cassava	2	0	0	2	3	88	3	13	<0.001
Bakery waste	2	15	65	16	0	0	0	0	<0.001
Protein by-products †	12	26	0	7	3	2	12	16	<0.001
Agricultural by-products ‡	2	5	0	9	0	5	0	37	<0.001
Commercial feed	7	0	0	7	0	0	21	0	<0.001
Forage plants	95	95	95	67,5	100	100	62,5	97,5	0.035

* P: Chi-square tests, probability between sites. † Protein by-products include fish meal and fresh gills, caterpillar meal, and okara.
‡ Agricultural by-product include corn bran, cassava and sweet potato peelings and flour by-products, palm kernels, and wheat bran.

Table 11: *Plant species and plant parts that were used by 319 Congolese farmers to feed pigs (% of response).*

		Kinshasa				*Bas-Congo*				
	Plant part	*N'sele*	*N'djili*	*Kimba*	*Mont*	*Boma*	*Mbanza*	*Kasang*	*Kisan*	χ^2, P †
Manihot esculenta	Leaves	13	5	8	10	75	90	41	26	<0.001
Ipomoea batatas	Aerial parts	13	30	18	23	15	85	27	16	<0.001
Vegetables *	Leaves and roots	5	57	47	20	13	10	41	95	<0.001
Eichhornia crassipes	Whole plant	56	38	53	13	10	0	5	3	<0.001
Psophocarpus scandens	Aerial parts	36	32	18	20	55	2	0	3	<0.001
Pueraria phaseoloides	Aerial parts	0	0	3	20	3	78	5	21	<0.001
Boerhavia diffusa	Aerial parts	8	3	11	7	68	0	9	3	<0.001
Musa spp.	Leaves	3	11	5	10	35	0	9	13	<0.001
Carica papaya	Leaves and fruits	15	8	8	13	20	0	5	13	<0.001

* unfit for human consumption or unsold; † P: Chi-square tests, probability between sites for the same plant species.

Table 12: *Average selling price of live animal and pork on eight study sites in the Democratic Republic of Congo ($ USD/kg).*

	Kinshasa				*Bas-Congo*			
	N'sele	*N'djili*	*Kimba*	*Mont*	*Boma*	*Mbanza*	*Kasang*	*Kisan*
Live animal	$3.24^{b} \pm 1.1$	$3.28^{b} \pm 0.9$	$3.00^{b} \pm 0.7$	3.91 ± 1.1	$2.00^{a} \pm 0.2$	$2.17^{a} \pm 0.9$	4.12 ± 11.0	$2.18^{a} \pm 1.1$
Pork	$3.75^{bc} \pm 0.8$	$4.28^{cd} \pm 0.8$	$4.35^{bcd} \pm 1.1$	$4.96^{d} \pm 0.8$	$3.00^{a} \pm 0.1$	$3.39^{ab} \pm 0.6$	$4.50^{d} \pm 1.1$	$3.39^{ab} \pm 0.9$

In a row, means followed by a different letter differ at a significance level of 0.05.

The average herd size was higher (18 individuals) than what has been reported in Northeast India (Kumaresan *et al.*, 2009a) and in most developing countries, e.g. herd size of six individuals in Vietnam (Lemke *et al.*, 2007), three individuals in Nigeria (Ajala *et al.*, 2007) or approximately 4 individuals per herd in western Kenya (Kagira *et al.*, 2010). This herd size can be considered as indication of market orientation. Sites in the outskirts of the metropolis of Kinshasa had a herd of swine of greater size than those in rural areas. Kasangulu is in Bas-Congo closest to Kinshasa. This position justified the large size of livestock and high price of livestock products. The large average herd size in Mbanza-Ngungu is probably related to the fact that it is located far from fishing sites (as opposed to Boma) and the low cost imports of Kinshasa which forces the population to raise their own pigs to be supplied with animal protein sources. Pig production received less attention in Boma because of supply of Congo River fish. The productive outputs in Kasangulu are higher than in most of the other sites, especially regarding weaning weight and the number of born and weaned piglets per litter (Table 3). Kansangulu is located quite close to Kinshasa (approx. 50 km) which with its 8 million inhabitants represents a huge market. Farms in Kansangulu still benefit from low costs of transportation for both pig products and feed and agro-industrial by-products for feeding pigs. Farmers are more prone to increase productivity by, among others, feeding more concentrate and agro-industrial by products and hire skilled workers. Moreover, farmers in Kansangulu do not suffer from environmental constraints as the farms located in more densely populated periurban municipalities. Herd size is also likely to be related to availability of land (Katongole *et al.*, 2012). This explains why bigger herds were observed in the rural location close to Kinshasa (Kasangulu) than in the periurban areas of Kinshasa. In the studied system, the majority of the farmers were breeding sows for the production of piglets. They fatten their offspring and sometimes additional piglets are bought from other pig smallholders. A weakness of this system is that a large number of farmers do not have their own boars which may lead to inbreeding (Kagira *et al.*, 2010; Lemke *et al.*, 2007). Mating fees practices, charging or by submitting a female piglet at weaning, is similar to what has been observed in other smallholder systems (Lañada *et al.*, 2005; Mutua *et al.*, 2011).

Weaning occurred late compared to what was observed with native pigs in Kenya (Mutua *et al.*, 2011) and Creole piglets in Guadeloupe (Gourdine *et al.*, 2006) but coincided with observations from free-range systems in western Kenya (Kagira *et al.*, 2010). The weaning age was more determined by the health of the piglets and the sow as well as the quality and availability of feed rather than by managerial decision based on age or weight of the litter. Late weaning age was probably related to insufficient and unbalanced diet and resulted in a reduction in the numbers of litters per years. The distribution of unbalanced diets to pigs is known for causing a decrease in animal performances (Kumaresan *et al.*, 2009b). Because of these probably unbalanced diets weaning weight was low, although piglets were weaned quite late and some of the surveyed pigs were hybrids of improved breeds which performances were expected to be better than those of local pigs.

The average number of pigs born alive was consistent with what was observed in other developing countries for native breeds (Mutua *et al.*, 2011; Ocampo *et al.*, 2005) but lower than that for improved breeds raised on well balanced diets in open-air stables in the tropics (Suriyasomboon *et al.*, 2006; Tantasuparuk *et al.*, 2000). The small litter size can be attributed to poor diets and inbreeding because inbreeding negatively affects litter size (Toro *et al.*, 1988), birth weight (Brandt *et al.*, 2002) daily gain and final weight (Fernandez *et al.*, 2002). Inbreeding also stems from the fact that pig farmers started generally this activity with poor breeders purchased from neighbors without breeding selection. In addition, farmers reformed sows early (after three parities) which reduced the possibility of having large litter sizes since it is known that litter size is usually smaller in the first parity and rises to a maximum between the third and fifth litter (Koketsu & Dial, 1998; Tummaruk *et al.*, 2001).

All the diseases mentioned by the farmers in this survey were also reported in African free-range pig systems (Ajala *et al.*, 2007; Kagira *et al.*, 2010). The greatest health risks associated with pig farming in this region are ASF and cysticercosis (Praet *et al.*, 2010), although in our study, cysticercosis was neither mentioned by the Congolese pig farmers nor by the area's veterinaries, probably because it has no overt disease-specific manifestations (Praet *et al.*, 2010) and its prevalence is higher in free-roaming and scavenging pig systems. ASF causes major economic losses, threatens food security and limits pig production in affected areas (Costard *et al.*, 2009; Fasina *et al.*, 2011). It spreads quickly among smallholders for several reasons: transfer of animals from one farm to another without quarantine, moving boars for mating, buying feed to retailers who own livestock themselves, and closeness between farms. The current study also put in evidence that farmers are often misinformed or misadvised over the effectiveness of some veterinary treatments and vaccines.

Pig trypanosomiasis as zoonosis deserves a special attention to avoid circulation of this disease between humans, pigs and tsetse flies. *Trypanosoma brucei gambiense* was identified in tsetse fly with a blood meal from a pig in Kinshasa. In addition, pigsties occurred to be the most favorable biotope for tsetse flies (Simo *et al.*, 2006a,b). Poor hygienic conditions make pigs less productive and more susceptible to diseases (Renaudeau, 2009). Absence of feeders and subsequent distribution of feeds on the floor lead likely to contaminations and increase the incidence of worm infection.

The results of the current study showed that the animals were mainly given agro-industrials and agricultural by-products and plants even when other feed ingredients more energetic such as corn, cassava and potato tubers were available. Also, ingredients used in pig diets varied with location depending on local availabilities and what potential customers were willing to pay. Unlike other sites, pig breeders of the rural Kasangulu area seemed to use the same pig feeds as the farmer in urban sites. Brewer's grains were used near breweries which were located in Kinshasa and Boma and were used thus by more pig farmers in Kinshasa than by those farmers in Kasangulu and Boma and rarely by farmers in Kisantu and Mbanza-Ngungu. For the same reasons, also forage plants were less used in Kasangulu than in other sites. Palm cakes were less used in Mbanza-Ngungu probably due to the high transport cost because this site is located at 150 km from Kinshasa and 370 km from Boma were oil cakes were pressed. Cassava is the main source of energy used in Mbanza-Ngungu probably because of its affordability due to its availability. Most of these feed ingredients are low in protein. The use of corn to feed pigs was considered as a waste of money by rural pig farmers as they considered that they earn more money by selling the grain directly than using it to feed their pigs. Instead of using corn, cassava or potato tubers, they used fiber-rich ingredients such as wheat bran, palm kernel cake, brewers' grains or plants to feed the animals. They used those ingredients regardless of the nutrients that they provide. The majority of farmers producing pig and crops were even not able to cover household self-sufficiency with their crop production. Their exceeding crop products were rather a source of income than used as feed ingredients. They preferred to use plants as feed ingredients instead. This choice not to divert food resources such as corn that could be eaten by the family or sold on the market to feed pigs was a consequence of a least developed country production environment where humans and animals are in direct competition for grains. Cooked cassava leaves were more frequently used in rural sites than Kinshasa because in the capital city of DRC, there is a high demand for cassava leaves to prepare the traditional dish called pondu, and hence only few leaves were available for pigs. Sweet potato leaves were more used in Mbanza-Ngungu where there is a large production of potato tubers. *Eichhornia crassipes* is fed to pigs in Kinshasa close to the places where it can be found floating on rivers and ponds. *Psophocarpus scandens* a protein-rich legume (Bindelle *et al.*, 2009) is offered to pigs in Kinshasa and in Boma only. The system of raising pigs on locally available resources has been already reported in Northeast India (Kumaresan *et al.*, 2009a) and in North Vietnam (Lemke *et al.*, 2006). However, the choice of plant as feed for pigs was not motivated by their palatability or nutritional value, but rather by their availability. The lack of information on the chemical composition and the role of each nutrient on pig growth is an obstacle to formulate balanced diet for weaned piglets, and gestating and lactating sows which have highest nutrient requirements. Determining the chemical composition and nutritive value would allow farmers to select plants that are nutrient-dense, palatable, digestible and capable of covering the requirements of the animals to obtain a good growth from their pigs.

A large proportion of the Congolese smallholder pig production were market directed, as already mentioned for other African areas (Ajala *et al.*, 2007; Kagira *et al.*, 2010), aiming, first, to provide cash to the family. Supporting the family's consumption of animal products came only in the second position. This lies in contrast with Asian areas where pigs are less market oriented but fulfil functions related to savings and household consumption (Kumaresan *et al.*, 2009a; Lemke *et al.*, 2006).

Although no general differences were observed between the four rural and the four periurban sites, it can be concluded that pig husbandry depends on the local environment as strong differences were observed between rural sites, particularly in terms of workforces, herd structure and characteristics, production parameters, pig building materials, selling price and especially in feed resources. Farmers used several alternative feed ingredients to feed pigs such as agro-industrial by-products as long as the industry was not located too far away and the cost of transportation could be coped with thanks to high pig selling prices. Any further actions to improve pig production in Congolese pig production systems should consider differences in system's resources and constraints. Such actions should be articulated around three major pillars that were identified in this survey as the most critical: (1) a reduction in inbreeding, (2) an improvement in biosafety to reduce the incidence of African swine fever and the spread of

other diseases, and (3) an improvement in feeding practices. The first two aims can be reached by training pig producing farmers, while an improvement in pig diets quality requires further research on the nutritional value of different feed resources and plant materials locally available, especially those rich in protein.

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