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Artificial insemination: Factors influencing its utilisation by beef cattle farmers in Southern and Ghanzi districts in Botswana

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ABSTRACT

The use of assisted reproductive technologies to improve productivity in livestock industry is becoming popular. The study aimed to determine the utilisation of artificial insemination (AI) and to find out the factors associated with adoption of AI by beef farmers in selected areas of Southern and Ghanzi districts. The data were collected through a survey where a questionnaire was administered to beef farmers. Random sampling was used to interview 54 beef farmers in Southern district and 40 beef farmers in Ghanzi district. The data were analysed using Frequency procedure in Statistical Package for Social Sciences (SPSS). The association between the nominal variables was tested using Pearson Chi-square in SPSS. There is significant ($P < 0.05$) association between AI utilization by beef farmers and these socio-economic factors; district where farming is done, age of the farmer, education level, occupation of the farmer, purpose of rearing cattle (commercial or subsistence) and land (communal or ranches). Gender of the farmer is not associated with AI utilization.

1. Introduction

Botswana is one of the beef exporting countries to the international market for foreign exchange. In order to Improve the quality of cattle herds in Botswana, artificial insemination (AI) was introduced in the 1960 s and frozen semen was purchased from South Africa, but now semen is produced locally (Mocheregwa, 2016; Moreki et al., 2019). AI is one of the oldest assisted-reproductive technologies (ART), it involves the physical placement of bull semen in the female reproductive tract as means of achieving pregnancy rather than natural mating (Morrell, 2011).

The use of AI in other countries has been reported in several studies. Pen et al. (2010) reported that beef cattle farmer in Cambodia did not use AI. Adoption of AI has been reported to receive low adoption in sub-Saharan African countries (Mwanga et al., 2018). The governments of different countries in Africa are coming up with programs that can enhance the use of assisted reproductive technologies, one of those countries is South Africa where Livestock Development program was established in 2012 to introduce assisted reproductive technologies to smallholder cattle farmers (Nengovhela et al., 2021). In Ethiopia the provision of AI technology in the National Regional State of Tigray was started more than 20 years back in the capital city of the region (Mekelle) and Adigrat town (Gebre et al., 2022). In India the use of AI in buffalos is increasing with 80 % of buffaloes in large farms being serviced through AI (Singh and Balhara, 2016). The trend of use of AI in cattle has been fluctuating in Malaysia since 1981 until 2009 (Raymond and Saifullizam, 2010).

AI is one of the reproductive technologies that can be utilised in order to solve the major challenge faced by beef farmers to satisfy the rise in demand for livestock products (Roe, 2009). In addition, there are various challenges faced by beef farmers which include spread of sexually transmitted diseases, poor conception rates caused by several factors such as low sperm count, low sperm quality, lack of cooperation between farmers to share quality bulls, lack of money to buy quality bulls (Gahakwa et al., 2014). All these challenges can be solved or lowered by using AI. Other benefits of AI on beef cattle include genetic improvement of carcass yield and meat quality as farmers have access to superior bulls through AI. Although many farmers in Botswana and other parts of Africa are aware of the advantages and benefits of AI, studies from Africa reveal that few farmers have adopted the use of AI (Howley et al., 2012). Therefore, the aim of this study was to determine the utilisation of artificial insemination and to find out the factors associated with adoption of AI by beef farmers in selected areas of southern and Ghanzi districts, Botswana.

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2. Materials and methods

2.1. Study area and data collection

The research was conducted in the Southern and Ghanzi districts of Botswana. In Southern district it was conducted in Kanye and surrounding areas (Mmathethe, Gasita, Metlobo, Lokabi) while at Ghanzi district it was conducted at Chobokwane, Kalkfontein and Charlesshill. The data were collected through a survey where a questionnaire was administered to beef farmers. Random sampling was used to interview 54 beef farmers in Southern district and 40 beef farmers in Ghanzi district. The data collected included the socio-economic factors of the farmers and beef cattle production parameters together with the use of AI in beef cattle production. The socio-economic factors covered the age, gender, education status and occupation. Some of the aspects covered under beef cattle production and use of AI are whether the farmer was a commercial or subsistence farmer, whether cattle were kept in ranches or in communal land, number of cattle kept, breeds kept, whether the farmer use AI or not, and challenges of using AI.

2.2. Data analysis

The qualitative data were analysed in Statistical Package for Social Sciences (SPSS) using descriptive statistics to determine the frequencies of utilization of artificial insemination and factors associated with adoption of AI by beef farmers. The association between the nominal variables was tested using Pearson Chi-square in SPSS. The means of cattle numbers were also computed using descriptive statistics in SPSS.

3. Results

3.1. Farmers' socio-economic characteristics

Among the interviewed beef cattle farmers, 79.8 % were males while 20.2 % were females. The socio-economic characteristics of beef farmers are presented in Table 1.

3.2. Cattle numbers in the two areas

Ghanzi district beef farmers had significantly higher ($P < 0.05$) herd sizes than Southern district beef farmers (Table 2).

3.3. Beef cattle production and utilization of AI

Most interviewed farmers reported to have heard about AI from other farmers (41.5 %), followed by those who heard about AI from other sources (30.9 %) while 16 % and 9.6 % got the information from extension officers and kgotla meetings, respectively. Tswana breed was the most preferred breed in this study. Out of the 94 beef farmers who participated in this study, 43 (45.7 %) farmers used AI while 51 (54.3 %) did not practice AI. The common exotic breeds kept together with Tswana cattle are Brahman and Simmental.

3.4. Reasons for using AI and breed preferred for semen

Among the 43 farmers who use AI, majority of them (41) use both AI and natural mating while only 2 farmers use AI only (Table 3). Most respondents (29) inseminate Tswana cows, with few farmers practising AI on exotic breeds. The preferred bull as semen donor is Brahman (39) with 2 farmers preferring both Brahman and Simmental and only 1 farmer preferring Brahman and Charolais. Most farmers in Southern district send their cows to AI camps for insemination while all the interviewed farmers in Ghanzi practised their AI on farm. The farmers utilized AI mainly to improve the body weight and subsequently carcass weight and all the respondent farmers are seeing the impact/benefits of using AI in their cattle production. The benefits of using AI, included

Table 1
Socio-economic characteristics of beef cattle farmer's frequencies in the studied areas.

Descriptors	Ghanzi Frequency	%	Southern (Kanye) Frequency	%	Total Frequency (n)
Gender					
Male	31	77.5	44	81.5	75
Female	9	22.5	10	18.5	19
Age					
18–35	7	17.5	8	14.8	15
36–60	27	67.5	26	48.1	53
> 60	6	15	20	37	26
Education					
None	0	0	16	29.6	16
Primary school	1	2.5	12	22.2	13
Junior school	6	15	14	25.9	20
Senior Secondary school	26	65	6	11.1	32
Tertiary	7	17.5	6	11.1	13
Occupation					
Formal employment	14	35	8	14.8	22
Non-formal employment	17	42.5	8	14.8	25
Solely a farmer	6	15	38	70.4	44
Pensioner/ retired	3	7.5	0	0	3
Purpose					
Commercial	32	80	5	9.3	37
Subsistence	8	20	49	90.7	57
Land					
Communal	24	60	51	94.4	75
Ranch	16	40	3	5.6	19
Breed kept					
Tswana	6	15	29	53.7	35
Tswana and Brahman	15	37.5	9	16.7	24
Tswana, Brahman and Charolais	0	0	2	3.7	2
Tswana, Brahman, Charolais and Simmental	0	0	1	1.9	1
Tswana, Brahman and Simmental	5	12.5	4	7.4	9
Tswana, Brahman, Simmental and Limousine	0	0	1	1.9	1
Tswana and Charolais	3	7.5	1	1.9	4
Tswana, Charolais and Simmental	1	2.5	0	0	1
Tswana and Simmental	8	20	5	9.3	13
Tswana and Limousine	1	2.5	0	0	1
Brahman and Charolais	1	2.5	1	1.9	1
Brahman and Simmental	1	2.5	0	0	1
Brahman, Simmental and Limousine	1	2.5	0	0	1

Table 2
Mean ± S.E herd sizes and herd composition for beef cattle farmers in Ghanzi and Southern districts.

Animals category	Ghanzi Mean	Southern (Kanye) Mean
Total	112.18 ± 15.66[a]	35.31 ± 3.5[b]
Number of cows	57.53 ± 7.67[a]	20.98 ± 2.31[b]
Number of Bulls	5.32 ± 0.39[a]	7.78 ± 0.93[b]
Number of steers	49.28 ± 8.57[a]	6.57 ± 0.89[b]

Table 3
Frequencies for respondents who use AI.

Descriptors	Ghanzi	Southern	Total
Use AI only			
Yes	2	0	2
Both AI and Natural Mating	32	9	41
Breed inseminated			
Tswana	23	6	29
Tswana and Brahman	4	2	6
Tswana, Brahman and Simmental	1	1	2
Tswana and Charolais	1	0	1
Tswana and Simmental	3	0	3
Brahman and Simmental	1	0	1
Brahman, Simmental and Limousine	1	0	1
Breed semen preferred			
Brahman	33	6	39
Brahman and Charolais	0	1	1
Brahman and Simmental	1	1	2
Brahman, Simmental and Limousine	0	1	1
AI location			
AI Camp	18	9	27
On farm	16	0	16
Transport			
Trekking	1	6	7
Use vehicles	21	3	24
Reasons for using AI			
Improvement	16	0	16
Improvement and Increase carcass weight	0	4	4
Improvement and Preference	0	2	2
Increase carcass weight	13	0	13
Preference	5	3	8
Impact			
Yes	34	9	43
No	0	0	0
Benefits			
Improved weights	24	2	26
Improved weights and Preference	1	1	2
Improved weights, Preference and Good profit	0	3	3
Improved weights and good profit	1	3	4
Preference	4	0	4
Good profit	3	0	3
How long have you been using AI			
1 to 5 years	24	3	27
6 to 10 years	8	4	12
11 to 15 years	2	1	3
16 to 20 years	0	0	0
More than 20 years	0	1	1

improved weights, good profit and contentment of the farmer (preference). Most farmers have been using AI for 10 years and less.

3.5. Association between characteristics/factors of farmers and the utilisation of AI

The associations between the socio-economic factors and the utilisation of AI are presented in Table 4. The factors that significantly ($P < 0.05$) influenced the utilisation of AI were districts where the beef farmers were found, age of the farmer, education level, occupation, purpose of farming (commercial or subsistence) and land (communal/ranches). Gender of the farmer did not influence the utilization of AI.

3.6. Challenges

The challenges faced by respondents who use AI included long distance (14 %) to AI camps, limited number of cows (14 %) accepted at AI cows per breeding season, low conception rate (20.9 %), high feed intake of exotic breeds (7 %), lack of consistency of AI camps in collecting cows for AI (14 %) and failure of adaptability of exotic breeds (9.3 %). Some farmers experienced a combination of the above challenges as follows; long distance, limited cows accepted at AI camp per breeding season and low conception rate (4.7 %); long distance, limited cows accepted at AI camp per breeding season and lack of consistency of AI camps in collecting cows for AI (2.3 %); limited cows accepted at AI camp per breeding season, low conception rate and lack of consistency of AI camps in collecting cows for AI (2.3 %); limited number of cows and high feed intake of exotic breeds (2.3 %); limited number of cows and lack of consistency of AI camps in collecting cows for AI (5 %); limited number of cows, lack of consistency of AI camps in collecting cows for AI and failure of adaptability of exotic breeds (2.3 %) and finally, limited number of cows and failure of adaptability of exotic breeds (2.3 %). All the 43 respondents indicated that artificial insemination is the only assisted reproductive technology they are using.

3.7. Reasons for non-utilization of AI by beef farmers

Reasons given for not using artificial insemination were lack of knowledge (25.5 %), having bulls (15.7 %), lack of time (2 %), long distance to AI camps (2 %), lack of resources to maintain the crosses (2 %), discouraged by low numbers allowed at AI camp per farmer per season (5.9 %), lack of interest in AI (5.9 %) and newness of farmers to farming (2 %). Other farmers had combinations of the above reasons for not using AI.

4. Discussion

4.1. Farmers' socio-economic characteristics

The higher number of male farmers than females in this study is consistent with Ainslie (2005)'s finding that indicated that 79 % of cattle farmers in South Africa were males. Various authors (Statistics Botswana, 2017; Must and Hovorka, 2019; Uchendu et al., 2021) have reported most cattle owners to be males. The reason for more males being involved in cattle rearing than females might be due to the heavy work that is needed to take care of cattle and because of African tradition where females take care of the household and small animals such as chickens and small stock while males are responsible for cattle.

The least participation of youth in this study concurs with Uchendu et al. (2021) who reported low involvement of youths in cattle farming in Botswana and majority of cattle farmers being between 30 and 55 of age. Contrary to Uchendu et al. (2021)'s findings, in this current study beef cattle farmers aged more than 60 years were more than youths. The fewer numbers of youths in beef cattle rearing is worrying because the youths have potential to bring innovative practices to the agricultural industry.

The high percentage of beef farmers being educated up to secondary school in this study concurs with the findings of Harton and Rohaeni (2014) in Indonesia. However, it differs with the findings of Nsoso and Rabasima (2004) which indicated farmers with no education and those with primary school education to be the majority. This discrepancy might be due to the difference in time periods between their study and the current study, currently cattle farming is not regarded as uneducated people's thing. In trying to diversify sources of income, educated people are developing interest in farming, hence the increased number of educated farmers compared to the year 2004.

The higher numbers of farmers keeping cattle for subsistence purposes is consistent with previous researches in other countries (Sodiq et al., 2019; Mugumaarhahama et al., 2021). Keeping cattle in a

Table 4
Effects of districts and socio-economic parameters of households on the utilization of AI.

Descriptors	Total number of farmers	Number using AI	Proportion using AI (%)	Number not using AI	Proportion not using AI (%)	P-value
District						$< 0.001^{***}$
Ghanzi	40	34	85	6	15	
Southern (Kanye)	54	9	16.7	45	83.3	
Gender						0.383
Male	75	36	48	39	52	
Female	19	7	36.8	12	63.2	
Age						0.040*
18–35	15	6	40	9	60	
36–60	53	30	56.6	23	43.4	
> 60	26	7	26.9	19	73.1	
Education						$< 0.001^{***}$
None	16	4	25	12	75	
Primary school	13	1	7.7	12	92.3	
Junior school	20	4	20	16	80	
Senior Secondary school	32	26	81.25	6	18.75	
Tertiary	13	8	61.5	5	38.5	
Occupation						0.004^{**}
Formal employment	22	14	63.6	8	36.4	
Non-formal employment	25	14	56	11	44	
Solely a farmer	44	12	27.3	32	72.7	
Pensioner/retire	3	3	100	0	0	
Purpose						$< 0.001^{***}$
Commercial	37	33	89.2	4	10.8	
Subsistence	57	10	17.5	47	82.5	
Land						$< 0.001^{***}$
Communal	74	26	35.1	48	64.9	
Ranch	19	17	89.5	2	10.5	

communal land is a common practice for subsistence farmers as it is reported by other researchers in other countries (Mumba et al., 2018; Tavirimirwa et al., 2013). The most common breed kept is Tswana, some farmers keep only Tswana breed while others keep Tswana breed and other breeds such as Simmental, Brahman, Charolais and Limousine breeds. This is consistent with Ndebele et al. (2007). The indigenous breed is preferred because it is hardy, has high level of tick tolerance and has small body frame which makes its feed intake less compared to exotic breeds.

4.2. The numbers of cattle in the two regions

The significant ($P < 0.05$) difference between the two districts in herd sizes is consistent with Statistics Botswana (2015). The lesser number of bulls in the herds of Ghanzi farmers compared to Southern farmers correspond to the fact that most Ghanzi farmers practice AI, therefore, they do not need to have more bulls in their kraals.

4.3. Knowledge of artificial insemination

Most interviewed farmers reported to have heard about AI from other farmers (41.5 %), followed by those who heard about AI from other sources such as national television, radios, taught at schools, relatives and friends (30.9 %) while 16 % and 9.6 % got the information from extension officers and kgotla meetings (community meetings in traditional law court of villages), respectively. Farmers being reported as the major source of information about AI in this study agrees with Adnyana et al. (2021), on the contrary, their study found that the second source of information was extension officers.

4.4. Beef cattle production and utilization of AI

The lower number of farmers practicing AI in this study is consistent with Mumba et al. (2018), who reported lower utilization of AI by beef farmers in Zambia. The same scenario is reported in dairy cattle (Mushonga et al., 2017). Similarly, in Ethiopia 76.47 % farmers were reported to be non-adopters of AI (Gebre et al., 2022). Sari et al. (2020) reported AI to be still constrained by the supply of superior bull cattle, costs and the unreadiness of farmers to adopt, they however, indicated that in Karanganyar district at Indonesia all beef cattle are bred with AI. Farmers that practise AI are more in Ghanzi than in the Southern. The differences might be attributed to the fact that most beef farmers in Ghanzi are commercial farmers, therefore, more effort is put to increase productivity, including using assisted reproductive technologies. The common exotic breeds kept together with Tswana cattle are Brahman and Simmental. Ndebele et al. (2007) also found that Brahman and Simmental were among the breeds preferred by farmers together with the indigenous breed in Zimbabwe.

4.5. Reasons for using AI and breed preferred for semen

The practice of inseminating indigenous breed with exotic breed is common. This is to improve the indigenous breed performance. Brahman and Simmental bulls are the most preferred breeds for inseminating indigenous breeds, this was also reported by (Agustine et al., 2019). Simmental is preferred because of its good body weight compared to indigenous breeds. The preference of Brahman semen for AI in this study is consistent with previous researches in Indonesia (Ervandi et al., 2019; Irwansyah et al., 2021). Some of the reasons and benefits of using AI indicated by beef farmers in Ghanzi and Southern district concurs with Zuidema et al. (2021). The fact that farmers see some benefits of utilising AI, gives hope to the beef industry because the farmers will share their testimony with other farmers and encourage them to adopt the technology.

4.6. Association between characteristics/factors of farmers and the utilisation of AI

Beef farmers in Ghanzi used AI more than farmers in Southern district. Beef farmers aged 36 to 60 used AI more than those aged 18 to 35 and those above 60 years. This might be because the middle-aged farmers are likely to be more educated and aware of the importance of assisted reproductive technologies in improving productivity. Howley et al. (2012) also reported that older farmers were not likely to use AI

compared to younger ones in dairy cattle in Ireland. Similarly, Sirajuddin et al. (2018) indicated that willingness to participate in AI declined with age. On the contrary, Abdullah et al. (2021) found that age is not associated with adoption of farming innovations such as AI in beef farmers in Malaysia.

Education level also influenced the adoption of AI with high proportion of farmers with secondary education and tertiary education using AI compared to those with junior school education and below. This concurs with what Quddus (2012) reported, that educated farmers are likely to adopt farming technologies more than uneducated farmers in Bangladesh. Similarly, Abdullah and Noor (2021)'s research indicated that level of education significantly influenced the use of AI by beef farmers in Malaysia. However, the age and education level did not influence the adoption of AI by smallholder dairy farmers in Uganda (Mugisha et al., 2014). Type of occupation also influenced use of AI among the farmers, with farmers having formal employment, non-formal employment and retired practising AI more than those who are solely farmers. High proportion of commercial farmers practised AI compared to subsistence farmers and those who had ranches practised AI more than those that kept their cattle in communal land. Gender of the farmer did not influence the utilization of AI, this agrees with Mugisha et al. (2014).

4.7. Challenges

The challenges faced by respondents who use AI in this study have been reported by other researchers before. Moreki *et al.* (2021) similarly reported long distance to AI camps as one of the challenges faced by AI users. The low conception rate as one of the challenges of AI in this study concurs with the report of Rugwiro et al. (2021). The high feed intake of exotic breeds and their crosses reported by beef farmers in this study is consistent with the findings of Mendonça et al. (2019).

AI being the only technology used is not surprising because AI is one of the assisted reproductive technologies that have been used for a long time to improve reproduction in livestock and its utilization has been developing over time (Nwoga et al., 2021). Compared to other assisted reproductive technologies, AI is cheap and easy to use.

The research limitations of this study were lack of funds and limited time. This study was done as part of the final year degree project and the time was limited to one semester only. Furthermore, the funds allocated to this study were not enough to cover the whole country and to interview more farmers. Therefore, further studies need to be conducted in other districts of the country to cover more farmers.

5. Conclusion

There is significant association between AI utilization by beef farmers and these socio-economic factors; district where farming is done, age of the farmer, education level, occupation of the farmer, purpose of rearing cattle (commercial or subsistence) and land (communal or ranches). Gender of the farmer is not associated with AI utilization. Lack of knowledge about AI seems to be the main reason why farmers do not use AI. Farmers should be taught about the importance of AI in productivity and that AI can be beneficial even to the subsistence farmers who keep their animals in communal land. The findings of this study add more knowledge to literature on the status of adoption of AI, especially that of the effect of district, education level and age of farmers on the use of AI. This information may assist policy makers to strategize how to increase the use of AI looking at those socio-economic factors that affect utilization of AI by beef cattle farmers.

Ethical statement

As this manuscript does not involve research on humans or animals, nor does it include vulnerable populations, an ethical statement is not applicable. However, if such research is included, it is essential to disclose all approval details.

This research does not include experimental research on humans or animals.

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CRediT authorship contribution statement

Ketshephaone Thutwa: Conceptualization, Formal analysis, Investigation, Methodology, Supervision, Validation, Visualization, Writing – review & editing. **Poloko Nthupisang:** Conceptualization, Investigation, Writing – original draft. **Thatoyaone Botlhe Nkamane:** Conceptualization, Investigation, Writing – original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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