Efficiency of Artificial Insemination (AI) Technology in Different dairy Herd Management Systems in the Southern Highland Zone (SHZ) of Tanzania

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ABSTRACT

The objective of the study was to establish the information on the performance of Artificial Insemination (AI) in different production systems in the Southern Highlands Zone of Tanzania. Three districts namely, Njombe, Mbeya and Mbozi were purposively selected for data collection in smallholder farms and three large scale farms of ASAS, Sao Hill and Kitulo were selected for data collection. Data from 1486 and 163 dairy cow’s records from large and smallholder farms, respectively were used and analyzed using General Linear Model (GLM) procedure of Statistical Analysis System (SAS). The overall number of services per conception (NSC) were 2.49 and 1.39 in smallholder farms and large farms, respectively. In smallholder farms, NSC was influenced by district, breed, parity, AI technician, age at first service, calving to first service Interval (CFSI) (days) and who detect heat. In large farms NSC was influenced by farm location, source of semen and effect of year. First service to conception (FSC) were 43.56% and 72.48% in smallholder farms and large farms, respectively. It was revealed that the value of NSC and FSC under smallholder farms were lower compared to recommended values, indicating inefficiency of AI performance under smallholder farmer’s conditions in SHZ of Tanzania. Contrary NSC and FSC under larger farms were good indicating that AI is efficiency under large farms in SHZ of Tanzania. Hence there is a need to train smallholder dairy farmers on heat detection and good herd management so as to improve dairy reproductive efficiency in the country.

Keywords: AI. technician, Age at First Service, First Service to Conception, Number of Service per Conception.

I. INTRODUCTION

Tanzania is richly endowed with huge livestock resources base, which consist of 30.5 million cattle out of which 98% comprise of the Tanzania short horn zebu (TSHZ) and the remaining 2% are exotic and their crossbreed namely Friesian, Jersey, Ayrshire and Boran [1]. Despite Tanzania is ranking third in terms of cattle populations in Africa, the productivity per cattle is low due to the fact that 98% of the herd is TSHZ which is characterised by low genetic potential resulting into low productivity in terms of milk, meat and calf crops. Improved cattle in Tanzania are mostly kept in Northern highland, Southern highlands (SHZ), Tanga and Kagera regions. The total population of improved cattle in Tanzania is just 20% of the neighbouring Kenya [2]. According to [3], worldwide standards per capita consumption of meat and milk is about 50 kg and 200 litres respectively. In Tanzania per capita consumption of meat and milk is 12 kg and 45 litres, this has been associated with low genetic potential of the indigenous cattle. Artificial insemination (AI) has been advocated as a quick way to improve productivity of existing stocks. The use of AI provides an opportunity to farmers in different management system to transform herd size by introducing germplasm (new blood) with high genetic potential [4]. Despite the importance of artificial insemination as one of the best way to improve genetic potential of dairy cattle’s, the adoption and utilization of this technology is very low and not commonly available in different party of the country due to many factors including poor AI infrastructures in most of the developing countries [5], [6]. Other factors include low conception rate, long post-partum anoestrus and long calving interval [7]. Thus, this study was conducted to evaluate the efficiency of AI under different management systems in selected areas of SHZ.

II. MATERIALS AND METHODS

A. Description of the Study Area

The study was conducted in small scale dairy herds and medium / larger Scale farms in Southern Highland land zone of Tanzania. SHZ is comprise of seven (7) regions which are Katavi, Rukwa, Songwe, Mbeya, Iringa, Njombe and Ruvuma, bordering Malawi, Mozambique, and Zambia. The zone lies between latitude 6°S and 12°S and Longitude 290 E - 380 E. The area receives uni-modal rainfall pattern between 823 mm up to 2850 mm and tends to start in
November and April. The annual temperature is between 130 °C and 190 °C. The study farms and respective sites are given in Table I.

| Category        | Farm       | Region | District |
|-----------------|------------|--------|---------|
| Large scale     | Kitulo     | Njombe | Makeni  |
| Large scale     | LMU Sio-Hill | Iringa | Malinga |
| Large scale     | ASAS       | Iringa | Mbinga  |
| Smallholder     | Smallholder dairy farm | Mbeya | Mbozi   |
| Smallholder     | Smallholder dairy farm | Njombe | Njombe  |
| Smallholder     | Smallholder dairy farm | Mbeya | Mbeya   |

B. Data Collection and Derivation of Study Variables

1) Data collection

Field survey was conducted to evaluate the efficiency of AI service in different herd management systems in Tanzania. Retrospective study used data from 1,486 dairy cow records and 163 cow records under AI use from larger scale and small-scale management system respectively were used. Data on Artificial insemination records were obtained from inseminator’s recording book in larger scale farm and information on individual animal from cow cards/recording books under small holder farms.

Data collected under large dairy scale management system (ASAS farm, Sao Hill farm and Kitulo farm) were type of management system, Breed of cows, Parity number, season of service, year of service, AI technician ID, semen source, the date of last calving, date of first service and subsequent services.

Under small scale management system (Mbozi, Njombe districts and Mbeya) data collected were Breed of cows, Parity number, Season of service, AI technician ID and age at first service and subsequent services.

2) Derived traits and factors

Information from AI book records and cow cards were used to obtain the following parameters.

a) Number of services per conception (NSC) was obtained by counting the frequency of service until a heifer/cow conceives.

b) First service conception (FSC) was calculated as the proportional of heifer/cow that conceived after first service.

c) Overall, first service conception is the average percentage or proportion of heifer/cow conceived from all the animals conceive on the first service.

d) Age at first service this was considered as the age when a heifer serviced for the first time after maturity.

e) Months of the year was grouped into four seasons for larger scale management, Early dry (July to August), Early rain (December to February), Late dry (September to November) and mid rain (March to May) and only 2 categories were used for smallholder farms based on rainfall pattern wet (December to June) and dry season (July to November).

f) Parity (Number of different times a female animal has had offspring) was divided into five category, 0-heifer, 1, 2, 3, and >4.

3) Data processing and analyses

Data from inseminations, number of services per conception were tested for normality using UNIVARIATE procedure of (SAS 2004) and found to conform to the normal distribution. The final analysis of the data was carried out using the General Linear Model (GLM) procedure of (SAS 2004). All factors which did not appear in other locations were nested within the district and differences were observed. The least square means obtained for the effects was compared using the Probability of Difference (PDIFF) procedure of (SAS 2004).

First Service Conception (FSC) was analyzed by using Chi-square procedure of SAS and frequencies / percentage were established.

Different models were used for Data analyses. Model I was used in small scale dairy management system and model II was used in larger scale dairy management system.

Model I.

\[ Y_{ijklmp} = \mu + D_i + B_j + P_k + S_{0l} + I_{mn} + I_{jn} + \text{year} + e_{ijkmnp} \]

where

- \[ Y_{ijklmp} \] = Number of service per conception (NSC); \[ \mu \] = Overall mean;
- \[ D_i \] = effect of i\text{th} district (Njombe, Mbeya and Mbozi);
- \[ B_j \] = effect of j\text{th} Breed (Frisian and Ayrshire);
- \[ P_k \] = effect of k\text{th} Parity number (parity 1, 2, 3, and >); \[ S_{0l} \] = effect of l\text{th} season (Wet and Dry);
- \[ I_{mn} \] = effect of m\text{th} AI technician nested within district;
- \[ I_{jn} \] = effect of n\text{th} age at first service (19 months, 20-24 months and > 24);
- \[ \text{year} \] = effect of p\text{th} year which detect signs of heat (Family member, owner and stockman);
- \[ e_{ijkmnp} \] = random error specific to each individual.

Model II.

\[ Y_{ijklmnp} = \mu + D_i + B_j + P_k + S_{0l} + I_{mn} + S_{em} + \text{year} + e_{ijklmnp} \]

where

- \[ Y_{ijklmnp} \] = dependent variable Number of service per conception (NSC);
- \[ \mu \] = Overall mean;
- \[ D_i \] = effect of i\text{th} Farm (Asas, Sao Hill and Kitulo);
- \[ B_j \] = effect of j\text{th} breed nested within farm (Friesian, Aryshire and Boran);
- \[ P_k \] = effect of k\text{th} parity (0, 1, 2, 3 and > 4);
- \[ S_{0l} \] = effect of l\text{th} source of semen nested within farm (Holland and NAIC);
- \[ S_{em} \] = effect of m\text{th} season of mating;
- \[ \text{year} \] = effect of n\text{th} year (2011, 2012, 2013 and 2014);
- \[ e_{ijklmnp} \] = random error to each specific individual.

III. RESULTS AND DISCUSSION

A. Results

1) Number of services per conception (NSC) under smallholder herd management system

The overall mean of number of services per conception (NSC) under smallholder farmer was found to be 2.58±0.44 and differed (p < 0.01) between districts, breeds (p < 0.01), parity (p > 0.01), AI technician (p > 0.01) and age at first service (p > 0.05), who detect heat (p > 0.05) and season of mating (p > 0.05). Njombe and Mbeya districts had lower NSC 1.06 and 1.43, respectively while Mbozi district had the highest value of 2.32 (Table II). Regarding breed, Friesian crosses had the highest NSC of 1.82, while for Ayrshire the value was small 1.12 (Table II). On the other hand, Parity...
indicated that the NSC in heifers was higher (1.63) than that of other cows and generally NSC decreased up to third parity. There after there was increased trend from parity four and above (Table II). Season of insemination had no significant (p >0.05) effect on number of services per conception. But results showed small difference in NSC where wet season mating had fewer number compared to dry season mating (Table II). It was also observed that there was higher variability in NSC in districts and NSC varied (p >0.05) between inseminators (Table II).

Age at First Service significantly (p <0.05) influenced NSC whereby animals inseminated at 24 months had lower value for NSC (1.31) while animal inseminated before or at 19 months had higher value (2.03) (Table II). Likewise, animals inseminated 4 months after calving had significantly (p<0.05) lower NSC than those inseminated at 2 and 3 months (Table II). It was also observed that the NSC was to larger extent affected by who detect heat signs and generally, heat detection by family members had lower values compared to owner and higher NSC was observed when the stockman detects heat (Table II).

![Table II: Least squares means (LSM) ± SE for NSC under smallholder farms](image)

| Source of variation | Levels | LSM ± SE |
|---------------------|--------|----------|
| Overall mean        | NSC    | 2.58±0.44 |
|                     | Njombe | 1.06±0.58* |
| District            | Mbeya  | 1.43±0.41* |
|                     | Mbozi  | 2.32±0.34* |
| Breed               | Ayrshire (Cross) | 1.12±0.46* |
|                     | Friesian (cross) | 1.82±0.32* |
|                     | 1      | 1.37±0.48* |
|                     | 2      | 1.26±0.44b |
|                     | 3      | 2.27±0.46* |
|                     | >4     | 1.81±0.44b |
| Season              | Dry    | 1.66±0.37 |
|                     | Wet    | 1.28±0.39 |
| Al technician ID*   | (within district) |          |
|                     | Njombe | ZN 1.45 ± 0.63 |
|                     |        | ZP 1.87 ± 0.79 |
|                     | Mbeya  | KAM 1.48 ± 0.53 |
|                     |        | KISO 1.83 ± 0.48 |
|                     | Mbozi  | MK 1.97 ± 0.64 |
|                     |        | K 1.79 ± 0.56 |
|                     |        | M 3.57 ± 0.39 |
| Age at first service (AFS) | Below 19 months | 2.03±0.35* |
|                     |        | Between 20 – 24 months | 1.31±0.46 |
| Calving to First service interval (CFSI) | 2 months | 1.19 ± 0.79* |
|                     |        | 3 months | 2.27±0.28* |
|                     |        | 4 months | 1.93±0.28* |
| Who detects heat signs | Family members | 1.09±0.39 |
|                     |        | Owner | 1.24±0.36* |
|                     |        | Stockman | 2.08±0.51* |

*Names of AI technician.

2) Number of service per conception (NSC) under larger scale dairy herd farms

Factors influencing NSC are shown in Table III. Significant difference was observed for NSC among larger scale dairy farms. The average mean for NSC was found to be 1.39±0.05 and was significantly (p<0.05) influenced by farm location (0.001), semen source (0.001) and year of servicing (0.05). Breed, parity, season had no influence (p >0.05) on NSC although there was slightly variation on NSC between seasons. The NSC was significantly lower at Sao hill farm (1.19) followed by Kitulo farm (1.40) and ASAS farm (1.57). It was also observed that source of semen influenced NSC whereby, Sao hill which use semen from NAIC (Tanzania) had lower NSC (1.19). Nonetheless, there were no variation on the value of NSC between ASAS farm which use imported semen from Holland and cows in Kitulo farm were inseminated with semen from NAIC (Tanzania). However, there was significant differences between farms which uses imported semen (Kitulo and ASAS) whereby larger value for NSC was observed in ASAS (1.57) compared to Kitulo (1.24).

Regarding year of service, animal inseminated in 2014 had lower value for number of services per conception (1.29) compared to other years. NSC on animals inseminated between 2011 to 2013 did not differ significantly.

It was also apparently that NSC was not influenced by breed of the cow though F1 Ayrshire cross tended to show lower NSC compared to pure Ayrshire, Friesian and Boran.

Likewise, Season of service had no influence on the number of services per conception and animals serviced during the mid-rain tended to have lower NSC (1.35) compared to those serviced during long dry season (1.43)

![Table III: Least squares means (LSM) ± SE for NSC in large farms](image)

| Source of variation | Levels | LSM (se) |
|---------------------|--------|----------|
| Overall mean        | NSC    | 1.39±0.05 |
| District            | Iringa rural ASAS | 1.57±0.04* |
|                     | Mufindi Saohill | 1.19±0.05* |
| Breed               | Makete Kitulo | 1.40±0.05* |
|                     | Asas Ayshire | 1.60±0.05 |
|                     | Friesian | 1.53±0.05 |
| Parity              | 1      | 1.35±0.06 |
|                     | 2      | 1.41±0.06 |
|                     | 3      | 1.30±0.05 |
|                     | >4     | 1.41±0.03 |
| Source of semen (district) | Asas Sao hill | 1.57±0.04* |
|                     | NAIC Kitulo | 1.19±0.05* |
|                     | NAIC KITULO | 1.24±0.05* |
|                     | NAIC | 1.57±0.08* |
| Age at first service (AFS) | Early dry | 1.37±0.04 |
|                     | Early rain | 1.39±0.05 |
|                     | Late dry | 1.43±0.04 |
|                     | Mid rain | 1.35±0.06 |
|                     | 2011 | 1.38±0.04* |
|                     | 2012 | 1.43±0.05* |
|                     | 2013 | 1.43±0.05* |
|                     | 2014 | 1.29±0.04* |

3) First Service to conception (FSC) under smallholder dairy farms

Table IV shows the factors that influence first service conception under smallholder farmers. The overall first service to conception (FSC) was 43.6%. Higher conceptions on first insemination were observed in Njombe district (58.33%) while Mbozi had the lowest value (31.65%).

Breeds did not influence first service to conception although there was a small variation in FSC between breeds. Friesian cross breed tended to have higher FSC (77.46%) compared to Ayrshire cross breed (22.54 %). Nonetheless, parity significantly (P>0.05) influenced FSC whereby heifer had lower FSC (40%) and the frequency of services decrease
in subsequent parities. It was also observed that FSC tended to decrease at the beginning of fourth parity. Greater variation was observed among technician in Mbozi, where one inseminator had higher value up to 71.43% whilst the lowest inseminator had FSC of 18.18%. In other districts the variation in First service conception was small. Seasons of service were not influencing FSC significantly. Although cows/heifer inseminated during wet season had slightly FSC (54.6%) compared to the ones inseminated during dry period (45.4%).

![Average FSC and Districts](image)

**Fig. 1.** First service to conception (%) under smallholder farmers.

**Table IV: First service to conception (%) under smallholder farmers.**

| Factors          | Levels   | Number of records | % FSC | Level of significance |
|------------------|----------|-------------------|-------|-----------------------|
| District         | Overall  | 71                | 43.56 | 0.01                  |
|                  | Njombe   | 14                | 58.33 | 0.02                  |
|                  | Mbeya    | 32                | 53.33 | 0.02                  |
|                  | Mbozi    | 25                | 31.65 | 0.02                  |
| Breed            | Ayrshire | 16                | 25.24 | 0.35                  |
|                  | Friesian | 55                | 77.46 | 0.09                  |
| Parity           | 0        | 6                 | 40.00 | 0.02                  |
|                  | 1        | 24                | 66.67 | 0.02                  |
|                  | 2        | 17                | 43.39 | 0.02                  |
|                  | 3        | 9                 | 33.33 | 0.02                  |
|                  | 4<       | 15                | 32.61 | 0.02                  |
| Season           | Wet      | 44                | 54.60 | 0.02                  |
|                  | Dry      | 27                | 45.40 | 0.02                  |
| A.I technician   | Njombe   | ZN 10             | 62.50 | 0.02                  |
|                  | Mbeya    | ZP 4              | 50.00 | 0.02                  |
|                  | KAM      | 6                 | 46.15 | 0.02                  |
|                  | KISO     | 14                | 50.00 | 0.02                  |
|                  | MK       | 6                 | 46.15 | 0.02                  |
|                  | Mbozi    | K 7               | 46.67 | 0.02                  |
|                  |          | M 11              | 23.91 | 0.02                  |
|                  |          | N 5               | 71.43 | 0.02                  |
|                  |          | Z 2               | 18.18 | 0.02                  |

**4) First Service to conception (FSC) under larger farms**

Farm location significantly (p<0.01) influenced First Service to Conception under larger scale farms. Overall, first service to conception under larger scale herd management system was found to be 72.48%. Sao Hill farm in Mufindi district had the highest FSC (83.9%), followed by Kitulo farm (74.83%) whilst ASAS farm had the lowest FSC (61.35%) as illustrated on Fig. 2.

![First service to conception (%) under larger farms](image)

**Fig. 2.** First service to conception (%) under large farms.

**Table V: Factors Influencing First Service to Conception (%) under large farms.**

| Factors          | Level               | Number of records(N) | % FSC | Level of significance |
|------------------|---------------------|-----------------------|-------|-----------------------|
| Breed(Farm)      | Overall             | 1077                  | 72.48 | 0.0001                |
|                  | Ayrshire            | 170                   | 61.59 | 0.0001                |
|                  | Boran               | 275                   | 81.36 | 0.0001                |
|                  | Fi                  | 121                   | 90.30 | 0.0001                |
|                  | Friesian            | 511                   | 69.66 | 0.0001                |
| Parity           | 0                   | 219                   | 71.34 | 0.582                 |
|                  | 1                   | 104                   | 73.34 | 0.582                 |
|                  | 2                   | 123                   | 73.65 | 0.582                 |
|                  | 3                   | 159                   | 76.81 | 0.582                 |
|                  | >4                  | 472                   | 71.19 | 0.582                 |
| Season           | Early Dry           | 275                   | 72.94 | 0.6347                |
|                  | Early Rain          | 218                   | 69.56 | 0.6347                |
|                  | Long dry            | 118                   | 72.39 | 0.6347                |
|                  | Mid rain            | 466                   | 73.62 | 0.6347                |
| Semen Source     | NAIC                | 603                   | 40.58 | 0.0001                |
| (Farm)           | Holland             | 883                   | 59.42 | 0.0001                |
| Year             | 2011                | 304                   | 72.38 | 0.0001                |
|                  | 2012                | 199                   | 64.19 | 0.0001                |
|                  | 2013                | 224                   | 67.67 | 0.0001                |
|                  | 2014                | 350                   | 82.35 | 0.0001                |

**B. Discussion**

1) **Number of services per conception under smallholder farmers and larger scale herd management systems**

The overall mean NSC for smallholder farmers was 2.58; Njombe district had lower value of 1.06 while Mbozi had highest value of 2.32. Overall, NSC was higher compared to results reported by other researcher in smallholders’ system elsewhere. For examples [8] and [9] reported a value of 1.8
on crossbreed cow and Holstein Friesian (HF) crossbreed respectively. [10] Observed value of 1.54 in Ethiopia cross breed while [11] reported value of 1.66 on cross bred cows in Tanzania. The result obtained in Mbozi district concur with the results observed by [12] and [12] in South Africa and Ethiopia where a value of 2.55 and 2.3 respectively where reported. The results from this study are within the range between 1.5 to 2.5 reported by [14], and [15] in Ethiopia and 2-3 reported by [16] on Ayrshire and boran crossbreed in Tanzania. To the contrary higher value of 3.6 was reported in India by [17] and 3.0 by [18] on cross of Jersey and Sahiwal cows under small holder farmer’s condition.

In generally it appears that NSC tends to vary greatly depending on location. But value higher than 2 under any smallholder units are regarded as poor or under performance of AI service [19], [20]. Whilst the NSC under smallholder could be considered as being poor the overall NSC under larger scale farms was (1.39). ASAS farm had slightly higher value of 1.57 while and Sao hill had lower value of 1.19. Low number of services per conception is one of the good indicators to know whether the dairy farm is operating profitable or not, and the benchmark to this is that in any profit marking dairy cattle farm NSC should not exceed 1.33 [21].

Overall NSC found in the current study in large scale farms compared well to results obtained elsewhere for examples [22], [23]) reported values of 1.32 and 1.4 respectively.

Another study conducted in Nigeria by [24], Ethiopia [25] and Iran by [26] reported higher values than those found in Njombe and Mbozi districts in Tanzania. Lower NSC under different larger scale herd management systems observed in this study conformed to the observation done by [27], who found higher value of NSC on smallholder farms compared to large farm. This can be due animal factors, difference in management, ecological differences, semen quality, and skill of inseminators, better veterinary service, AI storage facility, inappropriate heat detection and time of insemination. Other factors which can result into higher values of NSC in smallholder units could be prevalence and occurrences of diseases and reproductive disorder related to cows/heifer which is more likely to occur under smallholder system where regular supervision by veterinary officer might be lacking.

2) Factors affecting NSC

From comparison of least square means under smallholder farmers (Table II) Friesian crosses were observed to require 0.7 more services to conceive than Ayrshire breed. Under lager farms Ayrshire in ASAS farm had higher value of 1.6 compared to Sao hill Ayrshire and Boran breed (1.21). This variation can be due level of exotic blood and level of milk yield. Most breed kept in ASAS and Kitulo farms had higher potential for milk production. Higher milk producer had been observed to have poor fertility [28], [29]. Also, under smallholder farmers higher NSC were observed in Friesian cross breed compared to Ayrshire breed.

[30], [31], and [32] observed that increase in level of exotic blood can be source of increased NSC under different herd managements. Most farmers had dairy cows with exotic blood more than 75%, whilst breed kept under larger scale were more or less pure. Though Breed can have significant effect on NSC, [33] observed that it is not easy to know exactly the effects of cattle genotype (breed) on their fertility instead environmental (Ecological differences) and management practices have more influence on fertility. It was also revealed that parity influenced NSC under smallholder farmer but not in big farms. In general heifer and first calvers had higher NSC which decreases up to 4th parity and rise again. Higher NSC in heifer than old cows have also been reported by [7], [34] and [35].

While the districts experienced different weather conditions, seasons did not influence number of services per conception significantly under both herd management systems, but there were slightly differences regarding to season under wet season in smallholder farmers and mid rain in big farms. In general, lower values were observed in wet season similar to findings reported by [11] and [36]. This observation could be explained by availability of feeds during wet seasons and is more vivid under small farmers where they depend solely on cut and carry method.

Apart from season, AI technicians and source of semen also influence NSC whereby, technician M and Z in Mbozi had higher NSC than those from another district. Non genetic factors such as skills and experience of AI technician were also important determinant of number of services per conception, effect on skills of inseminator on NSC was also reported by [8]. There has also been concern on the quality of semen produced locally by NAIC. In this study it was revealed that semen source influenced NSC especially under larger scale farms. Results showed that Sao hill farm which use only semen from NAIC had lower NSC than the other two farms (Table III). On the contrary Kitulo farm which use imported semen had lower NSC than NAIC semen, but within the farm there was no difference on performance between imported and NAIC semen on NSC. Thus, the differences in NSC could be attributed to breed effects and other management factors rather than source of semen.

It was also apparent that animals inseminated above 24 months had lower NSC compared to those inseminated at the lower age. Surprisingly, animal inseminated at 19 months or below had higher value of NSC, though most exotic breed can be bred at 18months. This variation on NSC can be due to the fact that animal in the tropics tends to have delayed maturity due to fluctuation in feed availability and associated farm management practices [37]. Results in Table II shows that the longer CFSI was associated with lower NSC. In the tropics normal number of days for CFSI range between 90 to 100 days [38]. Cows inseminated 2 months and 3 months postpartum had higher NSC compared to 4 months. This difference could be due to the poor feeding under smallholder which make cows to required longer time to recycle and retain optimum body condition to be able to conceive again. [38] Observed that cows breed at 50 days postpartum are characterized with poor conception. Thus, will require more service per conception [39].

With regards to heat detection, the study revealed that Stockmen as heat detector were associated with higher NSC (Table IV). This difference can be due to the factor that heat detection is tedious work and the stockman alone cannot be efficient on heat detection given the recommended frequency of three times per day [40]. More so the efficiency of stockman depends on his experience and if indeed he has been trained on heat signs both primary and secondary.
3) First service to conception (FSC) under smallholder farms and large-scale farms

Out of 71 heifers/cows inseminated, 43.56% conceived on first insemination in smallholder farm units. More animals which conceived on first insemination were from Njombe district, followed by Mbeya, Mbozi district had fewer animals that conceived on first service (58.3%, 53.33% and 31.65%), respectively. A lot of dairy research works have been conducted in Njombe DC in preceding years, which is likely to have improved the knowledge on heat detection and knowing the appropriate time of insemination. [41] Emphasized on the importance of farmers knowledge on heat detection in influencing reproductive efficiency. Other reasons could be related to overall better infrastructure for semen handling. According [42], good infrastructure and proper semen handling results into high FSC. Furthermore, in Njombe district AI is mainly supported by district council, while in Mbozi it is privately operated.

The overall FSC obtained for smallholder famers in this study was slightly higher than value of 34.5 % reported by [43] and 41.8% by [10], (33.9%) on crossbreed cow in Kashmir [44]. However, it is within the range reported by other scholar under smallholder farmer’s condition (22-46%) [45] and lower than 64% observed by [12] in South Africa on Holstein cows. These differences reported in different location are attributed mainly by ecological difference, level of skills, presence of adequate facilities, and provision of adequate nutritional and management aspects.

In large scale herds, out of 1077 cows/heifer inseminated 72.5% conceived on first insemination. Sao hill farm had the highest value (83.90%) followed by Kitulo 74.83% and ASAS farm (61.35%). The values obtained in this study conform to the value of 72.8% reported by [46] but, higher compared to 41-45% observed by [15] in Ethiopia. Values greater than 70% had been reported by [47] and [48], who reported FSC of 77.7% and 82.2%, respectively. However, the differences observed in Kitulo and ASAS farm, can be possibly explained by environment and herd management practices. Kitulo has more or less temperate climate and most of the dairy cows originated from this climate while ASAS farm lay in the lowlands with slightly high temperature.

4) Factors affecting first service conception (FSC)

In smallholder farms breed had no significant influence on FSC and Friesian crosses had better FSC of (77%) compared to Ayrshire crosses (22.5%). To the contrary in larger farms breed significantly influenced on FSC whereby, Ayrshire and Boran breed kept in Sao hill had good performance compared to Ayrshire and Friesian breed kept in other farms. Other scholar reported breed to have no significant influence on conception rate [49], [33], while [50] found cow breed to influence significantly the conception rate.

Under smallholder farms parity significantly influence FSC, but not in larger farms. In both management system heifer had lower FSC which increased during 2nd and 3rd parities, this inefficiency of heifer and first calvers was also observed on NSC. [51], [33] also observed similar trend where FSC increase up to 2nd parity and then decrease on subsequent parity. From these observations, it can conclude that reproductive efficiency especially on FSC is better in older cow than in heifer or first calvers, but if cows are better managed as in larger scale farms the effect of parity become insignificant.

It was also observed that cows had better conception during wet (rain) season than in the dry season. Under smallholder, FSC was (44%) during wet season and (27%) during dry season. In big farm mid rain had higher FSC (82.35%) which was higher than that obtained during the dry periods. Also, early rain which is a period following long dry period was found to have slightly lower FSC (69.65%). The lower FSC could be attributed to effect of long dry periods. Thus, to a larger extent FSC seem to be associated with availability of feeds in terms of quality and quantity. This contention was also reported by [11].

The study also reveals that FSC was influenced by AI technician and semen sources. The variation associated with AI technicians can be as results of inseminator experience and skills on insemination [8]. Most of inseminators in Mbozi district had no more than five years working as AI technician. Likewise, semen transportation and storage under field conditions could be a reason to the underperformance of AI technician. Furthermore, imported semen gave better FSC (59.2%) in larger farms compared to local semen (40.54%). It is speculated that the major reason which lead to this difference was mainly related to management, cow factors and possibly inseminator skills. This can be confirmed by the fact that breed kept at Saohill which use only local semen performed better than ASAS farm which use imported semen.

IV. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusion

From this study it can be concluded that:

(i) The value for Number of Service per Conception (NSC) and First service conception (FSC) under smallholder farms were lower compared to recommended values. Indicating inefficiency of AI performance under farmer’s conditions in SHZ. Contrary the Number of services per conception (NSC) and First service to conception (FSC) under larger farms were good indicating that AI is efficiency under big farms in SHZ of Tanzania.

(ii) Time of insemination, poor knowledge on heat detection practices, animal factors, Inseminators factors and location factors contributed to inefficiency of AI under smallholder farmers in SHZ of Tanzania.

B. Recommendations

(i) There is a need for training of smallholder dairy farmers on the heat detection, herd management, breeding and nutrition to improve dairy reproductive efficiency.

(ii) It is further recommended that AI infrastructures be uplifted coupled with simple and functioning recording system under smallholder farmer which will assist in making the right decision on breeding programs.

(iii) There is a need to improve genetic and none genetic factors under smallholder farms so as to reduce NSC and increase FSC.
CONFLICT OF INTEREST

We certify that there is no conflict of interest with any financial organization regarding the material discussed in the paper.

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