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The potential of reproductive technologies in breeding smallholder cattle populations in Zimbabwe

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Cattle are critical to most smallholder agricultural livelihoods in Sub-Saharan Africa. A study was carried out to assess breed and trait preferences, breeding practices, application and potential adoption of novel reproductive technologies by smallholder cattle farmers in four districts of Zimbabwe. The study revealed that farmers are subsistence oriented and follow a resource driven production system. Herd size averaged 7.5 ± 6.42 , with dominance of indigenous breeds and their crosses, open communal breeding and non-existence of reproductive technology application. The major challenges faced include reproductive and tick-borne diseases, dry season feed shortage, and poor access to affordable good quality bulls. Brahman, Mashona, Afrikaner and Tuli were the most preferred breeds for their hardiness, fertility, reproductive efficiency and draught performance attributes. Low reproductive efficiency was revealed by long bull retention periods (>5 years), long calving intervals (>18 months), low pregnancy rates (41% of cows) and high ages at first calving (34 months). Farmers indicated moderate knowledge of artificial insemination and keen interest in using this technology with semen frozen from locally bred, indigenous sires to improve their herds. There is therefore both need and potential for the application of assisted reproduction techniques for improved genetic gain, performance and reduced inbreeding in smallholder cattle herds.

Key words: Smallholder, cattle breeds, assisted reproductive technologies, Zimbabwe.

INTRODUCTION

Agriculture is central to Sub-Saharan Africa's development process and is dominated by smallholder family farms, producing over 70 % of all food. Most of these farms are multi-enterprise in nature, and are based on an integration of livestock and crops (van Vliet et al.,

2015). On such farms, cattle are multi-functional, providing a wide variety of goods and services that generate income, ensure food security, and support rural livelihoods (Nyamushamba et al., 2017; Assan, 2012). These functions include livestock-derived food (meat, milk),

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transport and agricultural draft power, hides and skins, manure for soil fertility amelioration, dung as a source of fuel, income from sale of live animals and/or their products, provision of savings and insurance services (especially where these services are non-existent, inaccessible or unreliable), diversification of rural livelihood options, and meeting the socio-cultural roles and obligations of their owners (Nyamushamba et al., 2017; Rege et al., 2011). Cattle also form a social safety net and an important component of the resilience (to crop pest, disease and drought occurrences) of land based livelihoods for millions of people living in marginal production areas (Murungweni et al., 2014; van Vliet et al., 2015).

Zimbabwe's cattle genetic resource base is wide and includes several breed types such as the Zebu (Brahman and Boran), Sanga (Mashona, Nkone, Tuli, Afrikaner), European taurine breeds (Hereford, Angus, Sussex, Simmental, Limousin), and composite breeds (Beefmaster, Bonsmara, Chabray, Brangus). Ninety one per cent of the nation's 5.2 million cattle head is kept under smallholder grazing systems (MAMID, 2014; Nyamushamba et al., 2017). Sanga and Zebu breeds and their crosses form the bulk of the nation's cattle genetic resources (Hirwa et al., 2017; Rowlands et al., 2003). These breeds have demonstrated superior performance in fertility, reproduction, hardiness, survivability and climatic stress resistance traits over their exotic counterparts under prevailing environmental and management conditions (d'Hotman and Hatendi, 1998; Moyo, 1997). The peculiarity of these local breeds is also perceptible in higher heat tolerance, resistance to local disease epidemics, ticks and tick borne diseases, as well as improved and diversified production ability, making them better adapted to survive and tolerate harsh environments (Nyamushamba et al., 2017; Hirwa et al., 2017). They are therefore not only acclimatised to their habitat but also fit for their purpose (Wilson, 2009). These observed phenotypic and productive performance attributes justify wide-scale use of these native breeds as dam lines in various crossbreeding systems on commercial farms in Zimbabwe and elsewhere. In addition, they are potentially valuable resources for use in regions facing similar biological stresses, climate change resilience and response to the future needs of livestock production (FAO, 2015; van Arendonk, 2011).

However, native breeds are slower growing, have smaller stature and produce much less milk compared to imported breeds (Hirwa et al., 2017). In recent decades, there has been a rapid change in cattle breeds used on farms in favour of the larger framed faster growing exotic breeds most suited to demand-driven and market-oriented production. These imported genotypes may not survive or produce optimally under resource constrained, smallholder systems (Wilson, 2009). Thus, replacement of local breeds may have serious consequences on genetic diversity, performance and capacity to cope with

future changes in markets, production environments and breeding goals (Traoré et al., 2017).

Given smallholder production features, it is critical to generate experiential knowledge on, not only which breeds farmers consider to be the most suitable for meeting their multiple needs, but also their perceptions of the important breed attributes and the factors which affect their breeding strategies (Hansen, 2014). It has been postulated that success of novel reproductive technology interventions for smallholder farmers depends on which livestock breeds are fit for purpose, their production potential, suitability to farmer circumstances, preference by farmers, as well as farmer discretion in breed choice and breeding decisions (van Arendonk, 2011; Wilson, 2009; Rege et al., 2011). Technical interventions are always appropriate when conceived and formulated based on research evidence and in the context of the targeted beneficiaries' circumstances and production systems.

However, there is a paucity of information regarding breed and trait preferences, as well as the present application of, and perceptions on, assisted reproductive and breeding technology used by smallholder livestock farmers in Zimbabwe. Efforts to address the above knowledge gaps necessitated the present study. The aim was to determine herd sizes and composition, reproductive performance, breed ownership, breed and trait preferences, and breeding practices; and to assess current knowledge, application, perceptions and potential adoption of novel cattle breeding and reproductive technologies by the smallholder cattle farming sector of Zimbabwe. The study was premised on the fact that understanding farmers' production objectives, preferred breeds and valuation of different traits is the starting point to define appropriate breeding goals and set up sustainable livestock systems (Traoré et al., 2017; Desta et al., 2011). Without this information, targeting intervention in cattle reproduction and breeding for smallholder farmers remains difficult due to a mismatch between technology and its context of application. The gain for the country in conducting this study is promotion of widespread awareness of the cattle resources that farmers prefer and the utilisation options available to ensure sustainable and cost-effective access by the poor.

MATERIALS AND METHODS

Study area

The study was conducted between January and April, 2014 in four districts of Mashonaland West Province, Zimbabwe and covers an area of 57,441 km². Data was collected from five wards (10-13 and 23) in Hurungwe, five wards (13-18) in Makonde, two wards (5 and 6) in Mhondoro-Ngezi and three wards (10, 11 and 13) in Sanyati. Livelihoods in the study areas are predominantly dependent on rain fed crop farming, with livestock as a secondary activity. In the areas studied (except in Hurungwe), small-scale artisanal gold mining is also an important livelihood option. Areas sampled in Hurungwe,

Mhondoro-Ngezi and Sanyati districts are located in the semi-intensive, lower rainfall farming region (NRIII), while Makonde district is located in an intensive, high rainfall farming region (NRII) of the country.

Selection of respondents

Selection of households for the study was done in a stepwise manner. The province was purposively selected for reasons of convenience, proximity and cost. The four districts were selected at random, whereas wards within district were purposively selected for concentration of cattle. Individual households within wards were then selected at random using sampling frames obtained from the Chinhoyi offices of the Ministry of Agriculture and Local Government, Zimbabwe. Sample households that did not own any cattle were not interviewed.

Data collection

Data collection comprised general observation and semi-structured questionnaire based farmer interviews of 261 smallholder farming households from Hurungwe (n=106), Makonde (n=79), Sanyati (n=41) and Mhondoro-Ngezi (n=39) districts. The questionnaire was designed to collect data on household characteristics, herd composition, herd dynamics, breeding and reproductive management, reproductive performance, breed types kept, breeds preferred in future, preferential traits, and use of and perceptions regarding any assisted reproductive technologies. The questionnaire was pretested on a sample of 10 farmers in Chitomborwizi, Makonde district. These farmers were excluded from the final analysis.

Statistical analyses

Statistical analyses involved all 261 sample households. Data was handled and analysed using IBM SPSS Statistics Version 20 (IBM, 2011) for descriptive statistics, frequencies, means, and cross-tabulations to explore relationships. Analysis of variance (ANOVA) was used to investigate effects of district on herd sizes. Means were separated by Pearson's Least Significant Difference (LSD) post-hoc tool at the 5% significance level. Chi-square (χ^2) tests were performed to investigate the degree of variability in frequencies for breed types kept, breeds preferred and preference attributes across districts and farming systems (communal and resettlement).

RESULTS AND DISCUSSION

Farmer demographic data

Household headship was dominated by men across the entire sample (77%). Frequencies for this parameter significantly differed between districts ($\chi^2 = 25.138$, $P < 0.01$), as follows: Hurungwe (84%), Sanyati (80%), Mhondoro-Ngezi (74%) and Makonde (67%). These results are similar to findings by Chawatama et al. (2005) in Chikomba (88%), Matobo (73%) and Sanyati (73%) districts, where men headed most of the households. Age of household head ranged from 23 to 87 years, with median and average values of 54 and 53.3 ± 17.00 years, respectively. Although, there was no significant difference

($P > 0.05$) across district for this parameter, Mhondoro-Ngezi had the oldest (58.3 ± 17.9 years) respondent household head, followed by Sanyati (56.2 ± 18.3 years), Makonde (52.8 ± 15.9) and lastly Hurungwe (51.0 ± 16.7 years). Mapiye et al. (2007) reported a marginally lower mean household head age of 50 in eight smallholder dairy schemes in Zimbabwe, respectively. In the present study, only 27% of respondent household heads were 40 years and less. These results show that the older generation dominate decision making systems on smallholder farms in the country.

Figure 1 shows the education levels of respondents disaggregated by gender. About 13, 39, 46 and 2% of respondents had never attended school, attained primary, secondary and tertiary education, respectively. Differences in education status of household heads were significantly different across the four districts ($\chi^2 = 40.122$, $P < 0.001$), two genders ($\chi^2 = 31.866$, $P < 0.001$) and non-significant across the two land tenure systems ($\chi^2 = 8.803$, $P > 0.05$). Makonde and Mhondoro-Ngezi districts had the highest number of respondents without formal education (30%) and with at most primary education status, respectively. Male household heads had higher formal education status compared to female household heads, with 80% of all female household heads having attained just the primary level of education. A big gender disparity in education status was therefore observed in the areas studied. Madzimore et al. (2015) observed that age, education background, gender and household headship are key demographic characteristics affecting production decisions on small scale farms.

Production features

Almost all the farms studied were family-owned and multi-enterprise in nature, dominated by integration of cattle and field crops (64%) or several livestock species and field crops (35%). The crop enterprise benefited livestock through feeding on crop residues after harvest (97% of farms) and cereal grains in supplements or fattener diets (0.4%). Almost 20% of respondents reported occasional use of crop cash income for the purchase of livestock feed supplements, vaccines and medicines. Farmers benefit from cattle through food (meat, milk), transport and agricultural draft power, hides and skins, manure for crop fields, dung as a fuel source, income from sale of live animals and milk, as well as provision of savings and insurance services. In addition, livestock cash income is used to finance purchase of crop inputs, pay for school fees, buy assets and food purchases in drought cases.

In all, a total of six major functions are derived from cattle ownership by smallholder farmers studied: draught power supply, manure, sale for income, milk, meat and social security (savings) (Figure 2). Almost all respondents keep cattle for draught power purposes. After draught power, manure was the second most

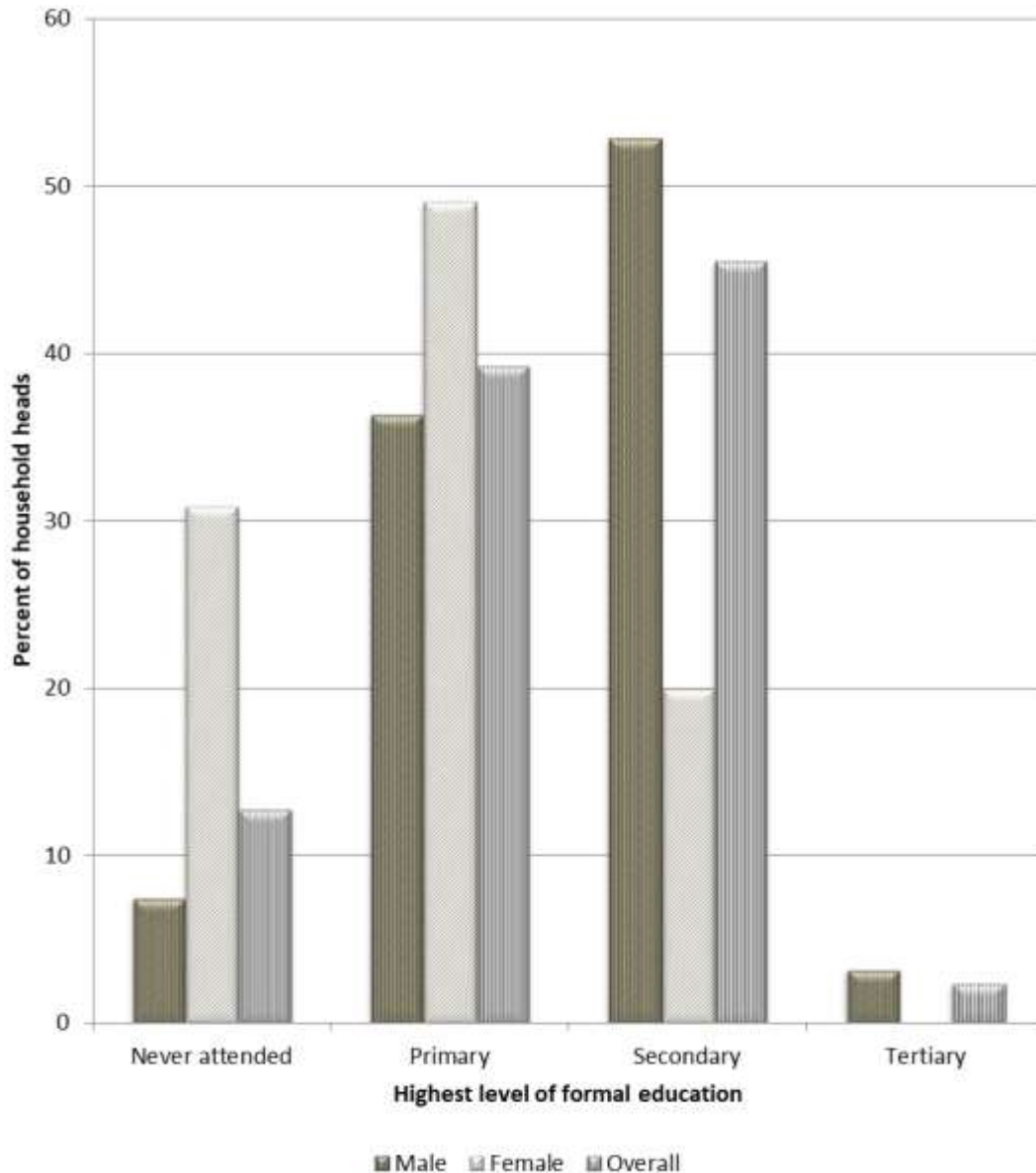


Figure 1. Frequency for highest education level attained by gender of smallholder farm household head in Mashonaland West Province, Zimbabwe.

important use of cattle in Sanyati and Makonde, while income was second most important in Hurungwe and Mhondoro-Ngezi. The relative emphasis on manure over livestock sales in Sanyati and Makonde is probably due to presence of alternate income from cash crop farming (cotton, maize, and soyabean) and mining activities in these districts.

Many researchers have observed that cattle provide a variety of goods and services that generate income, ensure food security, and support smallholder rural livelihoods (Nyamushamba et al., 2017; Wilson, 2009). In Rwanda, Hirwa et al. (2017) reported seven major reasons for keeping cattle among smallholder farmers-

meat, income, savings, conservation, beauty/aesthetics, milk and cultural uses. Interestingly, farmers did not report keeping cattle for any cultural reasons such as payment of dowry (*lobola*) in the current study. Thornton and Herrero (2015) noted that crop-livestock integration leads to production of mutually beneficial resources in the form of feed biomass, manure, draught power, cash and savings. However, findings from the current study corroborate observations in many publications that smallholder farms in Africa are diversified, and keep multi-functional livestock resources (Rege et al., 2011; van Vliet et al., 2015). The study also confirms the conclusion by Murungweni et al. (2014) that cattle

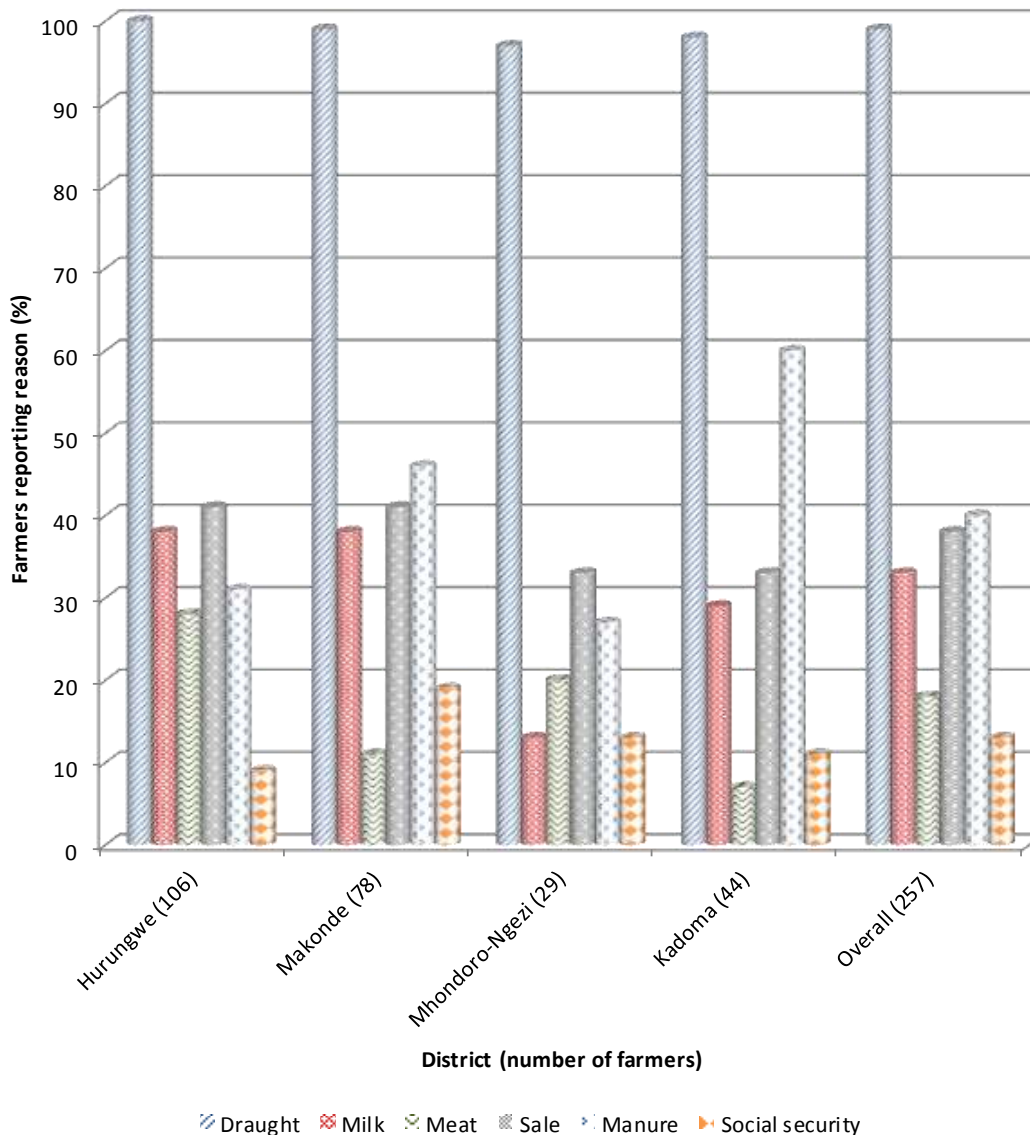


Figure 2. Proportion of respondent smallholder farm households and their major reasons for cattle rearing in Mashonaland West Province of Zimbabwe.

ownership is important for resilience to climate change and variability in Zimbabwe’s multi-enterprise smallholder farms.

Total herd size differed ($P < 0.001$) across districts and averaged 7.5 ± 6.42 , with a range of 1 to 45 head (Table 1). Sanyati does not only have the highest number of cattle per household, but also the widest variation in household herd size. No significant differences ($P > 0.05$) were observed in herd size between gender of household head, education level of household head and farming system. However, female headed households on average owned more cattle (8.0 ± 6.14), particularly in Hurungwe and Mhondoro-Ngezi, compared to male-headed households (7.4 ± 6.51). Chawatama et al. (2005) reported similar findings in Sanyati, Matobo and Chikomba

districts for cattle herd size disaggregated by gender. However, other researchers (Mutibvu et al., 2012; Ndebele et al., 2007) reported higher herd sizes in Gokwe South (8.2 ± 6 head) and Gwaayi (10 ± 3 head), respectively.

Twenty-two percent of households owned a designated breeding bull retained from within own herd. Bulling ratios were significantly different across districts ($P < 0.05$) and average of 27.7% among bull owners (Table 2) and 6% overall, which is higher than the recommended commercial bulling rates of 2.5 to 4% (Phillips, 2010). Farmers practiced an uncontrolled natural breeding system on communal grazing lands with bulls and cows of unknown genetic merit and bloodlines running together all year round. The average reproductive lifetime of cows

Table 1. Cattle herd structure (Mean±SD) for smallholder farmers in Mashonaland West Province, Zimbabwe.

Class	Herd size	District				Significance
		Hurungwe	Makonde	Mhondoro-Ngezi	Sanyati	
Bulls	1.11±1.954	1.09±0.288 ^b	1.93±3.305 ^c	0.65±0.702 ^{ab}	0.50±0.648 ^a	*
Cows	2.93±2.537	2.40±1.593 ^a	2.63±1.695 ^a	3.11±2.331 ^b	4.45±4.321 ^c	***
Heifers	1.97±1.583	1.77±1.108	2.17±1.419	1.63±1.690	2.26±2.214	NS
Steers	2.55±2.023	2.26±1.208	2.79±2.208	2.93±2.434	2.47±2.482	NS
Calves	2.03±1.636	1.67±0.870 ^a	1.96±1.045 ^a	2.00±2.629 ^a	2.76±2.253 ^b	*
Total herd	7.53±6.422	5.89±3.838 ^a	7.05±4.833 ^b	8.81±7.786 ^c	11.33±10.088 ^d	***

^{abcd} Values with same superscript in the same row do not differ. NS: Not significant ($P > 0.05$), * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

Table 2. Reproductive performance parameters for smallholder cattle herds in Mashonaland West Province, Zimbabwe.

Attribute	N	Median	Mean±SD	Significance
Bull ownership (%)	95	-	21.7	NS
Bulling ratio (%)	89	-	27.7±27.53	*
Number of pregnant cows	238	1	1.2±1.30	NS
Age at first calving (months)	231	36	35.4±8.78	***
Calving interval (months)	240	18	20.2±8.90	NS
Number of parturitions before culling	215	6	6.0±1.81	*
Reproductive lifetime of cows (years)	215	8.5	9.1±2.13	NS

Across districts, parameters were: NS: Not significantly different ($P > 0.05$) or significantly different at * $P < 0.05$, ** $P < 0.01$ or *** $P < 0.001$.

mentioned was 9.1 years (or six parturitions) in the herd, while bulls are used for at least five years before replacement. No voluntary culling decisions were made by the farmers, especially based on reproductive performance. Ndebele et al. (2007) reported 32% bull ownership and eight years bull retention in Gwaayi. Reproductive performance was poor as reflected by low pregnancy rates, higher age at first calving and long inter-calving periods, averaging 41%, 35.4 and 20.4 months, respectively (Table 2). There were significant differences ($P < 0.05$) between districts in age at first calving, number of parturitions and bulling ratios.

Current reproductive performance observations are comparable to results obtained elsewhere. In South Africa, Tada et al. (2013b) reported 32 and 15 to 17 months for age at first calving and inter-calving period, respectively. In Rwanda, Hirwa et al. (2017) reported higher pregnancy rates (70%), lower calving intervals (13.6 months) and similar age at first calving (33.8 months). Higher age at first calving (42 months) was reported in Ethiopia by Teshome et al. (2016). Current figures for calving interval were also better than 22 to 24 months obtained in Zimbabwe previously (Muchenje et al., 2007). Expected reproductive performance norms for beef cattle in tropical and sub-tropical regions include calving interval of 12 to 14 months, >80% pregnancy rates, and 24 to 30 months age at calving for heifers (Phillips, 2010). It is widely recognised that the age at

which herd replacement heifers reach puberty and therefore produce their first calf influences the reproductive efficiency of a beef herd. Heifers that calve first at 2 years old have been observed to produce more calves during their lifetime than heifers that calve first at ≥ 3 years of age (Phillips, 2010).

The problem of uncontrolled breeding and poor cattle reproductive performance in communal farming areas appears in many publications (Nyamushamba et al., 2017; Tada et al., 2013b). This may be contributing to high inbreeding levels and decreased performance in the smallholder cattle population (Musemwa et al., 2010). Inbreeding results from mating of animals which are more closely related than the average relationship of the population. Inbreeding's negative consequences include exposition of undesirable and sub-lethal genes, reduction in population genetic diversity and inbreeding depression. Inbreeding depression entails an overall decrease in the mean phenotypic value of traits associated with reproductive capacity and growth efficiency (Hansen, 2014; Ndebele et al., 2007).

The majority of farmers (54%) were not aware of inbreeding and its negative consequences. The majority (74%) of those who were aware and concerned about inbreeding's negative effects did nothing to mitigate the negative effects of inbreeding. Three main strategies were used by minority farmers to prevent inbreeding: frequent replacement of bulls (15%), castration of

Table 3. Frequency for cattle breed ownership, breed preference and preference attributes in Mashonaland West Province of Zimbabwe.

Parameter	Overall	District				χ^2 test	
		Hurungwe	Makonde	Mhondoro	Sanyati	χ^2 value	Significance
Breed type owned	n=203	n=83	n=67	n=19	n=34	41.006	0.000
Indigenous	72.4	74.3	88.1	63.2	47.1		
Exotic	3.0	3.6	4.5	0.0	0.0		
Interbreeds	21.7	24.1	7.5	21.1	44.1		
Exotic+Indigenous	3.0	0.0	0.0	15.8	8.8		
Most preferred breed¹	N=247	n=100	n=77	n=27	n=43	35.134	0.002
Mashona	28.3	25.0	37.7	3.7	34.9		
Tuli	6.9	7.0	7.8	3.7	7.0		
Nkone	0.4	0.0	0.0	3.7	0.0		
Brahman	36.4	42.0	24.7	66.7	25.6		
Afrikaner	27.5	26.0	29.9	22.2	30.2		
Other	0.4	0.0	0.0	0.0	2.3		
Breed attributes	N=247	n=102	n=75	n=29	n=45	69.738	0.000
Hardiness	45.4	39.2	48.0	44.8	55.6		
Fertility	15.1	26.5	10.7	0.0	7.9		
Size	21.5	23.5	28.0	6.9	15.6		
Draught power	9.6	2.9	4.0	44.8	11.1		
Other	8.4	7.8	9.3	3.4	11.1		

The data shows the top preferred breed and the main reason for its preference as reported by each respondent.

unwanted bull calves (7%) and use of neighbours' bulls (4%). Successful strategies used against inbreeding include frequent replacement of bulls, castration, facilitated exchange of bulls between farmers from different villages, use of reproductive technologies such as artificial insemination, and introduction of open nucleus or group breeding schemes (Ndebele et al., 2007; Wilson, 2009). In South Africa, the open nucleus breeding scheme for improving communal Nguni cattle production has largely been successful (Tada et al., 2013b). This means that assisted reproductive technology applications could play an important role to increase cattle reproductive efficiency in Zimbabwe's smallholder cattle production systems.

Preference for breeds and traits

Information on the type of breeds owned, breeds preferred and breed preference attributes in the study area were disaggregated by district and farming system (Table 3). Most farmers (84%) had knowledge of the cattle breeds that they kept and the remainder could not specify the breeds. More female household heads were not aware of the breeds they kept compared to male household heads ($\chi^2= 6.035$, $P<0.05$). There were significant differences between districts in frequency of

breed types held by farmers ($\chi^2 = 41.006$, $P<0.001$), preferred breeds ($\chi^2 = 35.134$, $P<0.01$) and breed preferential attributes ($\chi^2 = 69.738$, $P<0.001$). Most smallholder farmers had tropical Zebu (Brahman) and Sanga (Mashona, Afrikaner, and Tuli) breeds (72%) compared to crossbred genotypes (22%), combination of pure-bred indigenous and exotic breeds (3%) and exotic breeds only (3%). Sanyati had the highest proportion of farmers using interbreeds in their production system. Similarly, Ndebele et al. (2007) reported that an estimated 88% of communal farming households own indigenous cattle or crossbreds of predominantly the indigenous genotypes. Rowlands et al. (2003) found a dominance of Nkone and Tuli breeds in Matabeleland province while Mashona, Brahman and Afrikaner breeds predominate in cattle production systems in the rest of the country. Contrary to the assertion by some researchers (Muchenje et al., 2007; Ndebele et al., 2007; Phillips, 2010) that most smallholder farmers fancy and therefore prefer the larger framed, faster growing exotic breeds, the current study found a dominance of native breeds among farmers.

Respondents indicated a preference for Sanga (Mashona, Afrikaner, Tuli and Nkone) and Zebu (Brahman) cattle genotypes compared to exotic breeds (Table 3). Observed preferences significantly differed across districts ($\chi^2 = 35.134$, $P<0.01$). Brahman (Zebu)

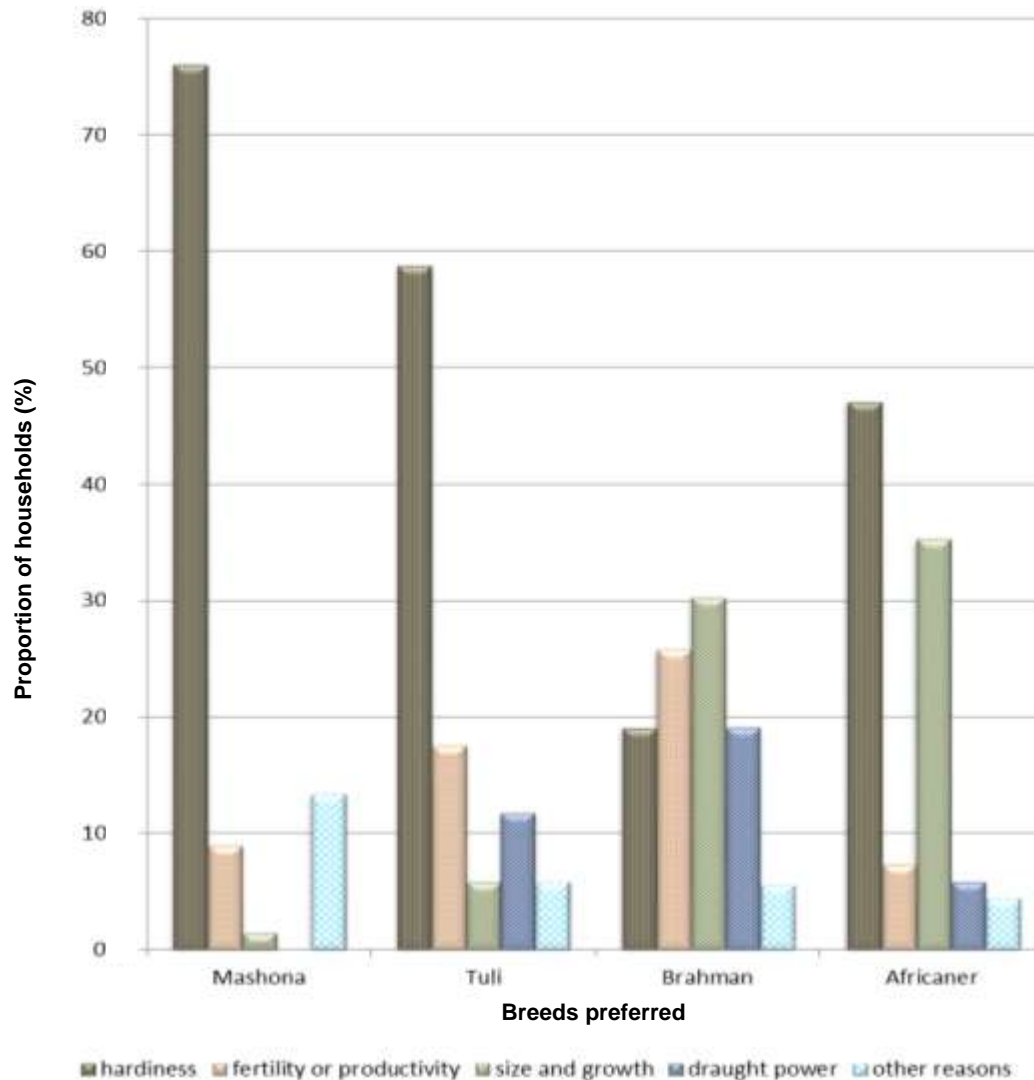


Figure 3. Reported main preference attributes for the four most preferred cattle breeds by smallholder farmers in Mashonaland West Province, Zimbabwe.

was the most preferred breed followed by the Sanga breeds (Mashona, Afrikaner, Tuli and Nkone) and exotic taurine breeds, respectively. The Brahman and Afrikaner breeds dominated farmer preferences in Hurungwe and Mhondoro-Ngezi, while the Mashona and Afrikaner were the most preferred breeds in Sanyati and Makonde. The Tuli and Nkone were not popular breeds in the study area. In Ethiopia, Desta et al. (2011) noted that farmers tend to prefer commonly found and more numerically abundant breeds whose performance and qualities they are more familiar with. This may partially explain the dominance of Brahman, Mashona and Tuli in farmer preferences observed in the present study.

Overall, the reported preference attributes of the breeds were hardiness (adaptation to local environment), size and growth rate, fertility and reproduction, and draught power potential. Significant differences ($P < 0.05$)

were observed for these attributes between districts. The most important preference traits in Hurungwe were fertility and hardiness, in Makonde (hardiness and size), in Mhondoro-Ngezi (hardiness and draught power) and in Sanyati (hardiness and size). The ranking of the selected traits significantly differs for each breed. The Brahman was moderate for all four major perception attributes mentioned, but is mostly preferred for its size, growth potential, good fertility and productivity (Figure 3). The Mashona is preferred for its hardiness and fertility, and ranked lowly for size, growth and draught power. For the Afrikaner, the most preferred attributes include its hardiness, size and growth potential while the Tuli's dominant attributes according to the respondents are hardiness, fertility and productivity. The data was also analysed for reason for preference disaggregated by breed preferred (Figure 4). Brahman surpassed other

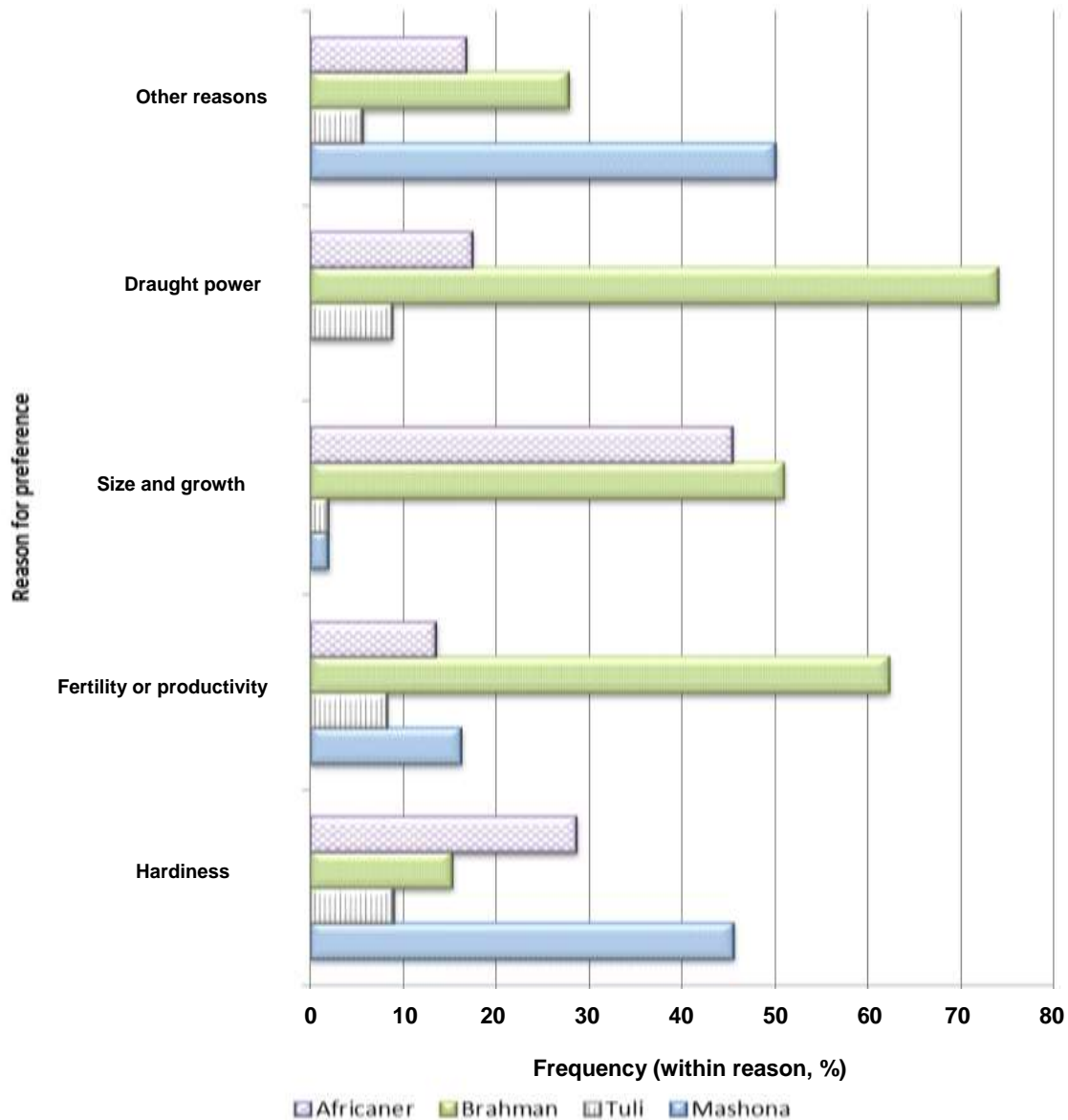


Figure 4. Preference attributes for cattle breeds in Mashonaland West Province of Zimbabwe clustered by breed preferred. The data shows the relative preference of the four breeds for each performance attribute.

breeds in three attributes: draught power, fertility and productivity, and size and growth potential; while the Mashona dominated on hardiness, milk production and docility.

Trait preferences for cattle found in this study reflect the multiple needs of smallholder farmers in Zimbabwe, and are comparable with the findings of similar studies conducted in Southern Mali (Traoré et al., 2017) and Kenya (Bebe et al., 2003). Rowlands et al. (2003) reported that the five traits farmers in Zimbabwe perceived by to be most important were size, adaptability, growth, temperament and fertility. Wilson (2009) summarised the qualities required of appropriate animal

genotypes in the right place, as: 'adaptation to local environment; acceptability to local people; survivability in the face of local parasites and diseases; good reproductive and growth performance; and adequate yields of meat, milk, draught power and other products.' In the present study, adaptive traits (hardiness) scored highly compared to the performance traits-size and growth potential, fertility, reproductive performance and draught potential, respectively. Tada et al. (2013a) observed that adaptive traits were ranked highly in smallholder resource-driven livestock production systems, while demand-driven production systems concentrated mostly on productive traits. Smallholder

enterprises studied are subsistence-oriented and followed the resource-driven system. The preference for a large body size in the present study may be related to higher market prices for larger cattle and draught power capacity, which is linked to animal size. Ranking of fertility traits shows that farmers place importance on reproduction to produce offspring that then perform various functions within the farm. Mention of draught power potential as a preference trait and reason for cattle rearing underlines the strong integration between crop and cattle production in the study area.

This study revealed a convergence of indigenous experiential knowledge of the farmers and technical results obtained in breed evaluation on research stations, thus leading to a preference for local breeds adapted to their multiple needs, production environment and local circumstances (Moyo, 1997; Wilson, 2009). In the context of climate change and variability, the adaptive traits of preferred Sanga cattle breeds justify the need for conservation of these unique breeds as insurance against unforeseen future changes (Traoré et al., 2017). Therefore, the use of principally Sanga, Brahman and Brahman based composite breeds may be considered the most suitable breeding strategy for smallholders in Southern Africa.

Assisted reproductive technology

Data on farmer perceptions regarding ease of acquiring new preferred cattle breeds revealed that farmers regarded it as both difficult and costly (56%), simple yet costly (29%), or difficult but cheap (15%). Only 2% of the respondents were of the opinion that acquiring preferred breeds was both simple and cheap. Although farmers indicated a preference for indigenous genotypes over exotic breeds, they lack ready access to affordable improved breeding stock of these preferred breeds. Breeding animals are too limited to meet demand for these valuable genotypes and too dear for smallholder farmers who need them most (MAMID, 2014). Bulls in Zimbabwe are sold through the auction system, and cost no less than US\$1,500 each. In addition, the buyer will incur costs of veterinary permits and transporting the animal to the farm. There is therefore need to address this access and affordability issue through cheaper alternatives such as semen cryopreservation and artificial insemination.

Knowledge of respondents on assisted reproduction technologies (ART) revealed that 40% had never heard of the term ART, although 59% were aware of artificial insemination (AI) and 1% were aware of both AI and oestrus synchronisation. Two farmers (<1%) reported ever receiving AI training, though they never practiced it in their own herds. Eighty-nine percent of respondents indicated an interest in getting training on and using AI, while 6% were not interested and 5% did not register

their opinion. Most of the respondents indicated a preference for semen from locally bred indigenous bulls (83%) compared to imported semen (6%) or both imported and local semen (3%). There were no assisted reproductive facilities or services in the areas studied, yet smallholder cattle farmers are willing to use these technologies and facilities in order to benefit through access to a wide variety of superior bulls and breeds (49%), skills and training (23%), storage for own semen (9%), reduced breeding related costs (5%), and improved overall herd performance. However, 13% could not give a response to the question because they could not think of any benefit they would get from the AI centre.

In the situation of novel reproductive technology facilities and services, farmers would expect to benefit in varied ways, and highly value use of locally adapted genotypes. Thus, for assisted reproductive technologies to be adopted on small multi-enterprise farms, important infrastructure and institutions need to be in existence to make such technologies economically viable. An interface between industry, research, academia and other stakeholders is necessary to translate technology into tangible benefits for small farmers. Presently, such institutions and infrastructure are non-existent in the area studied.

Key challenges in the sector

The application of novel animal reproductive technologies and breeding strategies to the livestock breeds used in smallholder agriculture systems may be constrained by a number of factors. It is important to have knowledge of such factors in order to be able to adapt technology application to that context (van Arendonk, 2011). The major cattle production constraints in the areas studied were related to disease outbreaks, particularly reproductive and tick-borne diseases, prohibitive cost and lack of access to good quality bulls, shortage of grazing during the rainy season limiting weight gains and draught performance, lack of funding or capital for buying breeding stock, drugs and supplementary feed, shortage of dry season feed, water shortages during the dry season coupled with long distance to water points, heavy tick challenges as tick control programs are failing, and stock-theft (Figure 5). Similar to findings of this study, Chawatama et al. (2005) and Ndebele et al. (2007) identified tick-borne diseases as the most serious constraint affecting cattle production in Zimbabwe. In the current study, constraints to do with bull quality, availability and access were ranked by farmers as their second biggest challenge (after disease), affecting breeding and reproductive performance of their herd. This creates an opportunity for reproductive biotechnology application to bridge the bull access, supply and affordability gap, enhance cattle reproductive performance, and improve cattle based smallholder livelihoods.

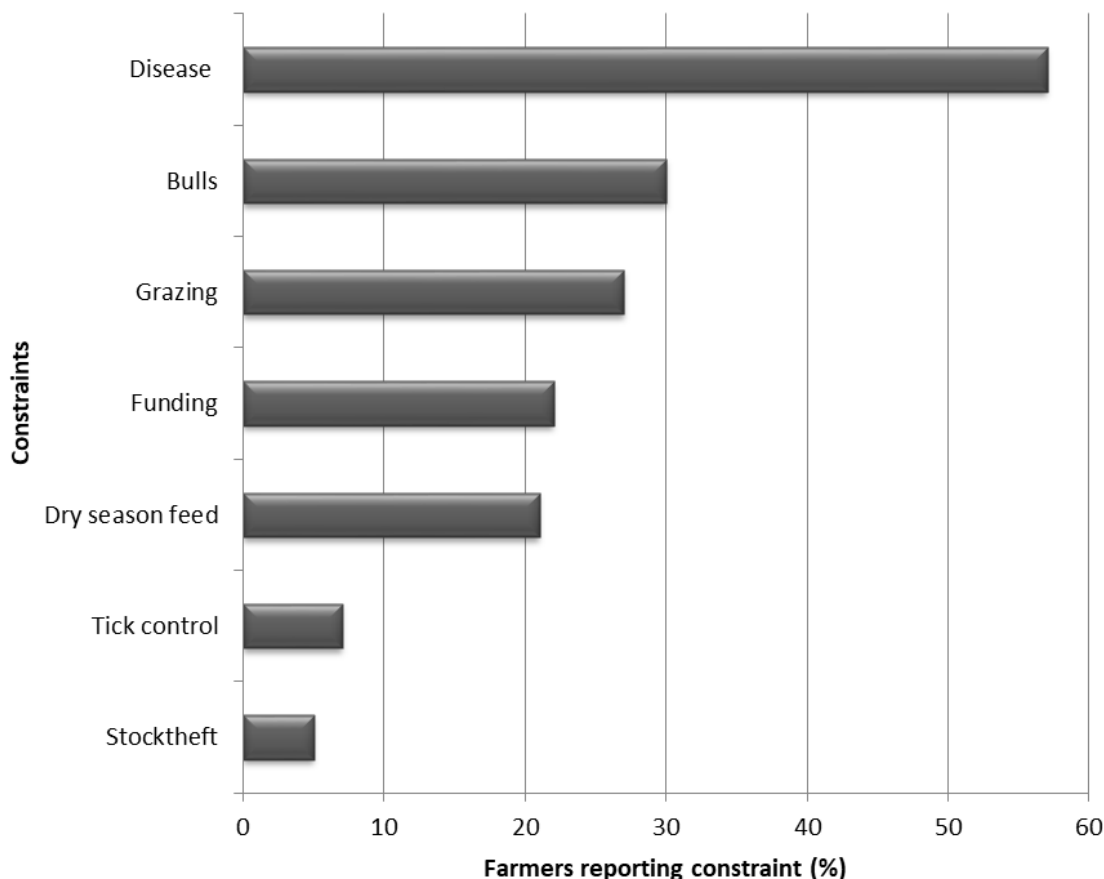


Figure 5. Major challenges faced by smallholder cattle farmers in Mashonaland East Province, Zimbabwe.

Conclusions

The key cattle production features for smallholder farms observed include integration with crops, open breeding, long bull retention periods, poor reproductive performance, high inbreeding levels, and lack of access to affordable bulls of preferred breeds. The study indicated that smallholder farmers in Zimbabwe have multiple production objectives, and breed preferences are dominated by locally adapted Zebu (Brahman) and Sanga (Mashona, Tuli, Afrikaner and Nkone) breeds. Hardness, size and growth potential, fertility and reproduction, and draught potential were ranked the most important traits for cattle. Therefore, use of locally bred Sanga breeds, Brahman and Brahman derivatives such as Braford, Brangus, Charbray, and Simbra may be considered a suitable breeding strategy for these farmers. Farmers were willing to use novel reproductive technologies to improve performance of their herds and access improved breeding stock. Scope therefore exists for using assisted reproductive techniques to increase cattle reproductive efficiency, reduce inbreeding, conserve locally adapted breeds and improve smallholder cattle farmers' livelihoods.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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