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Distribution and relative abundance of pig breeds in South-Western Agro-ecological Zone, Uganda: Status of locally adapted pigs

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A cross-sectional study was conducted in five districts in South Western Agro-Ecological Zone (SWAEZ), Uganda, to map pig breed distribution and determine their abundance and population structure. Purposive and snowball sampling methods were used to identify pig farmers whose pigs were included in the study. Pig breeds were identified using the NAADS user guide on pig husbandry. The breeds that were properly identified in the study districts included Camborough, Landrace, and Large White; crosses and locally adapted pig populations were not differentiated into specific breeds. Camborough breed was the least abundant (0.69%), Landrace (5.0%), Large white (15.75%), crosses constituted 23.35% and majority of the pigs (55.2%) belonged to the non-descript locally adapted ecotypes. Piglets (36.82%), constituted the highest percentage to the total pig population followed by females (30.22%), growing females (15%), growing males (11%) and the least were adult males (6.89%). More farms kept the locally adapted populations (56.5%) compared to those with the other breed types, all combined and majority of the farms were owned by females (63.22%). Herd size ranged from 1 to 3 pigs at any given time. Exotic breeds and or crossbreds were kept in big numbers while the locally adapted pigs were few per household; 20.1% of the farms had only one pig. Tethering was the most used type of holding at the farms (62.55%). Exotic breeds have penetrated the rural areas and are very abundant. Locally adapted ecotypes are therefore threatened by continued crossbreeding for breed improvement and introduction of new breeds. Farms keeping locally adapted pigs can be facilitated to increase their herd sizes for profitable projects instead of changing breeds. New breed introduction and promotion should be regulated and monitored.

Key words: Pig breeds, distribution, abundance, Southwestern Agro-ecological zone.

INTRODUCTION

Livestock production is an important sub-sector of agriculture in Uganda contributing about 7.5% to the total gross domestic product (GDP) and 17% to agricultural GDP (Arnaoudov et al., 2017). About 58% of households in Uganda depend on livestock for their livelihoods and most of them are subsistence-oriented smallholder

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farmers (FAO, 2019) with small herd sizes usually between 2 and 20 (Dione et al., 2022; Bonis-Profumo et al., 2022). Pig production as part of the livestock sector is an important source of income and financial security for rural and middle income urban communities in Uganda (Morison et al., 2019). Pigs rank second to cattle in terms of meat production in Uganda (Uganda Bureau of Statistics, 2019). In South Western Agro-ecological Zone (SWAEZ) which lies in the traditionally known dry cattle corridor, pig production is a quick income earner compared to other types of livestock (Ndyomugyenyi and Kyasimire, 2015) and the region ranks second in terms of overall pig numbers (UBOS, 2015). The total pig population was 4.47 million kept by 1.3 million farmers in 2018 (UBOS, 2020a). In 2018, pigs had the highest percentage increase (3.3□) in numbers compared to other livestock species (UBOS, 2019); the number is now (2023) likely to be above 4.5 million pigs. Increase in pig production is fueled by increased pork consumption in urban communities (Thomas et al., 2013; Morison et al., 2019) due to rising incomes and urbanization (Ndyomugyenyi and Kyasimire, 2015). Both the previous and current statistics, however, do not provide disaggregated livestock data such as farmer, farm location, the number of livestock by specific breed type etc. (MOFEPD, 2021). The numbers given are often not differentiated into specific breeds whether indigenous breeds or exotic like for other livestock species- cattle, goats and poultry where it is clear that indigenous breeds continue to dominate the exotic ones; the case for pigs is not only blurred but also probably different (UBOS, 2019). The actual locally adapted pig population, composition and distribution is not well known in Uganda, the risk status is therefore unknown (FAO, 2015).

High annual growth rate of Uganda's population of an average of 3.03% between 2002 and 2014 (UBOS, 2015) coupled with urbanization is also exerting massive pressures on food supplies. Meeting the food needs of a growing urban population with rising incomes (more money) has had profound implications for the pig production sector. The increased demand for pork even in rural areas has forced farmers to abandon the 'less productive locally adapted populations for improved breeds and their crosses. To meet the high demand for pork, farmers are forced to not only change breeds and but also the management system (Babigumira et al., 2022). All modern piggeries use exclusively exotics (AU-IBAR, 2015; FAO, 2015) and most rural-based small scale farmers still keep the locally adapted pigs due to limitations of additional management inputs required (FAO, 2015). However, this is gradually changing given the rise of new trends in modern pig farming (Ndyomugyenyi and Kyasimire, 2015) and the threat to locally adapted pigs is thus apparent and real. Locally adapted pigs are sidelined from commercial production systems because of their supposed inferior growth characteristics and low reproductive performance despite having other known characteristics (Mosweu et al., 2020) such as hardiness, good disease tolerance and can cope with almost any feed (Marshall, 2020). While in ternational breeds have contributed to increasing the output of livestock products, there is concern that introduction of exotics breeds poses a challenge in terms of additional resources required, management skills and also the vulnerability of the animals to diseases, food shortages etc. (FAO, 2015) and future adaptation to climate change. Some smallholder farmers especially in the rural areas have indicated that the keeping of crossbreeds/exotics was not sustainable in their areas (Ouma et al., 2015).

Production efforts are emphasizing the need for breed improvement for better traits such as quick maturity and large litter through cross breeding, distribution and promotion of improved/exotic breeds (Mulindwa, 2016). Government through the national agricultural advisory services (NAADS) is the leading distributor and promoter of exotic breeds (Ouma et al., 2015). For example, from 2006 onwards, Camborough pigs have been imported, both for pure-breeding and for cross- breeding with the Ugandan local pig (FAO, 2015). Government documents, media reports and farmer forums are not actively involved in issues of pig genetics (Tatwangire, 2014), no organization is advocating for use or promotion of locally adapted pigs and there is no commercially viable enterprise involved in locally adapted pigs. Within the livestock industry in Uganda, pig sub-sector is least developed (Ndyomugyenyi and Kyasimire, 2015). Indigenous animal genetic resources (AnGR) are therefore in a continual state of decline due to indiscriminate crossbreeding and institutional policies that support use of high producing exotic breeds (AU-IBAR, 2019a). Farmers also tend to forget that breeds that are of little practical use today may prove very valuable under future conditions and that the value of animal genetic diversity therefore goes beyond benefits derived from its current use to the so-called "option values" which are equally or even more important FAO (2009). The unique attributes of locally adapted genotypes and the fear of losing them due to disease and replacement with exotic genotypes makes them suitable targets for conservation (AU-IBAR, 2019b) hence the justification for this study. It is important to identify potential threats to local animal genetic resources arising because particular breeds are no longer valued for their former functions and may therefore face an increased risk of extinction (FAO, 2015).

Most studies on pigs in Uganda have looked at different issues about pig production which include welfare (Dione et al., 2022); heat stress (Mutua et al., 2020; Zaake, 2019), diseases (Thompson, 2017; Atherstone et al., 2020), pig value chain (Tatwangire, 2014; Ouma et al., 2015; Ouma et al., 2017; Thompson, 2017); production systems (Muhanguzi et al., 2012; Nantima et al., 2015), pig feed diversity (Okello et al., 2021); trading networks

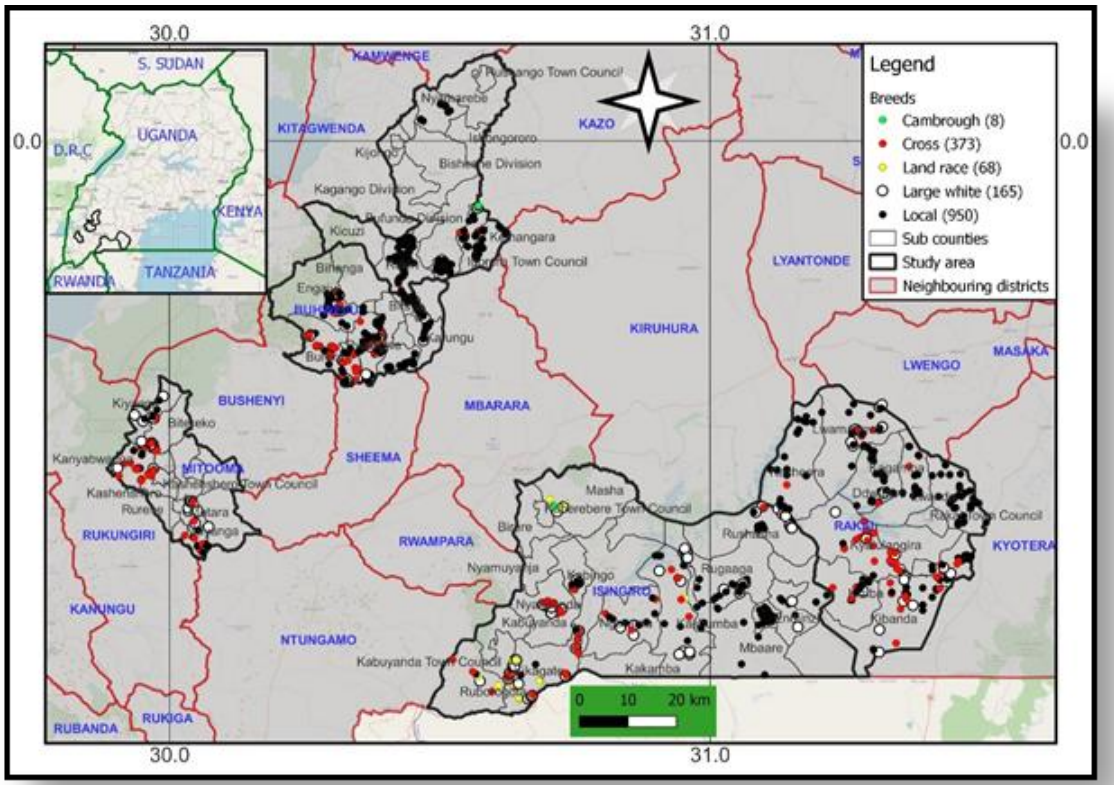

Figure 1. Map of Uganda showing the selected study districts and the distribution of pig breeds.
Source: (Extracted by Jackline Kampire (author) using ArchGIS 10.5)

(Atherstone et al., 2018), knowledge and attitudes (Roesel et al., 2019; Mutambo et al., 2019; Dione et al., 2020). Information on breed distribution and population structure is not only limited but is also not clear; reports showing increase in pig numbers as per annual statistical abstracts of Uganda Bureau of Standards (UBOS) do not normally differentiate the numbers into respective breeds. Censuses rarely distinguish between exotic and crossbred individuals and when the distinction is made, there is in general no differentiation between synthetic lines (Lero et al., 2015), and are therefore not very reliable for generation of data that may be used for conservation planning. Previous studies reported that the actual pig population, composition and distribution in Uganda is not well known (Noce et al., 2015), and little to describe the population composition in terms of breeds (Mujibi et al., 2018). At present, there is a real dearth of information in relation to the different breeds in Uganda; details of the main breeds kept by the farmers are almost lacking and the breed composition of most pigs in Uganda is largely unknown; any available information on breeds is mostly as reported by farmers (ILRI, 2011; Muhanguzi et al., 2012; Babigumira et al., 2021). Different institutions provide different estimated figures, and these miss an authoritative figure that could be used for planning and other uses. The lack of this vital information places the pig breeds genetic diversity at risk, as decline in numbers of indigenous populations may remain undetected and result in the complete loss of ecologically-important traits or entire local animal populations (AU-IBAR, 2019a). Data that is normally used for references is too old (2008 livestock census) and based on assumed percentage increase. It is therefore necessary to determine the distribution and abundance of pig breeds in SWAEZ to constitute a benchmark for evaluating any future breed conservation programs and to assess the risk of continued promotion of exotic breeds. Additionally, the findings are useful in planning for sustainable utilization and conservation of the locally-adapted breed for future generations.

METHODS

Study area

A cross-sectional study was conducted in five selected districts: Ibanda (0.1167°S, 30.2667°E); Isingiro (0.8333^{0}S, 30.8333^{0}E); Mitooma (0.6000°S, 30.0000°E), Buhweju (0.3000°S, 30.3333°E) and Rakai (0.7167°S, 31.4000°E) in the South Western Agro-Ecological Zone (SWAEZ) of Uganda (Figure 1). This zone has a fast-growing human population, estimated at 3.8 million people in 2014 (Uganda Bureau of Statistics, 2019) and also ranks second after the central region in terms of pig numbers (Uganda Bureau of

Figure 2. a-f: locally adapted pigs are small bodied and primarily characterised by black colour, or black and white together; **g** and **h:** Cross breeds are characterised by a mix of different colour combinations **i-**Camborough; **j:** Large White; **k:** Landrace are purely white coloured, have large body sizes at maturity and are differentiated by body shape and ear orientation.
Source: Photos: Jackline Kampire/Mbarara University of Science & Technology (MUST) (taken between Jan- Dec 2021) (Author's personal collection)

Statistics, 2015). The five districts were chosen on the basis of their location – distance from the city centre of Mbarara; and pig numbers as per the available report (MAAIF, 2010): it is assumed that locally adapted pigs are kept in very remote rural areas

Abundance and distribution of pig breed populations

To determine the abundance and distribution of pig populations in the study area, the study used a combination of the tools provided by FAO (2011) and FAO (2012). The abundance and distribution of pigs was mapped using: (1) geographical coordinates/ location of households with pigs, and (2) identifying and recording of the breed types per household as well as the production system (s) used.

Selection and sampling of study participants

We identified pig farmers using purposive and snowball sampling methods in the pre-liminary survey. At the sub-county level, farmers to be included in the study were identified by purposive and systematic random sampling where a farmer would be considered every after skipping two adjacent households. Pig breed types were differentiated using the NAADS (2011) user guide. Altogether, 1570 households with piggeries in the five districts were recruited into the study. Only one adult person was interviewed in every household.

Data collection

Interviews were conducted to collect information on the type of pig breeds kept by each household, structure and composition of the pig population and the production system. Pre-translated interview guides were used in farmers' local languages; Runyankore for the farmers in Isingiro, Mitooma, Ibanda and Buhweju districts, and Luganda for the farmers in Rakai district. Data collection was done by animal husbandry officers (AHO) recommended by the district production office and the district veterinary officers. The AHO have knowledge of pig breeds, are responsible for extension and provision of livestock related services and advice in their respective sub-counties.

Statistical analysis

The coordinates were plotted using ArcGIS to generate distribution maps. Data on breed populations and production system was analyzed by descriptive statistics in the SPSS (2011). Cross tabulations and chi-square tests were done for comparisons between the different districts.

Ethical considerations

Ethics approval was obtained from Mbarara University of Science

Table 1. Distribution of farms/households and total number of pigs in each district.

Distribution pig farms/households among number of pigs per district (N (%)		
District	**Total no. of farms**	**Total no. pigs**
Buhweju	409(26.1)	1494(25)
Ibanda	191(12.2)	660(11.1)
Isingiro	400(25.5)	1577(26.4)
Mitooma	171(10.9)	603(10.1)
Rakai	399(25.4)	1635(27.4)
Total	1570	5969

N – Number of pigs; percentage contribution to the total in parentheses.
Source: Produced by Jackline Kampire / Mbarara University of Science & Technology (MUST)

Table 2. Distribution of pig population along the age structure in the study districts

Distribution of the pig population per age structure in the study districts (N (%)						
District	**Males**	**Females**	**Growing males**	**Growing females**	**Piglets**	**Total no. pigs**
Buhweju	72(1.21)	417(7.0)	144(2.4)	234(3.9)	627(10.5)	1494(25)
Ibanda	51(0.85)	224(3.8)	78(1.3)	128(2.1)	179(3.0)	660(11.1)
Isingiro	126(2.11)	433(7.3)	243(4.1)	251(4.2)	524(8.8)	1577(26.4)
Mitooma	36(0.6)	190(3.2)	62(1.0)	93(1.6)	222(3.7)	603(10.1)
Rakai	126(2.11)	540(9.0)	120(2.0)	203(3.4)	646(10.8)	1635(27.4)
Total	411(6.9)	1804(30.2)	647(10.8)	909(15.2)	2198(36.8)	5969

N – Number of pigs; percentage contribution to the total in parentheses.
Source: Produced by Jackline Kampire / Mbarara University of Science & Technology (MUST).

and Technology Research Ethics Committee (Study No. 08/07-18). The study was also registered by the Uganda National Council for Science and Technology (N0. A44ES). Further permission to conduct the study in the selected districts was sought from the respective Chief Administrative Officers (CAOs). All study participants gave written consent prior to recruitment into the study.

RESULTS

Pig distribution, abundance, and farms in each district.

A total number of 5969 pigs were kept across the 1570 households/farms. Buhweju, Isingiro and Rakai districts had the biggest number of farms/households keeping pigs respectively; Mitooma and Ibanda had the least number of farms/households keeping pigs. Rakai, Isingiro and Buhweju had the biggest number of pigs respectively (Table 1). Majority of piggeries were owned by women (68.32%). Rearing of pigs was influenced by other economic activities such as proximity to protected areas, religion, and cultural beliefs. For instance, there were few or sometimes no pig farms in cattle keeping and Islamic communities since pigs are despised in these communities. In communities where other economic activities were doing well and labour intensive, very few pig farms were encountered, communities very close to the gazetted areas also had very few piggery projects.

Distribution of pig population along the age structure in the study districts

Piglets constituted the highest number of the total pig population with 36.8%, adult females 30.2% and the least were adult males (boars) with 6.9% contribution. Isingiro and Rakai districts had the biggest number of boars, Rakai had the biggest number of sows and piglets (Table 2).

Pig breeds distribution in South-Western Agro-Ecological Zone

Three distinctive pig breeds were identified by close observation using the NAADS farmers' guide and interviews with the owners. These included Camborough, Landrace, and Large White (Table 5). Other pigs were categorized as Crosses and Locally adapted pig (commonly considered as"indigenous/native") ecotypes. A very small number of farms 8 (1%) had Camborough breed, Landrace 68 (4%), Large White 165 (10%),

Table 3. Distribution of pig breeds in study districts.

Number of farms keeping each breed (N (%)							
District	**Camborough**	**Cross**	**Landrace**	**Large white**	**Local ecotypes**	**X^2**	**P-value**
Buhweju	1	112	0	24	272	438.3	0.000
Ibanda	2	17	0	1	171		
Isingiro	2	130	67	88	113		
Mitooma	3	74	1	27	66		
Rakai	0	109	0	25	265		
Total No. farms	8(0.5)	442(28.1)	68(4.3)	165(10.5)	887(56.5)		

N – Number of pigs; percentage contribution to the total in parentheses.
Source: Produced by Jackline Kampire / Mbarara University of Science & Technology (MUST)

Table 4. Households, herd size, and pig breeds kept by farmers in SWAEZ.

Herd size	Number of households keeping each breed under different herd-sizes							
	Camborough	**Cross**	**Land race**	**Large white**	**Local**	**Total No. of pigs**	**X^2**	**P-value**
1-3	6	249	45	97	676	2694	155.88	0.047
4-9	1	99	14	45	211	2162		
10-15	0	67	6	10	0	392		
16-20	0	16	02	04	0	202		
21-30	1	8	0	6	0	272		
31-45	0	3	1	3	0	247		
Total	8	442	68	165	887	5969		

Source: Produced by Jackline Kampire/Mbarara University of Science & Technology (MUST)

Crosses 442 (24%) while majority of the farms kept the locally adapted pig ecotypes 887(61%). The distribution of breeds varied highly across the districts as shown in Table 3. The difference in the distribution of the breeds across the districts was statistically significant (P<0.0001).

Households/farms, herd size and pig breeds kept by farmers in SWAEZ

There was a difference in the number of pigs kept (herd size) across the study districts, (p<0.047). Herd size for majority (43.1%) households ranged from 1 to 3 pigs; only 26.26% households kept 4 to 11 pigs while 5.42% kept over 11 pigs. The herd sizes and breeds kept by farmers are presented in Table 4. Piggeries with big numbers of pigs kept exotic breeds and/or crosses while those that kept locally adapted pigs had few numbers per household.315 (20.1%) of the farms with locally adapted pigs had only one pig per household**.**

Production system of the pigs

This was assessed on two different aspects: the type of holding or production system and type of feeds used.

Type of holding

Generally, most farms keeping locally adapted pig ecotypes 692 (78%) used tethering as a holding method. All Camborough pigs were housed. For Landrace and Large White breeds, 97.1% and 80% were housed, respectively. Only 22% of farms keeping locally adapted pigs housed their pigs (22%). More than half of the farms keeping crossbreds used tethering (56%) than housed (43.9%). The number of farms with housed and tethered animals varied significantly in the different districts (P<0.000) (Table 5).

Observed characteristics of pig breeds in SWAEZ

The physical differences of the different pig breeds as observed and identified on the farms using the NAADS farmers' guide and the experience of the animal husbandry officers are displayed in Figure 2.

Type of feeds

Majority of households used locally available food to feed their pigs (Table 6). Farmers mostly used a mixture of

Table 5. Number of farms with each type of breed under each type of holding.

Number of farms keeping the breed	No. of farms with breed under each type of holding N (%)		Chi-square (X^2)	P-value
	Housed	Tethered		
Cambrough (8)	8(100)	0	179.83	0.000
Crosses (442)	194(43.9)	248(56.1)		
Land race (68)	66(97.1)	2(2.9)		
Large white (165)	132(80)	33(20)		
Local (887)	195(22)	692(78%)		

Source: Produced by Jackline Kampire / Mbarara University of Science & Technology (MUST)

Table 6. Number of farms using the type of food for feeding different breeds.

Type of feed resource	Camborough	Crosses	Landrace	Large White	Local	Total number of farms N (%)
Greens (not from food crops)	5	380	68	157	350	960 (20.8)
Cassava leaves	0	54	27	25	37	143 (3.1)
Leftover food	7	308	68	145	263	791(17.1)
Maize bran	4	274	68	134	158	642(13.3)
Bananas andpeelings	4	182	68	156	238	648(14.4)
Yams (root and leaves)	6	220	54	114	163	557(12.1)
Sweet potatoes/leaves	4	208	62	125	116	515(11.2)
Ovacado	0	63	12	61	74	210(4.5)
Waste water	2	34	20	18	9	83(1.8)
Rice bran	0	11	3	3	2	19(0.4)
Dregs	0	9	3	6	12	30(0.6)
Pumpkin	0	0	0	3	0	3(0.1)
Pineapple peelings	0	0	2	3	9	14(0.3)
Sugarcane stem peelings	0	3	0	0	0	3(0.1)

N – Number of farms using the type of feed; percentage contribution to the total in parentheses.
Source: Produced by Jackline Kampire/Mbarara University of Science & Technology (MUST)

green plants as feeds. Few farms used maize bran (13.9%) as the main food for their pigs; it was mostly used in combination with other feeds. Farms with locally adapted pigs (350) especially with small herd sizes used locally available feeds while those with exotic breeds and crossbreds used improved food supplements in addition to the locally available feeds. Few farms 158 (17.8%) with locally adapted pigs used maize bran as feeds though without added supplements while most farms 480 (93.7%) with crosses and exotics used maize bran for feeding their pigs and with added supplements.

DISCUSSION

The distribution and abundance of pig breeds both in numbers and breed types in SWAEZ was disparate. This is in agreement with Gifford-Gonzalez and Hanotte (2011) who reported that the geographic distribution of pigs was generally erratic in comparison to other livestock species, likely reflecting cultural and religious practices. Small scale farmers dominate the pig sector in the rural areas and cannot afford expensive technological inputs like acquiring of modern breeds, feeds, medication, and construction of sties. The majority of pigs are kept by women in smallholder households, as part of the large informal sub-sector with limited access to technology, information and services (Thutwa et al., 2020). Pig rearing was influenced by factors such as location for easy access to feed sources, other economic activities, religious and cultural beliefs in each district. For example, in cattle keeping and Islamic communities, pig rearing and consumption are not generally tolerable and therefore had very few piggery farms. Pig rearing was done alongside other activities similar to what was observed by Greve (2015) and therefore a secondary activity for many farmers. In sub-Saharan Africa, Uganda inclusive, livestock ownership is a symbol of wealth, and culture influences gender-driven roles in pig production (Suparyanto, 2020; Taruvinga et al., 2022). Most pig

farms were owned by females and few piggery projects were co-owned by both males and females. Ouma et al. (2015) contended that regardless of who heads a household, it is widely agreed that women and children actively participate in managing pigs and other small animals that are reared in homesteads. Previous studies reported that pig ownership was inclusive of all genders, with a slightly higher number of female owners of locally adopted ones (Morison et al., 2019; Halimani et al., 2020) while males dominate ownership of exotic breeds and their crosses and with large numbers. The dominance of female owners and the spread of pigs within the gender is based on family connections where family members provide assistance in the care of pigs under the supervision of females who are always around home compared to the males (Halimani et al., 2020). Most (99.1%) of livestock keeping households in Uganda depend on family members for labor in livestock husbandry activities (Waiswa et al., 2021). While pigs have a lower social status than other livestock, they are cheap to purchase and to rear and are, therefore, a popular option for resource poor farmers (Thomas et al., 2013) particularly women. Exotic breeds in Uganda are also associated with higher status; a reason why they are dominantly owned by males. The increase in livestock rearing activities as reported in (UBOS, 2020a) may be because many areas are becoming too dry to support much cropping activities since the SWAEZ lies in the dry cattle corridor and, thus households rely extensively on livestock for their livelihoods (Nanfuka et. al., 2020). Pig rearing has partly increased because cattle rearing is not feasible for many people given the high cost acquisition, labour, grazing land, fodder cultivation and others (Woelders et al., 2014) amidst declining crop production. Uganda is associated with regular climatic extremes especially low rainfall and dry spells (FAO, 2019; UBOS, 2020a) and the impact of droughts is expected to worsen in future as are climate change associated problems and this poses a big threat to crop production making pig production the most feasible option.

The average population size per farm/household of approximately four pigs of 4 pigs per household was in line with what has been reported elsewhere (Ouma et al., 2015; Babigumira et al., 2022). There were few farms that had more than nine pigs and these kept crosses and or exotic breeds and the owners were better-off in terms of resource availability. In livestock production, the breed chosen and numbers kept by a farmer is a strong indicator of the farmer's market orientation and resource endowment (Okello et al., 2021). Tendency to keep low numbers of the locally adapted pigs is meant to match with available feed resources (Mosweu et al., 2020) which are always limited. Farms with locally adapted pigs had small herd sizes compared to those with exotic breeds and crosses. This observation is also similar to Zaake, (2019) who reported that there were small numbers of locally adapted breeds because of their inability to compete with the fast-growing, economically productive exotic breeds and crosses to mitigate resource constraints especially in rural areas. Small herds of one to three animals reflect limited mating options available to them, often depending on communal boars or boar born on the owners' farm (Ouma et al., 2015; Babigumira et al., 2022); this increases the chances of crossbreeding and or inbreeding depending on the source of the boar. Indiscriminate crossbreeding and breed substitution with exotic farm animal genetic resources (FAnGR) are a threat to indigenous livestock breeds and can lead to loss of ecologically important traits, such as disease tolerance (AU-IBAR, 2019b). There is however need to raise awareness of the advantages of rearing local native breeds, such as, inherent tolerance to heat and drought, resistance to parasitic infectious disease and adaptation to harsh production system (Arthur et al., 2018; Suparyanto, 2020). Besides, use of exotic breeds may be counter-productive because they are thought to be more vulnerable to subsequent droughts and climate change, that may lead to more severe animal losses (AU-IBAR, 2019b) in future. In view of the diverse roles indigenous pig play, it entails that there is need for an increased knowledge of the indigenous pig, their characterization and conservation to support sustainable agricultural development and maintain local breeds of pigs which have variable traits suited to a particular ecological zone (Weka et al., 2021) and production system. The need to conserve these unique genetic characteristics in the face of climate instability and changes cannot be overemphasized for long-term sustainability of livestock production in developing countries.

The pig population consisted largely of piglets which is suggestive of many upcoming pig farmers in the agro-ecological zone, similar to what was observed by Babigumira et al. (2022) who stated that is usually expensive to buy an adult sow for many rural small-scale famers at the onset of the project irrespective of whether it's an exotic or locally adapted. The findings of this study are similar to a previous study by Ouma, et al. (2015) who reported that smallholder piglet farms were the majority among the studied communities comprising 50 to 82% of the households. Most farmers have very small herds of 2-5 sows and do not normally keep a breeding boars (Ndyomugyenyi, 2015; Ouma, et al. (2015). Lack of breeding males makes it easier for farmers to cross breed their sows with exotic boars which are available as village boars and of known quality (Babigumira et al., 2022). Penetration of exotic breeds to the rural areas poses a threat to the existence of locally adapted pigs since many farms who keep locally adapted pigs will likely mate their sows with exotic boars which they presume to be of higher quality hence increased crossbreeding. This limits the chance for mating with the locally adapted boars even if they were available (Tatwangire, 2014). Besides many livestock keepers

(even those currently keeping locally adapted pigs) would prefer to upgrade to exotic and improved breeds (crossbreds) to the locally adapted breeds as observed by (Ouma et al., 2015). The black pigs present in the communities today may not really represent locally adapted pigs but are crosses given the widespread crossbreeding and poor record keeping (Tatwangire, 2014; Babigumira et al., 2022) especially in smallholder farmers. Farmers in developing countries tend to rely on crossbreeding to improve the local breeds and increase their performance, rather than within-breed improvement; genetic progress is therefore imported rather than generated domestically (Leroy et al., 2015).

The scarcity or total absence of locally adapted pigs in some urbanizing communities (trading centres) where resources are available is an indicator of potential total local breed replacement with exotic breeds and crossbreds. Local breed populations have been reported as largely (if not completely) replaced by exotic breeds and crossbred animals in some areas (Leroy et al*.,* 2015). For example, the Nigerian local pig breeds have been replaced by exotic breeds because of their advantageous characteristics, the Eastern African commercial pig industry including Uganda has also been replaced with exotic pig breeds such as Camborough, Landrace and Large White along with their crosses (Walugembe et al., 2014; Weka et al., 2021). This is worrying given that some farmers who still keep the locally adapted pigs do so because of economic constraints and have plans to change to keeping exotic breeds or crossbreds if their economic situation improved; very few farmers, however, would prefer to continue with the local breed (Ouma et al., 2015). Farmers with crossbreds and locally adapted pigs claimed that poor breeds were a big limitation in a study conducted by Ouma et al. (2015). The fact that the pig industry in Uganda used to largely depend on indigenous breeds due to their comparable high resilience to parasites and diseases (Muhanguzi et al., 2012) is now debatable. Generally, many pigs in Uganda are said to be crosses as most animals available from local markets or neighbours are of unknown breed or cross-bred type (Marshall, 2020; Babigumira et al., 2022). Farmers are even encouraged to use crosses (Marshall, 2020) that such crossbreds are good choices for rearing if one is not able to meet the feed and management needs of pure-bred exotics. Market preference is generally for the more exotic breeds which has resulted in the neglect and in some cases loss of indigenous breeds (AU-IBAR, 2019b). No recognition or effort is made to encourage or support the farmers who still keep the locally adapted pigs; all efforts by government target the farmers keeping exotic breeds and crossbred animals, the local pigs are thus declining (Tatwangire, 2014). Lack of incentives for investment in pig farming has constrained the industry notably among the resource poor farmers (FAO, AU_IBAR, 2017). Unfortunately, funding tends to be readily available to support short-term crossbreeding and introduction of exotic breeds without due consideration of the negative outcomes (AU-IBAR, 2019b). It is therefore imperative to draw attention to the disappearance of the indigenous African pig breeds (Weka, et al., 2021) whose other advantages are not normally considered while evaluating them. The on-going and random distribution of exotic pig breeds in Uganda (Mulindwa, 2016) will continue to dilute the locally adapted pigs' genetic stock; characterisation and evaluation of the genetic uniqueness and diversity of locally adapted pig populations is therefore necessary (Animal Genetic Resources, 2012) before they are lost. Indigenous breeds are at risk because most farmers want to have improved breeds owing to their high production performances and economic returns (AU-IBAR, 2019b). The introduction of exotic germplasm and use in crossbreeding (both controlled and uncontrolled) is causing significant introgression of the exotic genes and dilution of the indigenous germplasm and as a result, the indigenous breeds are being threatened (AU-IBAR, 2019b).

The most practiced holding system was tethering; a semi/intensive/extensive system where animal movement is restricted with ropes. The small-scale subsistence system where pigs are mostly left to freely move around the homesteads was not observed in all the study districts, similar to what Ndyomugyenyi, (2015) reported that no farmers were observed practicing free range system in a study conducted in Kichwamba sub-county. This was probably because of issues associated with land scarcity, pigs destroying other peoples' crops, being stolen or even contracting diseases which was also reported in previous studies (Tatwangire, 2014; Nantima et al., 2015; Ouma et al., 2015; Zaake, 2019). The other reason could be because the scavenging production system is being abandoned altogether. Mutua et al. (2020) argued that though smallholder low-input systems are dominant in Uganda, intensive systems had increased in number over the years. Intensive pig farming systems where pigs are kept housed all the time was practiced mostly in and around trading centres and pig breeds kept in this system were crosses and exotic breeds. This is similar to what was stated in previous studies by Zaake (2019) and Ouma et al., (2015) that intensive farming is practiced more in urban communities than in rural areas. However, this system is not suitable for rural small-scale farmers who keep locally adapted pigs. It is not only breeds that are changing but also production systems (Zaake, 2019) which is a big threat especially to continued existence of locally adapted pig ecotypes. The costs involved in preparing a concrete floor make this system un-affordable for rural farmers with low incomes, limited land and other resources (AFRII), 2016).

Feeding is one of the main constraints in smallholder pig production systems, due to seasonal variability in the availability and quality of feeds; farmers generally lack capacities to develop nutritionally balanced least-cost

rations or strategic supplementation of fodder-based diets. There was a wide range of feeds used among the studied districts but most farms used a mixture of green plants and leftover food wastes. The feeds used depended on the location of the source of the feeds and how easy it was (in terms of cost and availability) to obtain the respective feed resource for feeding their pigs (Okello et al., 2021). Farmers with more crop enterprise diversity had more pig feed diversity; the diversification of feed sources is highlighted by Okello et al. (2021) as a way of addressing the food challenge by resource constrained farmers who cannot afford the commercial feeds. The pig diet is closely similar to that of people and therefore a reliable, cheap local feed source is particularly important (Chanamuto and Hall, 2015). Feeding pigs with leftover waste is a common practice in Africa (Thutwa et al., 2020) especially during the dry season. Feed availability was most affected by seasons as observed in a different study by Morison et al. (2019) in Northern Uganda who noted that during the dry season, the feeds became scarce. Seasonal feed scarcity attributed to droughts is responsible for the variation in pig supply to markets (Okello et al., 2021). This explains why small scale farmers keep very small numbers of pigs since they cannot afford commercial feeds which are very expensive (Morison et al., 2019). Use of commercial feeds was very low as observed by Okello et al. (2021) and limited to farmers who kept exotic breeds and cross breeds (Morison et al., 2019). Okello et al. (2021) in a study in Northern Uganda found out that in livestock production, the breed chosen by a farmer is a strong indicator of the farmer's market orientation and resource endowment. Exotic breeds do not fit well into the management system of most small holder farmers given the high cost of maintenance and it is therefore important to identify and strengthen local breeds that have adapted to local climatic stress and feed sources (Calvosa et al., 2009). Although the productivity of indigenous breeds is considerably lower compared to their exotic counterparts, lifetime production of these breeds under harsh production conditions experienced by most livestock keepers in Africa makes them more productive and sustainable than exotic breeds under the same conditions (AU-IBAR, 2019b). It is widely agreed that exotic breeds cannot perform well on locally available feeds (Tatwangire, 2014), there is therefore a general failure of the exotic breeds to perform satisfactorily under the local environments (AU-IBAR, 2019b).

Conclusion

Exotic breeds have penetrated the rural areas and in big numbers posing an existential threat to the locally adapted ecotypes. It is therefore important and necessary to expand research on locally adapted breeds despite the negatives reported about them since the information may in turn produce greater market options and sustainable management and hence conservation. Government and research partners should provide incentives to breeders of locally adapted pigs and also help in the formation of breed specific associations which will help in the creation of niche markets to provide provide unique local breed products. Recording and identification of locally adapted pigs is necessary for tracing the locally adapted pigs. Farmers should be trained in performance record keeping of the pig breeds for proper valuation which is not biased and based on a few production characteristics. Production systems are also changing tending toward more intensive and this will have implications for different breeds in future. Government should facilitate/fund characterization of the pig breeds both at phenotypic and genetic levels take inventory of their numbers as prerequisites to selective breeding. Regulation and monitoring of the continued introduction and crossbreeding of the exotic breeds is very necessary.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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