Journal of Veterinary Science & Medical Diagnosis

Research Article

A SCITECHNOL JOURNAL

Application, Utilization and Uptake of Artificial Insemination Technology to Smallholder Farmers in the Traditional Agro-Pastoral Livestock Farming System: A Case of Mpwapwa District in the Central Zone of Tanzania

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Received date: 02 August, 2023, Manuscript No. JVSMD-23-108861

Editor assigned date: 04 August, 2023, PreQC No. JVSMD-23-108861 (PQ);

Reviewed date: 18 August, 2023, QC No. JVSMD-23-108861

Revised date: 25 August, 2023, Manuscript No. JVSMD-23-108861 (R);

Published date: 04 September, 2023, DOI: 10.4172/2325-9590.23.12.1000062

Abstract

Cattle breeding in the central zone of Tanzania is largely by unproven homebred bulls, with very limited use of Artificial Insemination (AI). Hence, beef herds in the region remain largely unimproved, with relatively low genetic merit and productivity. An outreach program was developed by the Tanzania Livestock Research Institute (TALIRI) to pilot AI service delivery to smallholder farmers in the central zone of Tanzania, with the objectives of: Identifying the processes required to develop an AI service; and improving farmers' understanding of the potential benefits to their herds through using AI. Smallholder farmers (100) in the Mpwapwa district of the Dodoma region in the central zone of Tanzania were recruited into the program. 200 cows were involved in the programme composed of the following breeds: Mpwapwa (100), Tanzania Short-horned Zebu (70) and Boran (30). The AI bulls used were from Mpwapwa and Boran breeds kept at the National Artificial Insemination Centre (NAIC) in Tanzania, selected based on pedigree information and growth performance. All cows were synchronized prior to AI using a Prostaglandin (PG)-based programme. Of the 200 cows, 110 cows were inseminated following oestrus observed after 1st PG, with 90 non-responding cows receiving a 2nd PG injection at day 11 with Fixed Time AI (FTAI) 72 hours later. Of the 200 cows, 110 (55%; 95% CI 48%-62%) became pregnant to AI. Bulls were introduced into the herd for 60 days, starting 60 days after FTAI, with 80/90 cows (89%; 95% CI 81%-94%) which did not get pregnant to AI becoming pregnant during this period. For widespread uptake of AI, the following issues need to be addressed: (i) the inability of farmers to accurately detect oestrus, probably necessitating use of low-cost whole herd FTAI programs; (ii) the dearth of trained AI technicians; and (iii) low background fertility of cows.

Keywords

Smallholder Farmers; Artificial Insemination; Natural Mating; Traditional Agro-Pastoralism

Abbreviations

TALIRI: Tanzania Livestock Research Institute; NAIC: National Artificial Insemination Centre; COSTECH: Commission of Science and Technology; MU: Massey University; ARTs: Assisted Reproductive Technology; AI: Artificial Insemination; FTAI: Fixed Time Artificial Insemination; PG/PGF: Prostaglandin; CL: Corpus Luteum; NM: Natural Mating; TSZ: Tanzania Short-Horned Zebu; AM: Ante Meridian; PM: Post Meridian

Introduction

The use of modern breeding technologies can enhance productivity by improving reproductive performances and, consequently, genetic make-up [1,2]. However, in Tanzania, the use of such technologies is rare, particularly in beef cattle [3,4]. This is particularly true in the central zone of Tanzania, a semi-arid agro-ecological zone, where traditional agro-pastoralism is by far the most common livestock keeping system [5,6]. Under this system, crops are integrated into an extensive, rangeland-based livestock system. Livestock keeping under agro-pastoralism faces wide range of challenges on the utilization of AI technology: inability of farmers to accurately detect oestrus, probably necessitating use of low-cost whole herd FTAI programs; dearth of trained AI technicians; and low background fertility of cows [7]. One key problem with agro-pastoralism, identified by both [3] and [4] is that, farmers rely on unproven naturally home-bred bulls to service their herds. The cause of the latter, is the low uptake of AI in such systems driven by farmers' lack of awareness of its benefits. This is a negative feedback loop as the low uptake of AI produces a lack of awareness of the benefits of AI and beef cattle breeding programmes in agro-pastoral communities. In the central zone of Tanzania, the low uptake of AI has been exacerbated the centralization AI delivery system (into Arusha) and inadequate the lack of trained-AI technicians [8,9]. Thus, the majority of the beef cattle ecotypes within the central zone are unimproved ecotypes characterized by low genetic merit and productivity [10] (Figure 1).

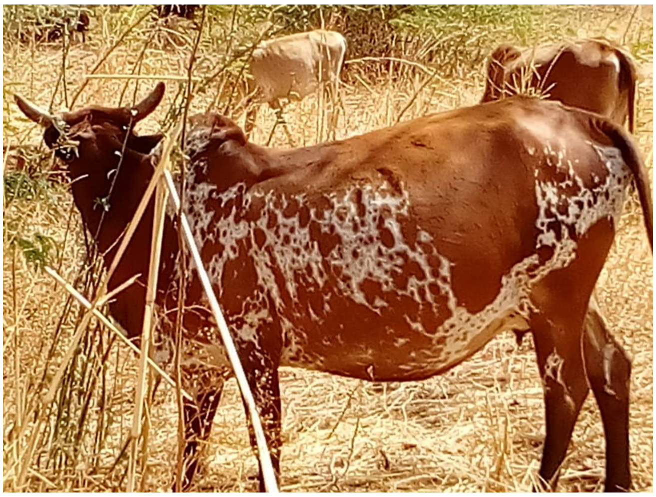

Figure 1: TSZ (Tanzania Short-horned Zebu) Cattle in a herd of a smallholder farmer at Wiyenzele village in Mpwapwa district.

Nonetheless, despite their low genetic merit, Tanzania Short-horned Zebu (TSZ) and related cattle to the vagaries of the Tanzanian environment has meant that such cattle are key contributors to the cattle population across Tanzania [10]. However, simply being suited to the environment is not sufficient if TSZ are to meet farmers' production goals for their cattle. In an attempt to address these needs, TALIRI and the Ministry of Livestock and Fisheries have initiated plans and programmes aimed at improving the genetic merits of TSZ cattle and their related eco-types throughout Tanzania.

As part of that initiative, TALIRI Mpwapwa developed a programme aimed at disseminating Mpwapwa cattle within the central zone of Tanzania using open nucleus breeding programmes. The Mpwapwa breed (a hybrid of African and Asian zebu and European dairy breeds) was chosen based on its: Production ability (for both meat and milk production); its resilience in a harsh semi-arid and tropical environment and the ability of Mpwapwa bulls to be used for draught power [11] (Figure 2). However, the rate of genetic gain using disseminated Mpwapwa bulls seemed to be slow under this approach. Thus, an alternative improvement strategy was opted using Assisted Reproductive Technologies (ARTs) especially AI in particular.

(a) **Wet season** **(b)** **Dry season**

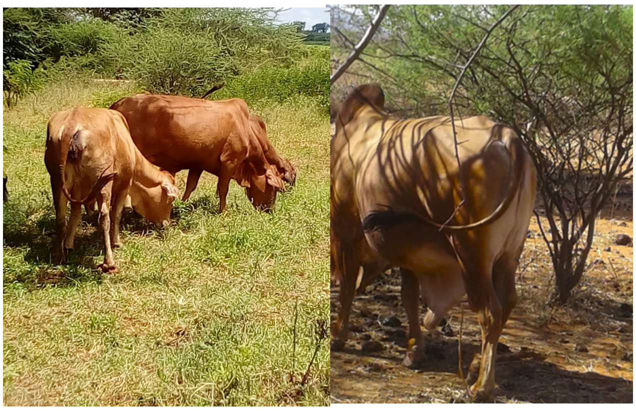

Figure 2: Mpwapwa cattle breed at Wiyenzele and Chipogoro villages in Mpwapwa district.

This study aimed to test the application, utilization and uptake of AI to smallholder farmers in the traditional agro-pastoral livestock farming system in Mpwapwa district of the central zone of Tanzania.

Materials and Methods

All animals' manipulations were approved by TALIRI prior to the start of the out-reach programme.

Selection of farmers

A convenience selection of smallholder farmers from Wiyenzele and Chipogoro villages within Mpwapwa district were used for this study. Each village contributed 50 farmers. These villages were chosen because; TALIRI Mpwapwa had previously established an on-farm multiplication of Mpwapwa cattle in these villages (Figure 3).

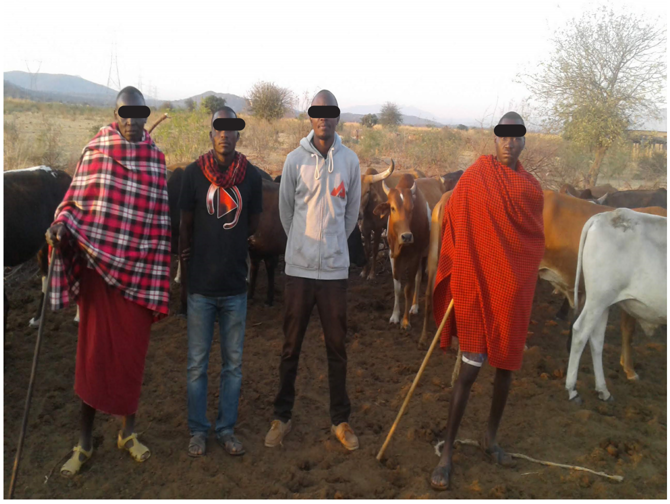

Figure 3: Smallholder farmers at Chipogoro village in Mpwapwa district.

The herds belonging to the selected farmers all underwent pregnancy diagnosis and of the 400 cows, 200 non-pregnant cows were selected. Of the 40 village bulls, 4 bulls were selected from Mpwapwa (n=2) and Boran (n=2) breeds with no records of reproductive disorders (Figure 4).

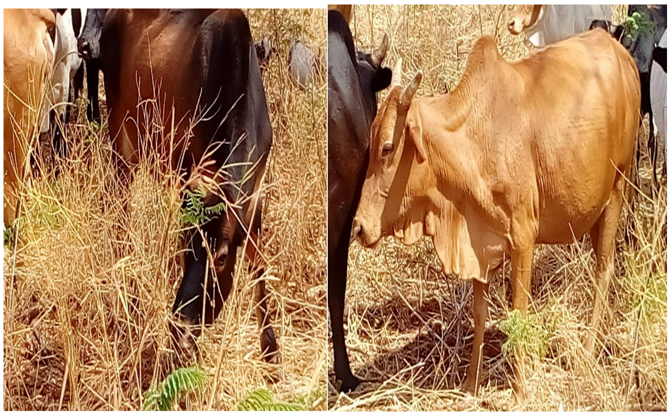

Figure 4: Selected cows at Wiyenzele and Chipogoro villages involved in the programme.

Management and treatment of animals after selection

As per normal practice in these villages, one group of cows from each village (n=100) were grazed together on unrestricted grazing on communally owned grazing land. No additional concentrates or minerals were provided. Dipping was conducted once per month to control ectoparasites, as is normal for these herds using Paranex (Alphacypermethrin 100 g/L, Farm base Ltd, Tanzania) (Figure 5).

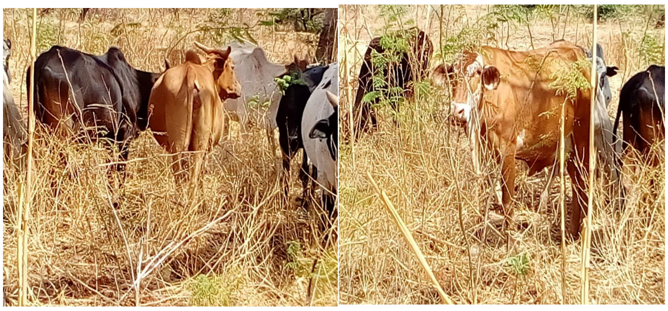

Figure 5: Selected cows in communal grazing land at Wiyenzele and Chipogoro villages.

Reproduction management

The 200 non-pregnant cows were selected from 400 cows based on their pregnancy status. They were divided into four mating groups of 50 cows based on that order, with the first cow going to mating group 1, the second cow going to mating group 2 and so on. The four groups were separated grazed. The PGF programme was staggered by group (Table 1). On day 0 in all the four mating groups, each cow received their first PGF injection (i.e. 500 µg cloprostenol (Estroplan, Parnell Australia)), with behavioral oestrus closely observed by herdsmen for the next 4 days. Three signs of oestrus were recorded: i) standing to be mounted; ii) mounting others; and iii) mucus discharge. Cows observed in oestrus were inseminated based on the AM/PM rule [12]. Cows that were not inseminated within 120 hours of the first PGF injection were retreated on Day 11, followed by Fixed Time AI (FTAI) at 72 hours post second PGF injection. The AI bulls used were two bulls (one Mpwapwa and one Boran) kept at the National Artificial Insemination Centre (NAIC) in Tanzania. They were selected based on pedigree information and growth performance. A post-thaw motility of >65% was confirmed for semen straw samples taken from both bulls prior to purchase. Prior to insemination, the semen straws were thawed in a thawing unit/incubator with inbuilt thermometer set at 36°C for 2 minutes. Pregnancy was confirmed by transrectal ultrasonography (Chison Medical Imaging Co, Jiangsu, China) 60 days after the last FTAI. After pregnancy diagnosis, tested bulls were introduced into the herd 60 days in a mating ratio of 1:50, with pregnancy diagnosis following 60 days later (Table 1).

Results

Of the 200 cows, 110 were observed in oestrus after 1st PGF injection (55%; 95% CI 48%-62%). Standing to be mounted was the most commonly observed behavior with 38 cows showing this sign of oestrus. 36 cows were observed mounting others, and of the 38 mounted cows, 36 were observed with mucus discharge. The number of cows standing to be mounted per group ranged from 9–11; there was thus no evidence that mating group had a large effect on proportion of cows showing observed oestrus (P=0.89).

Of the 200 cows, 110 became pregnant as a result of the PGF programme (55%; 95% CI 48%-62%). The number of cows pregnant per group after the PGF programme ranged from 25 to 31; as with oestrus behaviour after PGF there was no clear evidence that mating group had an impact on pregnancy rate after PGF programme (P=0.39). Of the 90 cows which did not become pregnant 80 became pregnant in the 60 days that the cows were run with the bull (89%; 95% CI 81%-94%). This meant that 10/200 cows failed to become pregnant during the breeding season (Table 2) (Figure 6).

Mating Groups	No. of. Cows	1st PGF Injection	Oestrus Detection+AI	2nd PGF Injection	FTAI	Bull Mating
Group 1	50	06/01/20	8-11/01/20	16/01/20	19/01/20	25/03/20
Group 2	50	20/01/20	22/01/20	30/01/20	02/02/20	08/04/20
Group 3	50	03/02/20	5-8/02/20	13/02/20	16/02/20	22/04/20
Group 4	50	17/02/20	18-21/02/20	27/02/20	01/03/20	07/05/20

Table 1: Mating plan of cows by PGF (Prostaglandin) injection.

Mating Group	No. of. Cows	Pregnant Cows (AI+FTAI)	No. of Returns after (AI+FTAI)	Pregnant Cows (NM)	No. of Returning After (NM)
Group 1	50	25	25	22	3
Group 2	50	24	26	22	4
Group 3	50	31	19	18	1
Group 4	50	30	20	18	2

Table 2: Pregnancy status in cows across mating groups.

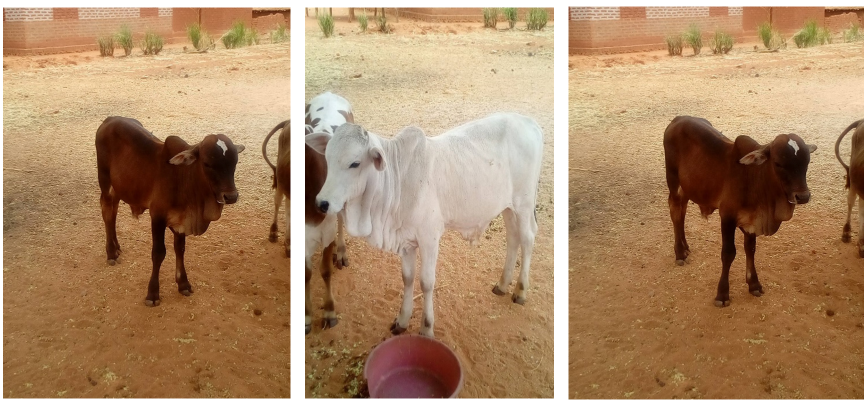

Figure 6: AI calves at Wiyenzele and Chipogoro villages sired by Mpwapwa and Boran semen.

Discussion

The cause for the low oestrus response was not clearly determined in the present study. In this study, it might be ineffective detection of oestrus or large number of cows had no responsive Corpus Luteum (CL) which is a function of PGF. This is the most probable reason for the low oestrus response for the first PGF injection [13].

In addition, if cows had an ovulatory anoestrus, this might also be responsible for the low response for the second PGF injection too. Thus, this might indicate that a large number of cows were in anoestrus. As a result, an investigation on the reproductive status is crucial prior to the start of the breeding season mainly to determine prevalence of anoestrus in the cows. If this is the case, treating anoestrus cows requires progesterone-based protocols [14]. Despite of being expensive, progesterone-based protocols as reported from different studies have proved to have shown positive results against anoestrus. However, cows with palpable Cl should be treated with PGF protocol [14].

On the other hand, nutrition plays a key role on cattle fertility, improving the quality and quantity of pastures in the communal grazing lands of the traditional agro-pastoral communities will mean that cows' feed intake will also increase [15-17]. This will consequently improve cows' fertility status resulting into better oestrus responses under AI programmes. Nonetheless, improving nutrition and health regimen, oestrus detection methods as well as insemination protocols can generally result into best conception outcomes.

Despite of the fewer number of cows which were involved, the study produced a pregnancy rate of 55% comparable to the results obtained in some of the trials conducted on-station at TALIRI Mpwapwa farm. For example, [3] reported 39% pregnancy rate in a FTAI experiment using standard 14-day PGF protocol tested against natural mating (NM) at TALIRI Mpwapwa farm during the March-May 2016 breeding season. Similar results have been reported from different studies. For example, a study conducted in Argentina in a semi-arid climate using Zebu and Bonsmara cattle during the 2002/03 and 2004/05 breeding seasons reported 49.1% (1053/2144), 47.9% (189/394) and 41.7% (951/2278) pregnancy rates for the heifers, dry and suckled beef cows respectively under the FTAI programme [18].

On the other hand, better pregnancy rates were obtained for the NM groups. However, the cows in these groups were few resulted from fewer numbers of returns from the FTAI groups bred with four bulls in a ratio of 1:22 and 1:23 (Table 2). In addition, cows in these groups had an advantage to be serviced several times with the bulls for 60 days.

Conclusion

Therefore, the performance shown from the study entails improvement to the following pre-breeding practices into the breeding programme of the Wiyenzele and Chipogoro villages: nutrition and health regimen as well as oestrus synchronization protocol and behavioural oestrus detection methods. However, the study had not only shown promising results but also its continuous application, utilization and uptake to the traditional agro-pastoral communities of Wiyenzele and Chipogoro villages within Mpwapwa district will eventually increase beef cattle productivity and their genetic gain within the district. As a result, this can be replicated to the other parts of the district and the entire central zone of Tanzania for a broader impact.

Acknowledgements

Authors acknowledge support on research assistance from TALIRI Mpwapwa, Massey University and the University of Edinburgh. The completion of this study was facilitated by the support of the Tanzania Livestock Research Institute (TALIRI), Massey University (MU) from New Zealand, the University of Edinburgh as well as the Tanzania Commission of Science and Technology (COSTECH) for the publication assistance. Authors also acknowledge the support from the Tanzania National Artificial Insemination Centre (NAIC) for the supply of semen straws.

Statement of Animal Rights

Research Ethical Approval which governs issues on animal rights and research protocols was sought from TALIRI prior to the start of the programme/study.

Statements and Declarations

Funding

This work was supported by the Tanzania Livestock Research Institute (TALIRI).

Competing interests

The authors have no relevant financial or non-financial interests to disclose.

Authors contributions

All authors contributed to the study conception design. Material preparation, data collection and analysis were performed by Mr. Kabuni Thomas Kabuni, Mr. Malongo Mwalingo, Mr. Geofrey Matimya and Prof. Richard Laven. The first draft of the manuscript was written by Mr. Kabuni Thomas Kabuni and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Data availability

The dataset generated during and/or analyzed during the current study are not publicly available due to patent but are available from the corresponding author on reasonable request.

Consent to participate

Informed consent was obtained from all individual farmers included in the study.

Consent to publish

The authors affirm that human research participants provided informed consent for publication of the images in Figure 3.

Conflict of interest

The authors declare that there is no conflict of interests regarding the publication of this article.

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