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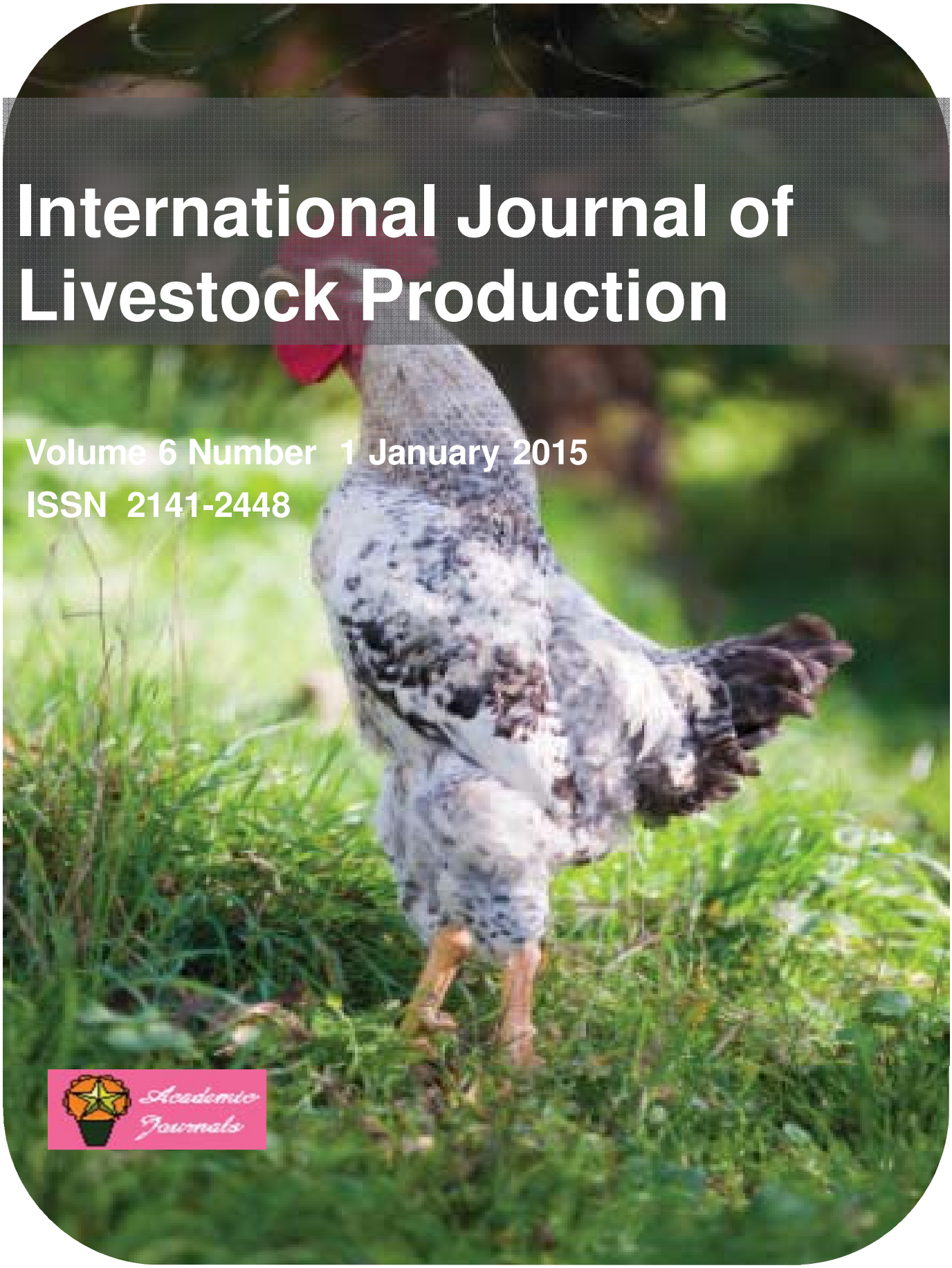

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*Full Length Research Paper*

# Analysis of performance, management practices and challenges to intensive pig farming in peri-urban Kampala, Uganda

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**Uganda is currently among the largest per capita consumers of pork in sub Saharan Africa. Most of this pork is consumed in "pork joints" in Kampala and other major urban centers in the country. However, the current productivity is low and cannot meet the soaring demand for pork. No information was previously available on the performance productivity of intensive piggeries in Uganda. This study was aimed at assessing the performance, factors affecting productivity and challenges to intensive pig farming in peri-urban Kampala. Production parameters were captured from purposively selected 332 sows and 521 grower pigs. Information on management practices, challenges and prospects of the industry was gathered through questionnaires administered to farmers, key informant interviews and stakeholder's focus group discussions. Results showed most farms had good level of management but the breeding practices were uniformly erratic in all the farms, and different breeds were crossed anyhow. Furthermore both reproduction and performance parameters were suboptimal. Analysis of management practices revealed that breed had a significant effect on growth performance ($p < 0.001$) and litter size ($p < 0.005$). Feeding had significant effects on litter size ($p < 0.001$), number weaned ($p < 0.01$), weight:age ratio ($p < 0.05$) and weaning to service interval ($p < 0.05$). The major constraints found were high feed costs, diseases and competition for land with the upcoming residential estates. The performance indices varied greatly between farms, indicating great potential for improved productivity. We recommend improved housing, breeding practices, feeding and biosecurity measures so as to improve on performance and productivity of peri-urban pig farming.**

**Key words:** Peri-urban farming, pig production, performance indices, management systems, challenges.

## INTRODUCTION

Peri-urban agriculture is an important economic activity in many sub-Saharan cities of Africa contributing significantly to the urban food supply, and is a source of livelihood for many households (Olufunke et al., 2003; Foeken and Owuor, 2008). In Uganda, peri-urban agriculture has become part of the development agenda and currently contributes up to half of total food consumed in Kampala (Makita 2009).

Poultry and pigs are the two main livestock species kept, followed by small ruminants and cattle (Maxwell, 1995; Makita 2009). The last livestock census report by UBOS (2009) estimated the domestic pig population in Uganda at 3.2 million heads, and the highest pig density was shown to be in peri-urban Kampala. In Africa, Uganda was ranked the third highest pig producer after South Africa and Nigeria, with estimated total annual production of 115000 tones of pork (FAOSTAT, 2012). In parallel, Uganda is also among the largest consumers of pig meat in sub-Saharan Africa with estimated per capita consumption of 3.4 kg/person/year (FAOSTAT, 2012). Most of this pork is consumed in "pork joints" in Kampala and other major urban centers in the country. However, the current production level is still low and the demand for pork and its products exceeds supply. This deficit is currently covered by imports majorly from Kenya and South Africa (FAOSTAT, 2011).

Productivity in piggery is measured by reproduction and growth performance, and these are influenced by genetic factors (Te Pas et al., 1999; Rehfeldt and Kuhn, 2006), feeding (Clawson et al., 1962; Wondra et al., 1995), environmental conditions (Prunier et al., 1997; Turner et al., 2000) and management practices such as lactation length (Xue et al., 1993), weaning age (Main et al., 2004) and parasite burden (Sykes, 1994). Productivity in breeding herds is measured by piglets weaned per female per year (PWFY), and is determined by indices such as litters per female per year (LFY), farrowing rate (FRATE), culling rate (CULLR), inter-farrowing interval (IFI), weaning-to-service interval (WTSI), number of piglets born alive (PBA) and pre-weaning piglet mortality (PWM) as defined by Stein et al. (1990). In finishing herds however, average daily weight gain (DWG) and weight:age ratio (WT/AGE) are the most important measures of productivity. These indices are influenced by a complex interplay of managerial, environmental and genetic factors (Tantasuparuk et al., 2000; De Grau et al., 2005; Kennedy and Moxley, 2010).

The performance of the local, exotic and crossbred pigs under the intensive system of production in peri-urban Kampala had not been previously reported. In this study, we assessed the performance of pig enterprises in peri-urban Kampala and identified key factors affecting productivity. The results of the study provide valuable information in understanding the sector and will guide in designing strategies for improved productivity.

## MATERIALS AND METHODS

### Study area

The study was carried out on intensive pig farms in peri-urban Kampala, the capital city of Uganda. Intensive pig farming was defined as a management system where pigs were kept in total confinement in pigpens and feeding was majorly based on commercial feedstuff. Kampala is an independent administrative district located on the northern shores of Lake Victoria, Central Uganda. Peri-urban Kampala referred to the rural-urban transition zone adjoining the capital district. The detailed spatial distribution and socio-economic characterization of this area was previously described by Makita et al. (2010). Both crop and livestock faming are integral part of the economic activities in the area.

### Study design

In this study, a cross-sectional field survey on intensive pig farms was conducted by stratified purposive sampling method. In the first stage, four town councils within peri-urban Kampala with the highest number of pig farms were selected. All the town councils were within a distance of 5 to 20 km from the borders of the city. A sample population of 346 intensive pig farms in the four town councils was established from available council records with the help of veterinary extension workers, from which 90 farms were sampled. Sample size determination was based on the table proposed by Bartlett et al. (2001) for continuous data (t=1.96, alpha=0.5, margin of error=0.03). Distribution of the farms among the town councils was as follows; Wakiso 18, Nangabo 20, Nansana 14 and 38 from Kira town council. The number of farms per town council was calculated based on sample population proportions. All sampled farms met the following criteria; farm had ≥5 sows, kept records and the farmer was willing to participate in the survey. Selected farms that did not meet the criteria were replaced. From each farm, information on husbandry practices, production indices, herd health/other challenges, and demographic characteristics of the respondents was collected using a semi-structured questionnaire. The questionnaires were pre-tested on 10 intensive pig farmers in Tororo District of Uganda that is located outside peri-urban Kampala. Since most farmers kept only partial records, a data capture form was designed to record information on breed, parity, age of sows, litter size, number born alive, number born dead, preweaning mortality, interfarrowing interval, weaning to service interval and age at weaning. Pre-weaning mortality was calculated from the percent ratio of piglets dead preweaning to piglets born alive. Breed types were determined from records and physical examination for characteristic features. Growth performance was estimated from a maximum of 15 randomly selected grower pigs per farm by taking weights and information on their ages from existing records or verbal history. Fifteen grower pigs were estimated as 30% of the average minimum number of grower pigs per sampled farm. Weighing was performed using sacs attached to a calibrated spring balance. Additional information on management practices such as feeding and parasite control, and challenges to production were collected through questionnaires, physical farm inspection, key informant (extension workers) interviews, and stakeholders' focus group discussions. The parasite control was categorized as: (a) Routinely every 3 months; (b) Every 6 months or (c) Seldom, when done after more than one year.

### Data analysis

Data was coded and entered into excel spreadsheets and descriptive statistics were performed. Additional analysis was

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performed using SPSS 22.0 software. The effects of management practices on the production parameters (indices) were determined using ANOVA statistics. P-values <0.05 were considered significant.

## RESULTS

### Characteristics of pig farming in peri-urban Kampala

Intensive pig farming in peri-urban Kampala was found to be a secondary activity for most respondents, and 46.7% (n=42) were civil servants. Only 27.8% (n=25) of the respondents were engaged in farming as primary activity. The majority of the farmers (78.9%, n=71) mentioned income generation as the reason for keeping pigs, while 15.6% (n=14) kept pigs for security and 5.6% (n=5) for traditional/cultural reasons. The sampled population comprised of 4 different types of farm enterprises: Farrow to weaner, 28.9% (n=26); farrow to finisher, 18.9% (n=17); weaner to finisher, 6.7% (n=6); and mixed enterprises (two or three previous types), 45.6% (n=41). The herd sizes and breeds kept by farmers were as summarized in Table 1. The majority of the farms (46.7%) had small herd sizes of less than 50 pigs, and Large White was the predominant breed reared on 40% of the sampled farms.

### Management types

The level of management on different farms was classified into 3 categories (above average, average and below average) based on the feeding systems, housing types and herd health practices. Under above average management, the pigs were housed in leak proof, hygienic (highly clean) and well ventilated houses with concrete or wooden floor above ground level and was cleaned daily. Feed types included commercial feeds, farm by-products and crop residues, and the pigs were dewormed routinely every three months. In average management, the pigs were housed in leak proof, well ventilated houses with moderate hygienic conditions, concrete floor or wooden floor above ground level and cleaned occassionally. Pigs were fed on variety of feeds including maize bran, rice bran, brewers waste and crop residues. Pigs under average management were also exposed to deworming routine of 6 months interval and ectoparasites were only occassionally controlled. In the below average management category, the pigs were housed in poor hygienic sheds with leaking roofs, poor ventilation and seldom cleaned. Feeds were provided erratically and comprised of locally available feed stuffs such as rice bran and crop market wastes comprised majorly of banana peelings, cabbage leaves and sweet potatoes vines. Under this system, ecto and endo parasite control was seldomly practiced. The majority of the farms kept pigs under average level of management conditions (46.6%, n=42), this was followed by farms that kept pigs under above average management conditions (34.4%, n=31), while 18.8% farms were under below average management.

**Table 1.** Pig herd sizes and breeds kept by farmers in peri-urban Kampala.

| Property | Frequency (Farms) | Percentage |
|---|---|---|
| **Herd size** | | |
| < 50 | 42 | 46.7 |
| 51-100 | 25 | 27.7 |
| 101-200 | 14 | 15.5 |
| 201-300 | 6 | 6.7 |
| > 300 | 3 | 3.3 |
| **Breeds** | | |
| Large White | 36 | 40.0 |
| Landrace | 1 | 1.1 |
| Camborough | 14 | 15.6 |
| Crosses[a] | 30 | 33.3 |
| Local breeds | 9 | 10.0 |

[a]Crosses were offsprings from parents of different breeds listed.

**Table 2.** Breeding methods practiced by farmers in peri-urban Kampala.

| Method | Frequency (Farms) | Percentage |
|---|---|---|
| Criss-crossing[a] | 44 | 48.9 |
| Terminal crossing[a] | 12 | 13.3 |
| Random breeding[a] | 34 | 37.8 |
| Total | 90 | 100.0 |

[a]Criss-crossing refers crossing of two or more breeds and alternately mating the F1 females with males of the parent breeds. In terminal crossing, specialized damn and sire parent breed are mated to produce F1 slaughter progeny. In random mating, no specific breeding scheme is followed.

### Breeding practices

Criss-crossing, the alternate reciprocal mating of F1 generation with the parent breeds, was the most widespread breeding scheme adopted by 48.9% of the farmers, followed by random breeding (37.8%) and terminal crossing was least practiced (Table 2). Criss-crossing involved crossing Large White with either Camborough or Landrace and alternate mating of the crossbred female with the parent breed. Breeding boars were kept on a farm for either 1-2 years (24.4%), 3-4 years (46.7%) or until they were unable to serve (28.8%). Average life span of a breeding sow was 5-8 years on most farms, and age at first service ranged from ≤ 10 months (61.1%), 10-12 months (27.8%) or >12 months in

**Table 3.** Mean reproductive performance indices (with standard deviations in parentheses) of the different pig breeds on farms in peri-urban Kampala (n=90 farms).

| Breeds | Reproductive indices | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Litter size | Litter number | Parity | Number born alive | Number born dead | Number weaned | Pre-weaning mortality | Farrowing index | Weaning to service interval (Days) | Inter-farrowing interval (Days) | Age at weaning (Days) |
| Large White | 10.6(4.1) | 258 | 3.1(2.1) | 9.9(3.7) | 0.7(1.3) | 8.2(2.9) | 1.7(1.5) | 1.8(0.2) | 47.1(4.3) | 214.2(29.8) | 53.4(8.6) |
| Landrace | 11.5(3.0) | 6 | 2.5(0.8) | 10.7(3.01) | 0.8(1.6) | 8.8(1.8) | 1.8(2.1) | 1.8(0.2) | 38.3(19) | 199.8(17.1) | 50(6.3) |
| Camborough | 11.7(3.3) | 94 | 2.27(1.3) | 10.9(2.8) | 0.8(1.1) | 9.0(2.4) | 1.9(1.5) | 1.8(0.2) | 53(34.2) | 222.2(32.6) | 57.5(9.3) |
| Crosses | 9.4(3.1) | 190 | 1.5(0.9) | 8.9(2.6) | 0.5(1.1) | 7.3(2.6) | 1.6(1.7) | 1.8(0.2) | 56.2(27.3) | 223.2(32.2) | 53.9(8.9) |
| Local breeds | 8.1(4.1) | 29 | 1.9(1.1) | 8(2.3) | 0.7(0.3) | 6.8(1.8) | 1.2(1.2) | 1.7(0.1) | 54.8(19.8) | 226.9(23.5) | 60.1(11.6) |
| Average | 10.5(3.9) | na | 2.6(1.9) | 9.8(3.4) | 0.7(1.2) | 8.2(2.8) | 1.7(1.5) | 1.8(0.2) | 49.9(26.9) | 217.5(30.6) | 54.5(9.1) |
| Benchmark indices | >11.5[a] | na | na | 11-12[a] | <0.2[a] | >9.5[a] | <1.4[a] | 2.4[a] | <7[a] | 144 | 28[a] |

[a]Althouse (2011). Litter number included repetitive measures for multiparous sows.

the rest of the farms. In all the farms, natural service was sole breeding method practiced.

## Health management

The principle health management practices comprised of endo and ecto parasite control, and bio-security measures. Most farmers carried out ecto and endo parasite control at an interval of 2 weeks (34.4%) and 3 months (46.6%), respectively. However, a considerable number of respondent farms reported to have carried out ecto parasite control (27.8%) and endo parasite control (24.4%) only when they saw the parasites or when the pigs were sick.

Biosecurity measures were in place in 63.3% (n=57) of the respondent farms whereas the rest had not instituted any form of biosecurity practices. The most common biosecurity practice in use by farmers was restricted access to their farms, fencing and less frequently footbaths. It was also noted that replacement stock often came from a variety of sources of unknown health status with no quarantine before entry.

## Pig production

### *Reproductive performance*

The average reproductive performance was computed from the data from 332 sows that were distributed over the 90 farms. The computed indices are summarized in Table 3. Average litter size and number of piglets born alive were 10.53 ± 3.91 and 9.84 ± 3.39, respectively. Camborough had the highest number of piglets of (11.7 ± 3.3), followed by Landrace (11.5 ± 3.0), Large White (10.6 ± 4.1), crosses (9.4 ± 3.1) and lastly the local breeds (8.1 ± 4.1). The results also indicate that on average 8.19 ± 2.77 piglets were weaned per litter representing a 16.3% pre-weaning mortality. Farrowing index of 1.8 ± 0.2 was consistent among all breeds except for the local pigs which was slightly lower (1.7). Average weaning age was computed at 54.5 ± 9.1 days, with Landrace having lowest weaning age of 50 ± 6.3 closely followed by Large White (53.4 ± 8.6), crosses (53.9 ± 8.9), Camborough (57.5 ± 9.3) and the local pigs had the highest weaning age of 60.1 ± 11.6. The average weaning to service interval was 49.9 ± 26.9 days but varied widely among the different breeds being shortest in Landrace (38.3 ± 19), and longest among the crosses (56.2 ± 27.3). The average inter-farrowing interval (IFI) was 217.5 ± 30.64 days. Landrace had the shortest IFI (199.8 ± 17.73), followed by Large White (214.2), Camborough (222.16), crosses (223.18) and the local pigs (226.86).

### *Performance of the grower/fattener pigs*

The growth performance indices (Table 4) were computed from randomly selected 521 grower pigs from the respondent farms. The overall recorded weight:age ratio was 6.4 ± 1.2. The results indicate that Camborough had the highest recorded weight:age ratio of 6.5 ± 1.0 meaning that on average, a grower/ fattener Camborough pig adds on 6.5 kg per month and this was closely followed by Large White at 6.4 kg per month, Landrace (5.5 kg/month) and lastly local breeds (5.1 kg/month).

### *Effect of management on performance indices*

The effect of management on the performance

**Table 4.** Growth performance estimates of grower pigs (with standard deviations in parentheses) from peri-urban farms in Kampala-Uganda.

| Breed | Growth performance indices(n=90 farms) | | |
|---|---|---|---|
| | Average age (Mo.) | Average weight (Kg) | Weight:Age (Kg/Mo.) |
| Large White | 6.4(2.4) | 41.7(17.9) | 6.4(1.2) |
| Landrace | 4.5(0.2) | 24.8(2.4) | 5.5(0.3) |
| Camborough | 6.7(3.4) | 43.0(20.8) | 6.5(1.0) |
| Crosses | 5.3(1.4) | 35.7(12.5) | 6.7(1.0) |
| Local breeds | 5.6(0.1) | 28.2(3.3) | 5.1(0.4) |
| Average | 6.1(2.1) | 39.6(17.1) | 6.4(1.2) |
| Reference[a] | 5.3 | 106 | 20 |

[a]Dunshea et al. (2003).

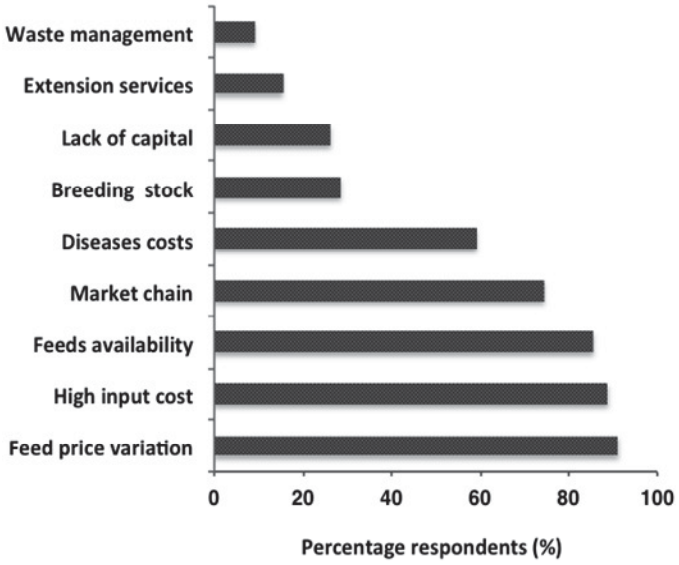


**Figure 1.** Constraints to pig farming in peri-urban Kampala, Uganda.

was determined using analysis of variance (ANOVA) at 5% significance level. The management practices considered were breed of the pigs, feed types and parasite control, while the production parameters included litter size, number weaned, farrowing index, weaning to service interval, interfarrowing interval, preweaning mortality and weight:age ratio. Breed had a significant effect on weight:age ratio ($F_{(4,536)}$ = 9.3, $p$ < 0.001) and litter size ($F_{(4,327)}$ = 4.28, $p$ < 0.005) but not on farrowing index ($F_{(4,327)}$ = 2.15, $p$ > 0.05) and weaning to service interval ($F_{(4,327)}$ = 1.93, $p$ > 0.05). Feeding had significant effects on litter size ($F_{(5,326)}$ = 1.06, $p$ < 0.001), farrowing index ($F_{(5,326)}$ = 0.53, *ns*), number weaned ($F_{(5,326)}$ = 3.07, $p$ < 0.01), weight:age ratio ($F_{(4,536)}$ = 8.7, $p$ < 0.05) and weaning to service interval ($F_{(5,326)}$ = 3.83, $p$ < 0.05), but was not significant on age at weaning ($F_{(5,326)}$ = 0.69, *ns*). Control of parasites had no significant effect on all the performance indices; Litter size ($F_{(4,327)}$ = 1.81, $p$ > 0.05), weight:age ratio ($F_{(4,536)}$ = 0.61, *ns*), and number weaned ($F_{(4,327)}$ = 1.27, $p$ > 0.05).

### Constraints to pig farming in peri-urban Kampala

The major constraints to pig farming reported by the interviewed farmers (n=90) included feed price fluctuation (91.2%), high input costs (88.9%), seasonal availability of feeds (85.6%), poor and unorganised market chain (74.5%) and diseases (59.2%) (Figure 1). Other constraints reported were lack of quality breeding stock, lack of capital, poor extension services and challenge of manure disposal.

## DISCUSSION

In peri-urban Kampala, the herd size of most piggeries were generally small (<100 pigs) probably because pig farming was a secondary activity for most farmers, and competition for land with the housing estates. The dominant breeds of pigs were Large White and crosses between Large White and Landrace. Farmers preferred Large White because of the perceived fast growth and larger litter sizes. The high percentage of crossbred pigs between Large White or Landrace and crosses was largely due to lack of a systematic breeding program. The average lifespan of the boars on the farms averaged 4 years and this is within recommended range for tropical regions (Huang et al., 2010). Sows, however, had a longer life span of 5-8 years, and this is above the minimum of 4 years or three parities required to achieve positive financial return (Stadler et al., 2003). Sows are removed for different reasons such as old age, reproductive disorders and low productivity (Engblom et al., 2007). The high average lifespan of sows on the studied farms indicate low removal rate, possibly due to attempt by farmers to achieve highest possible number of parity per sow over the entire lifetime given the low

farrowing index. Sow longevity has been argued to help farmers break even since financial return is projected to occur at the third farrowing (Stadler et al., 2003). In this situation, however, reducing the weaning age and the farrowing interval may be able to substantially improve profitability.

Overall, the performance indices were low compared to reference values (Althouse, 2011; Dunshea et al., 2003), mainly based on values from developed economies, but comparable to those of developing economies (Wabacha et al., 2004; Lemke et al., 2006). The low performance of pigs in tropical conditions was attributed to heat stress by Lutaaya et al. (2009), among other factors. Productivity can however be optimized by controlling the environmental conditions, feeding and selection. Litter size showed less deviation from the reference value in contrast to growth rate, although both traits are highly heritable (Kaplon et al., 1991). This difference could be explained by the extent of management effect on the two indices. Statistically, we could show that breed had significant effect on weight:age ratio ($F_{(4,536)}$ = 9.3, $p$ < 0.001) and litter size ($F_{(4,327)}$ = 4.28, $p$ < 0.005) but not on farrowing index ($F_{(4,327)}$ = 2.15, $p$ > 0.05) and weaning to service interval ($F_{(4,327)}$ = 1.93, $p$ > 0.05). The significant effect of breed type on the major production (weight:age ratio) and the reproduction (litter size) indices also explains the popularity of Landrace and Large White breeds that have high prolificacy and growth rate, traits with high heritability coefficients.

We found that the management system had a major influence on performance, and a majority of the farms had above average or average management system with hygienic housing, adequate feeding system, biosecurity measures and parasite control. This was in agreement with findings by Muhanguzi et al. (2012) from a related study within a limited subpopulation in this area. The good management could be attributed to extensive farmer training provided by extension workers through government initiatives and the ability of the farmers to meet capital and operational cost from alternative sources of income, since piggery was not the primary source of income for the majority of farmers. Feeding was a key management factor influencing performance (litter size (p = 0.001), farrowing index (p = 0.028), number weaned (0.009), weight:age ratio (p = 0.02) and weaning to service interval (p = 0.0458)). Most farmers were dependent on locally available feedstuff to reduce feed costs and cope with scarcity and seasonality. This feeding strategy is common in other tropical countries with comparable systems (Rekwot et al., 2005; Lemke et al., 2006; Kagira et al., 2010). These non-conventional feeds such as banana peelings, sweet potatoes vine and cabbage peelings (Drechsel and Dongus, 2010) have varied or unknown nutrient content and its use depends on seasonal availability (Katongole et al., 2011, 2013), making feed management a big challenge.

The major challenges to pig farming included feed availability and cost, market chain and diseases. Feeding is a major cost in piggery and affects both growth and reproductive performance. This is a common challenge in most developing economies as reported in previous studies (Morek and Mphinyane, 2011; Muhanguzi et al., 2012). During seasons of limited feed supply, there was an observable decline in body condition scores, and a similar scenario was reported in Zimbabwe by Chikwanha et al. (2011). Other minor challenges reported were waste management, lack of capital and extension services. Waste management is particularly a big challenge in peri-urban areas and most farms practiced composting to recycle organic waste. In recent years, however, the method has drawn attention due to concern over environment pollution.

In conclusion, this study revealed high variability in the performance indices of piggeries in peri-urban Kampala. These indices were suboptimal compared to the reference values (Althouse, 2011), but comparably similar to values from other developing economies. There is therefore a potential for increased productivity. Feeding was the main management factor affecting performance, with feed costs and seasonal availability reported as the main challenges. Fomunyam (1992) showed that incorporating banana peelings at maximum 30% in animal diet have economic benefits. Since these crops are common in the study area all year round, adopting this feeding strategy would reduce the cost of feeding especially during seasons of inadequate supply. However, more research should be done to develop standard feeding regimes based on affordable alternative feed resources. Other challenges included diseases, market chains and waste management. We recommend improved management system to increase farrowing index and stringent biosecurity measures to control diseases. To increase the farrowing index, the weaning age should be reduced from the reported average of 54.5 days to the recommended 28 days (Althouse, 2011). Additionally, early weaning at 4 weeks was also shown to improve health and growth performance of the piglets (De Grau et al, 2005). Finally, the reported endo-parasite control interval of 3 months should be reduced since it is longer than the recommended interval of 5 weeks that corresponds to the live cycle of *Ascaris suum,* the major endo-parasite of pigs (Roepstorff, 1997; Kanora, 2009).

## Conflict of Interest

The authors have not declared any conflict of interest.

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# Characterization of pastoral herding in Kanem (Chad)

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**The present survey was conducted to characterize herding practices and overall production performances of pastoral systems in the Kanem region, Chad. Overall, 69 livestock keepers were interviewed, among which 12 sedentary agro-breeders, 35 mobile agro-herders, and 22 nomadic herders. Species association is a main feature of the herd structure. Agro-herders make most often an association between cattle and small ruminants (47%). Among mobile agro-herders, the association between cattle and small ruminants is frequent (47%) whereas nomadic herders tend to show more diverse modalities of herd composition. Feed is mainly based on natural pastures. However, complementary feeding is provided, targeting the producing females and weaker stock during the maximal risk period. During the rainy and post-harvest season, milk yields are significantly higher among agro-herders than in other groups ($p$<0.05). In camels, the season of the year and the herding system have no effect on milk production. Regarding reproduction parameters, the mean age at first calving is 4.7±0.7 years in cows and 5.8±0.6 years in she-camels. The calving interval is 1.9±0.4 years in cows and 2.7±0.4 years in she-camels. The fecundity rate is around 63% in cows and 44% in she-camels. Simple husbandry techniques might help increasing production levels to the benefit of the households, as complementary feeding, which is already provided in a targeted way. The systematic implementation of this complementation faces constraints of availability of these agricultural by-products on the local markets. As far as research is concerned, the study recommends the implementation of herds monitoring of the area in order to precise the livestock breeding practice as well as zootechnical parameters.**

**Key words:** Agro-pastoral, cattle, camel, Chad, herding, Kanem, production performances.

## INTRODUCTION

In Sahelian countries, livestock plays an important economic, social and cultural role. The share of the livestock sector in the gross domestic product varies from 5 to 10% according to the country and at local levels; it contributes to food security in rural and urban households (Wane et al., 2009). Pastoral herding appears as the main mode for a sustainable utilization of the sparse and heterogeneous vegetation in the region. Furthermore, pastoral herding allows for a flexible and rapid adaptation to the wide seasonal variations in availability of water and plant resources (Gerber et al., 2012). Presently, pastoralism faces important ecological and socio-economic changes that include climate change, population growth, urbanization, market development,

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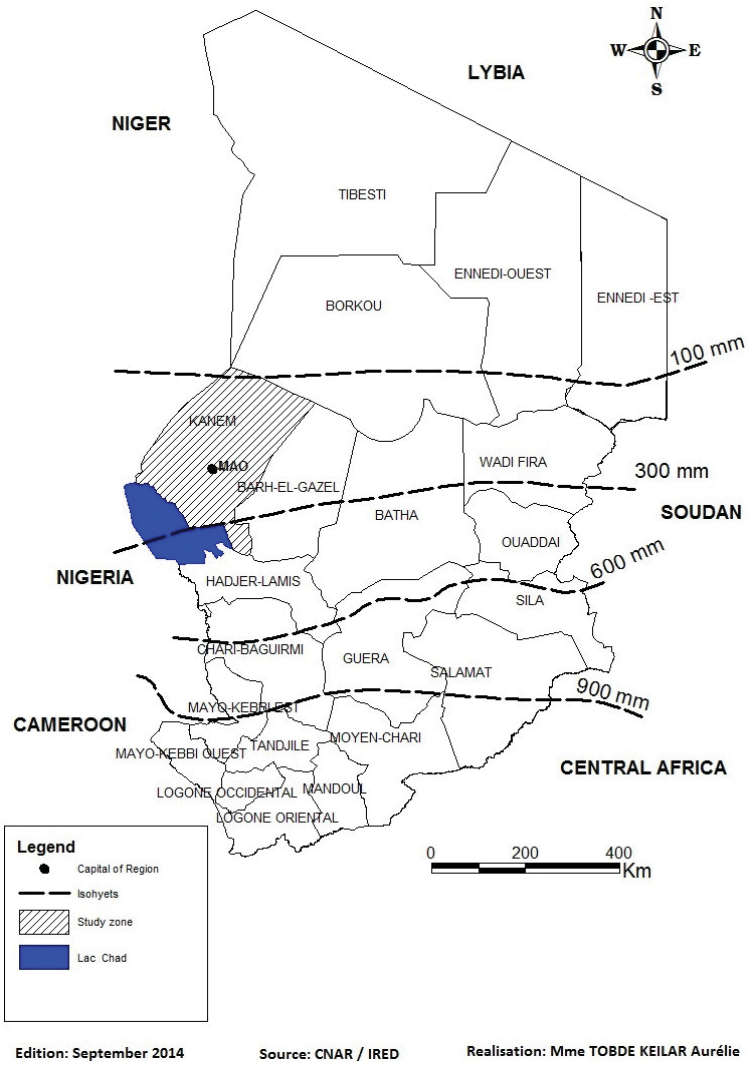


**Figure 1.** Study zone.

evolution of the demand for animal products, administrative decentralization and the withdrawal of the State from economic operations (Magrin et al., 2011).

In Chad, the Kanem region is a typical Sahelian agro-ecological context, of which pastoral herding is the main economic activity. Climatic changes have resulted in a higher frequency of severe annual rainfall deficits, leading the region to suffer from chronic food insecurity. Pastoral systems should hold in this context a key-role in the socio-economic development of the region, being the basis of the livelihoods of households and providing the meat needed on the national and sub-regional markets. To enable this development, investments and support will be necessary, needing in turn a thorough understanding of the constraints and opportunities of the system. Therefore, the present survey was conducted to characterize the herders' practices and production performances of pastoral systems in the Kanem region. It identifies future research area in order to deepen the thought on the performances of nomadic livestock breeding in Kanem.

## MATERIALS AND METHODS

### Study zone

The Kanem region (Figure 1) lie between the latitude 14° and 17° north. The climate is sahelo-saharian, that is, subdesertic in its northern part and Sahelian in its southern part. Annual rainfall vary from 100 to 200 mm, concentrated on one season, from July to October. The mean monthly temperatures are lowest in January, with 23°C, and peak in May at 45°C. The landscape is dominated by sand dunes and interspersed basins with temporary rivers, called Ouadis. Dune vegetation is sparse, of the pseudo-steppic type, with few trees (*Balanites aegyptiaca, Acacia raddiana, Acacia albida, Ziziphus mauritiana, etc.*) and annual grasses (*Panicum turgidum, Aristida mutabilis, Cenchrus biflorus, Aristida mutabilis, Eragrotis tremula, etc.)*. In the north, the vegetation becomes

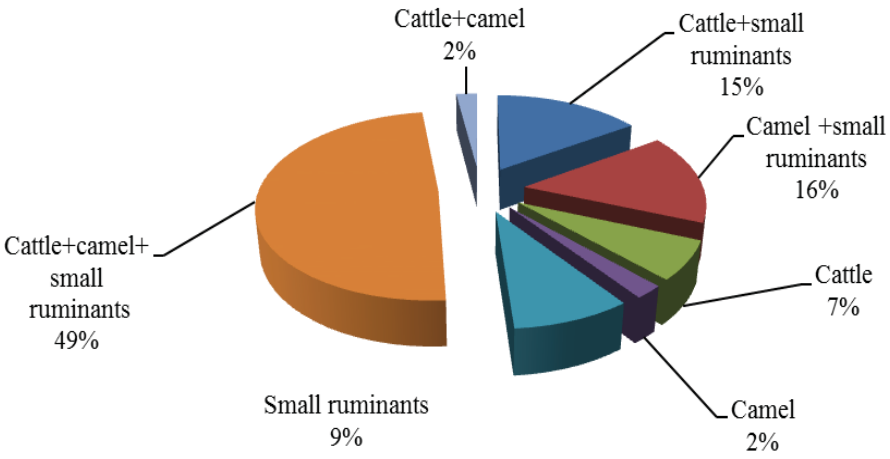


**Figure 2.** Distribution of species composition of herds in the Kanem Region (Chad).

sub-desertic with very sparse shrubby vegetation (*Leptadenia pyrotechnica*, *Calotropis procera*). In inter-dunar basins, vegetation is denser, mainly composed of above-mentioned tree species. Due to its aridity, the zone is weakly populated, with 2.4 inhabitants per km$^2$. Agricultural activities are marginal and consist of two crop types: Rainfed crops on the dunes, e.g. *Pennisetum glaucum* and *Vigna unguiculata,* and off-season crops in the Ouadi, e.g. maize, vegetables, cassava.

### Sampling and survey methods

The study sites were villages in the case of sedentary agro-breeders and transhumant agro-herders, and camps in the case of nomadic herders. Preliminary interviews with administrative leaders and local livestock services allowed for the localization of targets groups. Village or camp chiefs were contacted telephonically for appointments.

At the village or camp level, a focus group was held with all livestock keepers to present the research team, composed of three persons, and to explain the goals of the study. The interviewed livestock keepers were chosen on a voluntary basis, while maintaining the balance between the three main breeding systems: The sedentary agro-livestock system, the transhumant agro-herding system, and nomadic herding. Overall, 69 livestock keepers were interviewed, among which 12 sedentary agro-breeders, 35 transhumant agro-herders, and 22 nomadic herders. The questionnaire was applied through face-to-face interviews with the households' chief who is in charge of the herd management. The questions tackled the following topics: (i) Herd's structure (number, species, sex and age distribution); (ii) The feeding practices in the different seasons; (iii) Production and reproduction performances (estimated average daily milk quantity per animal in the different species, age at first parturition, intervals between parturitions, fecundity, off-take rate of the herd). The herders' wives were more particularly involved about questions on milk production.

### Data analysis

All statistical analyses were performed with the SPSS+ software. Analysis of variance was used to compare between livestock systems. To test the effect of season, the year was divided in four seasons, according to the local traditional classification: (i) *Darat*: Harvest season (September to October); (ii) *Chité*: Dry and colder season (November-February); (iii) *Sef*: Dry and hot season (February to April); (iv) *Rouchach*: First rainfalls (May to June); (v) *Kharif* : Rainy season (July to October). The rate of herd off-take is the number of animals exploited (culling, sale, gift) divided by the mean herd size. The fertility rate was calculated by dividing the 12 months of the year by the interval between calving.

## RESULTS

### Herd structure and composition

The species association of animals in a same herd is a common practice. The dominant modality is the association of cattle, camels and small ruminants (Figure 2). The association camels and small ruminants (16%) or cattle and small ruminants (15%) are the second modality. Herds exclusively composed of cattle, small ruminants or camels amount together to 20% of the total sample. The presence of cattle and camels in the same herd is rare (Figure 2).

The association between cattle and small ruminants is the only modality practiced by sedentary agro-breeders and is also practiced by 52% of transhumant agro-herders (Table 1). The species composition of herds is more variable among nomadic herders, with two main modalities (36% each), that is, herds exclusively composed of small ruminants and their association with camels. Exclusive camel herds are only found in nomadic systems.

Nomadic herders keep zebu cattle whereas the transhumant and sedentary breeds hybrids resulted from the cross between zebu and Kouri taurin.

### Feeding

#### *Rangelands*

In the North part of Kanem, animals (cattle and small

**Table 1.** Distribution of species composition according to the breeding system (%) in the Kanem Region (Chad).

| Association type | Transhumant agro-herders | Nomadic herders | Sedentary agro-breeders |
|---|---|---|---|
| Cattle + small ruminants | 52 | 21 | 100 |
| Camel + small ruminants | 11 | 36 | 0 |
| Cattle + small ruminants + camel | 30 | 0 | |
| Cattle | 7 | 0 | 0 |
| Camel | 0 | 7 | 0 |
| Small ruminants | 0 | 36 | 0 |
| Total | 100 | 100 | 100 |

**Table 2.** Different pastures used by livestock.

| Pastures | Season | | | | |
|---|---|---|---|---|---|
| | First rainfalls | Rainy | Post-harvest | Colder | Hot |
| Pastures of the dunes and trays (grasses and woody plants) | Cattle zebus, camels, small ruminants | Cattle zebus, camels, small ruminants | Cattle zebus, camels, small ruminants | Cattle zebus, camels, small ruminants | Cattle zebus, camels, small ruminants |
| Fileds (crop residues) | | | Cattle zebus, small ruminants | Cattle zebus, small ruminants | Cattle zebus, small ruminants |
| Polders of Chad Lake | | | | Taurine Kouri and hybrids, camels, small ruminants | Taurine Kouri and hybrids, camels, small ruminants |
| Islandes of Chad Lake | | | | Taurines Kouri | Taurines Kouri |
| Woody plants | Camel | Camel | Camel | Camel | Camel |

ruminants) of the nomadic herders are free all the year. They value all the year the grassy and woody pastures of the dunes and trays (Table 2). The different kinds of grasses are: *Panicum turgidum, Aristada mutablis* and *C. biflorus*. As for the shrub, it essentially consisted of *L. pyrotechnica* and *C. procera*. After the harvest, they go in the fields for eating the crop residues. The seasonal trips are scarce because the number of cattle and small ruminants is down. The pasture in the free space such as leaves, flowers and fruits of shrubs constitute the feeding of the camels. During the dry period, the herds of camels move more to the east in the area of rig-rig where the pastures are abundant. They use year-round the herbaceous pasture and woody plants of dunes and traps.

Unlike the North, in the southern part of Kanem, each morning, the herds of the transhumant agro-herders and agro-breeders are led to the pasture under the watch of a young shepherd. And then, cattle, small ruminants and camels are led near the Chad lake were the green grasses are abundant. The herders of taurine Kouri lead theirs in the Islands to breed the green grasses, particularly sedges and *Acacia* sp. In the rainy season, cattle move more in the northern of the Chad Lake where they take advantage of the breed pastures of the dunes and traps as well as cattle of nomadic herders.

### *Complementary feeding practice*

Complementary feeding is only practiced during the dry and hot season (*Sef*) and during the period just preceding rainfalls (*Rouchach*), when the shortage in fodder is the most limited. During the dry and cool season (*Chité*), dry season fodder and cereals straws are harvested and stocked by the 3/4 of sedentary agro-breeders to serve as complementary feed (Table 3). This practice is less frequent among transhumant agro-herders (19%) and is almost absent among nomadic herders (1%).

Agro-industrial by-products may also be used, particularly groundnut oilcake, being used by 75% of sedentary agro-breeders, 93% of transhumant agro-herders and 71% of nomadic herders. Other by-products used, include cereals brans, by 25% of agro-breeders, 81% of transhumant agro-herders and 43% of nomadic herders. Cereal grains may also be distributed in extreme cases, when other complements are not available on the market. In all cases, complementation is selective, targeting lactating and gestating females, weak animals or young stock. Salt complementation is a common

**Table 3.** Use of dietary supplements by type of farming (%).

| Supplements | Sedentary agro-breeders | Transhumants agro-breeders | Nomadic herders |
|---|---|---|---|
| Cereals straw | 75 | 26 | 1 |
| Cereal brans | 25 | 81 | 43 |
| Groundnut oilcake | 75 | 93 | 71 |
| Salt complementation | 100 | 100 | 71 |
| Cereals grains | 25 | 44 | 36 |

**Table 4.** Mean milk yield variation per cow according to the season and the herding system (liter/day) in Kanem Region (Chad).

| Herding system | Season | | | | |
|---|---|---|---|---|---|
| | ***Kharif*** | ***Darat*** | ***Chité*** | ***Sef*** | ***Rouchach*** |
| Sedentary agro-breeders | $3.24^{a}$±1.6 | $2.01^{a}$±1.0 | 1.15±0.8 | $0.60^{a}$±0.3 | 1.2±0.5 |
| Transhumant agro-herders | $1.94^{b}$±1.5 | $1.51^{b}$±1.0 | 1.02±0.8 | $0.25^{b}$±0.4 | 1.1±0.5 |
| Nomadic herders | $2.71^{c}$±0.8 | $1.60^{c}$±0.7 | 1.01±0.5 | $0.83^{a}$±0.4 | 1.2±0.6 |
| Total | 2.60±0.8 | 1.54±0.7 | 1.10±0.5 | 0.83±0.4 | 1.1±0.6 |

* Different superscripts (a, b, c) on a same column indicate statistically significant differences ($p< 0.05$).

practice of all livestock keepers), either in the form of sodium chloride (60% of cases, mainly sedentary agro-breeders and transhumant agro-herders in the South of Kanem) or in the form of sodium carbonate (40% of cases, mainly among nomadic herders from the North Kanem).

## Milk production

The daily milk yields per cow are presented in Table 4 for the three different systems. During the rainy and post-harvest seasons, milk production is significantly higher in sedentary agro-breeder system ($p<0.05$). During the dry and hot season, the dry and cool season and at the beginning of the rainy season, daily yields are generally low, under 1.5 L, for all three systems. During the dry season, the mobile agro-herders report significantly lower yields than in the two other systems ($p<0.05$).

In camels, except for agro-breeders who only own some males for transport, the breeding system (nomadic or transhumant) has no statistical effect on the reported milk yield for all seasons (Table 5). On the contrary, the season itself shows a significant effect on the reported milk yield, being lowest at the end of the dry and hot season (p< 0, 05).

## Reproduction performances

### *Age at first calving*

The mean age at first calving is 4.7 years old in cows and 5.8 years old in she-camels. This age does not vary significantly between breeding systems (p>0.05) (Table 6).

### *Calving interval*

The mean calving interval is 1.9 years in cows and 2.7 years in she-camels. In both cases, this interval was not influenced by the breeding system (Table 7).

### *Fecundity*

Mean fecundity, that is, the number of offspring per year and per animal is 0.63 in cows and 0.44 in she-camels.

### *Herd off-take*

In the Kanem region, this rate of herd off-take varies according to the breeding system and the animal species (Table 8).

Nomadic herders display the highest off-take rate among the three systems for cattle and sheep. The sedentary agro-breeders exploit fewer cattle than in other systems. The off-take rates in camels by nomadic herders and transhumantagro-breeders are similar. The small ruminants show the highest off-take rate in all breeding systems.

## DISCUSSION

### Herd structure and composition

Livestock keeping in the Sahelian context presents high risks due to the extreme environmental variability, both inter- and intra-annually. The particular vulnerability of the system appears at the end of the dry season, especially

**Table 5.** Mean milk yield variation per she-camel according to the season and the herding system (liter/day) in Kanem Region (Chad).

| Herding system | Season | | | | |
|---|---|---|---|---|---|
| | ***Kharif*** | ***Darat*** | ***Chité*** | ***Sef*** | ***Rouchach*** |
| Transhumant agro-herder | 3.09±1.6 | 3.04±1.3 | 2.00±1.1 | 2.01±0.8 | 1.60±0.5 |
| Nomadic herders | 3.29±1.7 | 3.09±1.1 | 2.03±0.6 | 2.01±0.5 | 1.60±0.4 |
| Total | 3.12±1.6 | 3.04±1.3 | 2.01±1.1 | 2.01±0.8 | 1.60±0.5 |

**Table 6.** Mean age at first calving in cows and she-camels per breeding system in Kanem Region (Chad).

| Herding system | Cow | She-camel |
|---|---|---|
| Transhumant agro-herders | 4.7±0.6 | 5.9±0.6 |
| Nomadic herders | 5.0±1.0 | 5.7±0.6 |
| Sedentary agro-breeder | 4.6±0.7 | - |
| Total | 4.7±0.7 | 5.8±0.6 |

**Table 7.** Mean calving interval in cows and she-camels per breeding system in Kanem Region (Chad).

| Herding system | Cow | She-camel |
|---|---|---|
| Transhumant agro-herders | 1.9±0.4 | 2.7±0.5 |
| Nomadic herders | 2.0±0.0 | 2.6±0.4 |
| Sedentary agro-breeder | 1.9±0.2 | - |
| Total | 1.9±0.4 | 2.7±0.4 |

in unusually dry years (Thébaud, 2002). To mitigate the effects of such droughts, herders developed strategies, among which the diversification of species (Faye, 1992; Bourgeot, 2009). Hence, cattle are usually associated to small ruminants or even to camels. This diversification of animal assets appears as a major characteristic of the herds in Kanem. This strategy allows taking advantage of each species (reproductive performance, resistance to drought and diseases, production of meat, milk and manure and lowers the risk of losing the whole herd upon drought or epizootics. Species association also bring benefits regarding the diverse economic and socio-cultural roles of each species: Goats and camels produce milk all year round, sheep are sold to cope with regular or exceptional financial needs and are also sacrificed for religious events (Maiga, 1995). An additional advantage is that these different species graze different vegetal strata; camels and goats graze shrubby and tree strata whereas cattle and sheep graze the herbaceous layer (César and Zoumana, 1999). This diversification is a widespread strategy across the Sahel.

## Rangelands

In Sahelian zone, natural pastures constitute the main part of ruminants feeding. However, their productivity varies widely in time and space. Hence, if during the rainy season, the pastures are rich in annual grasses such as *Aristida funiculata* and *A. mutabilis* and may cover the animal needs for maintenance and production. During the dry season, this fodder becomes dry, sparser and of poor nutritional quality (Boudet et al., 1967). This seasonal disequilibrium in nutritional resources on rangelands affects animals, resulting in weight loss, an overall weakness and drop in milk yield (Thébaud, 1990). To face this shortage, livestock keepers in the study zone distribute complements to their animals, as crop residues, by-products or even cereals. This distribution is restricted in terms of time, targeting the critical periods, and in terms of animals such as sick animals and lactating females. Nevertheless, the implementation at a wider scale and on a longer period of this practice faces constraints due to the poor accessibility of these products.

## Milk production

Milk plays an important role in the nutrition and economies of pastoral societies. Herders breed cattle and camel first for their milk and then for the sale of their offspring. Besides home consumption, the sale of transformed milk products (e.g. ghee) brings key income for the households (Kerven, 1987). In Kanem, this study confirms the wide seasonal variability of milk production. The highest yields are found in the rainy season (*Kharif*) and stay high in the post-harvest season, when animals have access to crop residues. The dry and hot season (*Sef*) is the harsher season and the time preceding the first rainfalls (*Rouchach*) is each year critical for herd survival, due to severe shortage in water and fodder. During this period, cow milk yield is lowest in the transhumant system but slightly higher and similar in the nomadic and sedentary systems. This result might indicate that the nomadic pastoralism is an efficient way of using the sparse vegetation and seasonal shortage (Colin de Verdière, 1995). Sedentary farms display similarly good yields in this period due to their complementary feeding practice and the presence in their herds of the Kuri breed that is known as a good milk breed. The breeding systems did not show an impact on camel production. This might be due to the fact that the nutrition of camels is based all year round on the tree fodder, mainly *Leptadenia pyrotechnia*.

**Table 8.** Mean rate of herd off-take (%) per species and per breeding system in Kanem Region (Chad).

| Herding system | Cattle | Sheep | Goat | Camel |
|---|---|---|---|---|
| Transhumant agro-herders | 12.1 | 30.7 | 25.2 | 11.3 |
| Nomadic herders | 14.5 | 36.3 | 28.3 | 10.3 |
| Sedentary agro-breeder | 8.2 | 22.0 | 30.5 | - |
| Total | 11.8 | 32.0 | 26.8 | 10.5 |

## Reproduction performances

The mean age of 4.7 years at first calving in cows is similar to those reported in by Wagenaar et al. (1988), Faye (1992), Colin de Verdière (1995) and Achard and Chanono (1997), who obtained ages comprised between 4 and 4.5 years old. The calving interval about 22 months is also higher than that reported by the same authors (16 to 18 months).

The studies on production parameters in camels in Africa are sparse. However, the mean age at first calving (5.8 years) and the calving interval (2.7 years) obtained in this study are similar to those reported by Vias et al. (2006) in Niger, that is, respectively 5.5 and 2.4 years. An age at first calving between 5 and 6 years is reported in different ecological zones of Ansongo region, Mali (Traoré et al., 2014).

A fecundity rate of 63% is obtained in cows and 44% in she-camels. These values are difficult to ascertain and difficult to compare between authors because of the diverse methods used. Ranges of values may nevertheless be proposed. Indeed, regarding cows, Sedes (1976) observes a fecundity rate between 53.8 and 63.5% in Arab zebu in Chad. Similarly, Achard and Chanono (1997) report a fecundity rate of 73 to 86% for the Azawak zebu in Niger. Regarding camels in pastoral systems, Mukasa-Mugerwa (1981) reported them to be lower than 50%.

The reproduction performances of zebu cattle and camels in the study zone are modest. These performances are constrained by the environment, indicating the poor availability and quality of fodder. Indeed, while local breeds might present genetically lower performances due to their adaptation to scarcity, several studies showed that the genetic potential of indigenous breeds might be better exploited by the adoption of simple husbandry techniques, relating to feeding and health follow-up, resulting in higher weight gains and milk yields (Achard and Chanono, 1997; Missohou et al., 1997; N'Djoya and Loko, 1997).

Off-take rates were highest in small ruminants, since these species are easier sold on Sahelian markets. Their sale aims at fulfilling medium financial needs of the household. They may be sacrificed for home consumption, more often than on religious occasions or to welcome important guests. Cattle and camels are sold to meet important expenses (maize stocks for agro-breeders and agro-herders, wedding, fines, etc.). The high off-take rate reported by nomadic herders for cattle relates to the volatility of food prices, as cereals, forcing them regularly to sell animals to buy food. This rate was more moderate in agro-breeders who produce part of their food and generate monetary incomes through other activities (e.g. the trade of sodium carbonate).

## Conclusion

This study highlights the strategies in different breeding systems in the Kanem Region, Chad. In many of them, species diversification is a key feature of their risk management. This practice allows taking advantage of the particular benefits of each species. However, there is a strong influence of the environment in particular food resources, including forage on livestock productivity and on reproductive parameters Systems strongly rely on highly variable environmental resources, impacting their production level. The main product of livestock is found to be milk, although animals are also sold or even home-consumed for meat. Milk yields are low for a large period of the year. Despite their poor quantitative performances, indigenous cattle and camels are found to be highly adapted to their environment and its variability, showing the crucial ability to survive and breed in harsh conditions. Simple husbandry techniques might help increasing production levels to the benefit of the households, as complementary feeding, which is already practiced in a targeted way. The more systematic implementation of this complementation nevertheless faces important constraints of availability of these agricultural by-products on the local markets. As far as research is concerned, the study recommends the implementation of herds monitoring of the area in order to precise the livestock breeding practice as well as zootechnical parameters.

## Conflict of Interest

The authors have not declared any conflict of interest.

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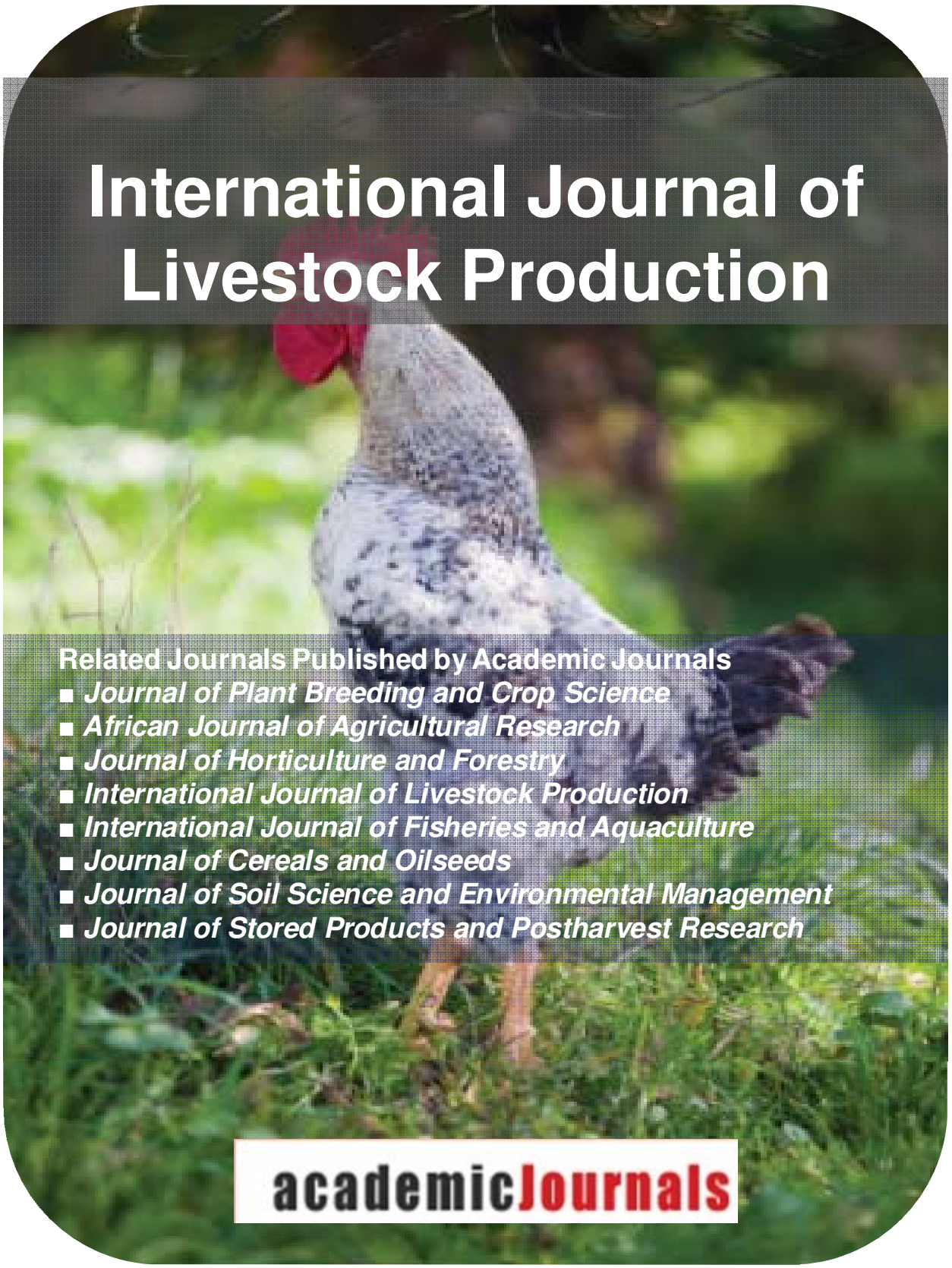

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