Reproductive performance of artificially inseminated dairy cows under smallholder production system in selected areas of Rwanda and Tanzania

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SUMMARY

This on-farm longitudinal study was carried out in artificially inseminated smallholder dairy cattle herds in Rwamagana and Kayonza districts, Eastern Province, Rwanda and in urban and peri-urban area of Tanga city, Tanzania. The objectives of the study were to generate a reliable field data set and analyze it to determine reproductive parameters/indices. A total of 280 and 400 households keeping 158 and 709 cows and heifers in Rwanda and Tanzania respectively were studied. Reproductive events: dates of heat, AI or NS, service number, sire ID, name of inseminator, PD results, calving date, abortions or other reproductive problems were recorded by the farmer or with assistance from the inseminator. Inseminations were carried out all year round but there was tendency for the majority to be carried out between June and October with a peak in August and September. The average CI (±SD), CCI (± SD) total number of inseminations performed, first service pregnancy rate, services per pregnancy (all cows) and services per pregnancy (pregnant cows only) was 429±30/490±119 days, 215±132/195.7±99.8 days, 353/1035, 31.6/44.7 %, 2.7/1.9 and 1.9/1.1 in Rwanda and Tanzania, respectively. In conclusion, sub-optimal reproductive performance and low AI success in artificially inseminated smallholder dairy cattle herds was characterized by long CI, low first service pregnancy rate and an average of two or more services per pregnancy. We recommend further research to determine specific causes of poor performance in order for appropriate corrective measures aimed at improving productivity in the smallholder dairy sub-sector to be carried out.

Keywords: Reproductive performance, AI service, smallholder dairy production

INTRODUCTION

The productivity of cattle largely depends on their reproductive performance and it is generally agreed that the greatest returns are possible from dairy cows that calve approximately once each year. Poor reproductive performance is caused by either failure of a cow/heifer to become pregnant, primarily due to anoestrus (prepubertal or postpartum) or failure to maintain pregnancy (Mukasa-Mugerwa, 1989). Common measures of reproductive performance are days to first service, days to conception, calving interval, services per pregnancy, and pregnancy rate (Donald 1985; FAO 1989; Gaines 1989; Gaines 1990; Kanuya *et al.*, 2000).

Low productivity in smallholder dairy sub-sector in the East and Central African sub-region is caused by a number of factors including limited availability of suitable improved heifers for herd replacement or

enterprise expansion. With the exception of few countries, the rate of growth of the sub-sector in the region has remained slow, partly because of poor results or unavailability of artificial insemination (AI) services. Increased use and adoption of AI as a breeding method would lead to accelerated genetic improvement since AI, unlike natural service enables an outstanding male to sire many offspring in a year, i.e. AI allows faster and wider dissemination of the selected breeding sire's genes (Mpofu, 2002). Low pregnancy rates following AI can be caused by many factors including those related to the cow, management of the animal, semen quality and handling, insemination technique, bull fertility and their interactions (Nordin et al., 2007) as well as occurrence of infectious reproductive diseases (Gaines, 1989).

In a baseline study conducted in Rwanda and Tanzania, it was found out that smallholder dairy farmers were discouraged from using AI because of poor success rates leading to many repeat inseminations (Kanuya et al., 2013). The first step when faced with an apparently sub-fertile herd is to determine its true reproductive performance to confirm that a problem exists (Gaines, 1989). However, review of the development of AI service in the East and Central African sub-region is hampered by the scarcity of complete and reliable data sets on the extent to which it is used and information on the technical results or success of the AI services performed.

The objectives of this longitudinal study were therefore, to generate a reliable on-farm data set as a case study and analyse it to determine reproductive parameters/indices in artificially inseminated smallholder dairy cattle herds in selected areas of Rwanda and Tanzania.

MATERIALS AND METHODS

The study area

This longitudinal on-farm study was conducted between September 2010 and December 2013 in Rwamagana and Kayonza districts, Eastern Province, Rwanda and in Tanga City and the surrounding peri-urban areas in Tanzania. The sites in both countries were purposively selected because smallholder dairying under zero-grazing production system is a major occupation of the farmers. The geographical locations of the two adjoining districts of Rwamagana and Kayonza in Rwanda is at Latitude: 1°56′55″ S, Longitude: 30°26′04″ E and at an elevation of 1507 m (4944 ft) above sea level. The geographic coordinates of Tanga City are Latitude: 5°04′00″ S, Longitude: 39°06′00″ E at an Elevation of 1 m (3 ft) above sea level in northeastern Tanzania.

Rwanda has a temperate tropical highland climate, with lower temperatures than is typical for equatorial countries. Rwanda's average temperature varies according to its topography. Due to high altitude, its temperature and rainfall are more moderate than the surrounding hot and humid equatorial regions. An average of 21 to 23°C is observed at Rwamagana and Kayonza. Average annual rainfall varies according to four seasons: A short rainy season from September to November and a longer season between March and May and two dry periods. Some parts of Rwanda have experienced unusual irregularities in climate patterns including variability in rainfall frequencies and intensity. The livelihoods of people in the project site in Rwanda are dependent on mixed crop-livestock agriculture.

On the other hand, the climate in the study area at Tanga City in Tanzania comprise of the humid coastal climate characterized by

high temperature. The annual average temperature is 26.3ºC (range 22.1-30.4ºC) and the average annual precipitation is 1262 mm. Most rainfall (rainy season) falls in March, April, May, October and November. On average, the warmest month is February and the coolest month is August. May is the wettest month and February is the driest month.

Study animals and their management

In both sites, the dairy cattle production systems is characterized by exclusively zero grazing in Rwamagana/Kayonza and within Tanga city but combined with some outdoor grazing in the peri-urban area. Other details of the households and animals included in the study were as shown in Table 1. Households were conveniently included in the study depending on their practicing smallholder dairy farming, ownership of piece of land for forage establishment and willingness to participate in the project.

In Rwamagana-Kayonza area cattle usually are fed on established pastures mainly comprising of Napier and Guatemala grass while in Tanga the cut and carry or outdoor grazing is mainly dependent on natural pasture species comprising of Napier grass, *Hyparrhenia rufa, H. dissolute, Setaria sphacelata* and *Andropogon schirensis.* Other grasses include *Cynodon dactylon, Panicum infestum, Digitaria mombasana* and *Bothriochloa glabra.* There are also several unpalatable legumes but their contributions to the livestock industry are questionable.

Table 1. Important details on households and cattle kept in smallholder dairy herds in Rwamagana/Kayonza (Rwanda) and Tanga (Tanzania)

Item	Rwanda	Tanzania
Study sites	Rwamagana /Kayonza	Tanga (urban and peri-urban)
Number of households (HHs)	280	400
Average number of cattle per HH	2	3
Breeds of dairy cattle	Friesian = 154 Friesian crossed with Ankole = 2 Ankole 2	Friesian cross = 648 Ayrshire cross = 60 Jersey cross =1
Parity	0 -11	0 - 8 (cows =573 & heifers = 136)

Artificial insemination (AI) service

For the Rwandan farmers, field AI service was provided by a non-governmental organization (NGO), Send-a-Cow Rwanda (SACR) but semen was obtained at a government subsidized price. In Tanga city the study formed a working partnership with a private livestock inputs supplier (Agri-Care Enterprises) to offer the service. In both sites, frozen-thawed semen sourced locally and some through importation was used. Farmers themselves decided on the sire breed of their choice to be used for the inseminations.

Field data collection

An individual cow/heifer Data Sheet was prepared and used for the field data collection at both sites. The data form was translated into Kinyarwanda for Rwandan farmers and Kiswahili for Tanzanian farmers. One copy of the data sheet was permanently kept at the respective household for regular updating. At the beginning of the study the reproductive history of individual cow or breeding heifer was recorded in this data collection sheet. Thereafter, all subsequent normal or

abnormal reproductive events such as dates of heat, AI or NS, service number, sire ID, name of inseminator, PD results, date of calving, occurrence of abortion or other reproductive problems were recorded by the members of a household assisted by the inseminator.

A copy of the individual cow data sheet was kept by the study team and the data on paper was periodically transferred to an electronic Excel file. The collected data was checked for accuracy of entry and biological meaning. Periodic physical verification was carried out whenever doubtful data was encountered.

Definition of reproductive parameters/indices

The calving interval (CI) was defined as the average interval between two most recent consecutive calving for all the cows in a particular study site. The calving to conception interval (CCI) or days to pregnancy was calculated as the average interval (number of days) from calving to the next pregnancy.

The first service pregnancy rate was defined as percentage of post-partum cows and heifers that became pregnant on the first service. It was obtained by dividing the number of successful first services by the total first services and then expressed as a percentage. Number of services per pregnancy was calculated by dividing the total number of services by the number of pregnant cows and heifers in the herd. The number of services per pregnancy was calculated taking into consideration either all cows and heifers that were inseminated or only the cows and heifers that subsequently became pregnant.

Data analysis

Collected data were checked for completeness and accuracy before being entered into a computer for analysis. The data were analyzed using Microsoft Excel® software, (2007) where simple descriptive statistics (mean ± SD) were generated.

RESULTS

Monthly inseminations

The total number of inseminations performed in the two study sites between September 2010 and December 2012 were as shown in Figure 1. Inseminations were carried out all year round but for both sites there was tendency for more inseminations to be carried out between June and October with a peak inseminations performed in August-September coinciding with the cool season in the year.

Reproductive performance indices (CI and CCI)

The average calving interval (CI) was 429±30 and 490±119 days (range 369 to 468 and /334 to 676 days) in Rwamagana/Kayonza and Tanga respectively as shown in Table 2. The average calving to conception interval (CCI) or days to pregnancy was 215±132 with a range from 84 to 578 days in Rwamagana/Kayonza and 195.7±99.8 days (range 59 to 470 days) in Tanga respectively.

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Table 2. Calving interval (CI) and Calving to Conception Interval (CCI) in smallholder dairy cattle herds in Rwamagana/Kayonza (Rwanda) and Tanga (urban and peri-urban) in Tanzania between September 2010 and June 2013

	Rwanda			Tanzania		
Parameter	Median	Range	Mean ± SD	Median	Range	Mean ± SD
Calving Interval (days)	439	369-469	429 ± 30	479	334-676	490±119 (n=11)
Calving to Conception Interval (days)	165	84-578	215 ±132	171	59-470	196±99 (n=56)

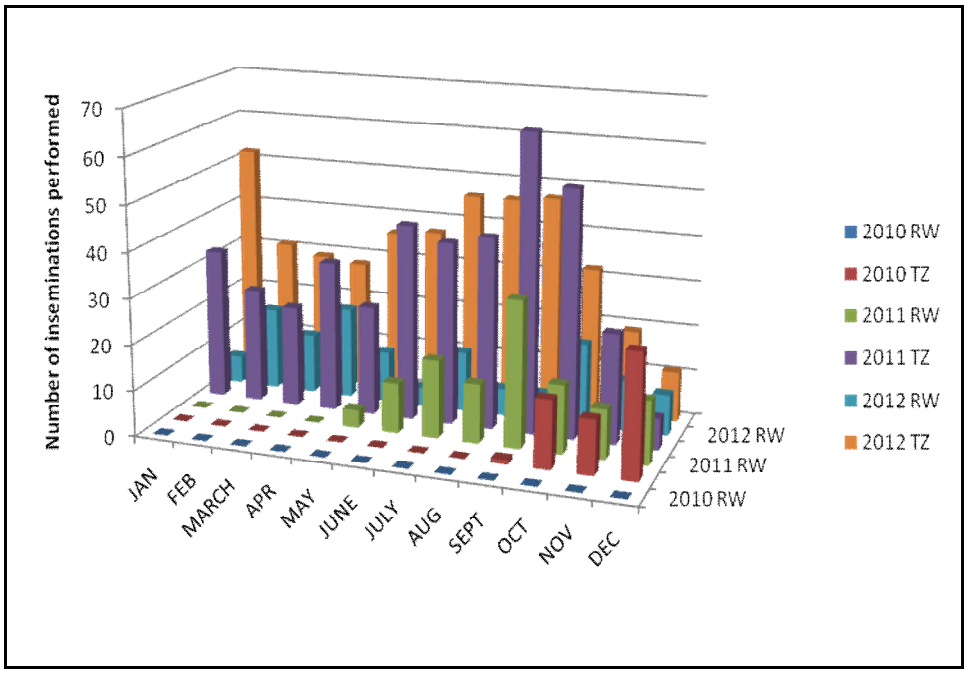

Figure 1. Total number of annual/monthly inseminations performed in smallholder dairy cattle herds in Rwamagana/Kayonza districts (Rwanda) and Tanga City/peri-urban between 2010 and 2012

Measures of success of artificial insemination service

During the study period, a total of 353 and 1305 inseminations were performed in Rwamagana/ Kayonza and Tanga respectively. The number of services per pregnancy for all inseminations, services per pregnancy for pregnant cows/heifers only and first service pregnancy rates were 2.7/1.9, 1.9/1.05 and 31.6/44.7% at Rwamagana/Kayonza and Tanga study sites respectively as shown in Table 3.

Table 3. Measures of success in artificial insemination performed from September 2010 to June 2013 in smallholder dairy herds in Rwamagana/Kayonza (Rwanda) and Tanga urban/peri-urban (Tanzania)

Parameter	Performance	
	Rwamagana/ Kayonza	Tanga
a) Number of inseminations to all cows and heifers	353	1,305
b) Number of First services	146	731
c) Number of inseminations to pregnant cows and heifers	249	718
d) Number of confirmed pregnancies	131	683
e) Number of cows and heifers pregnant to First Service	52	327
f) Services per pregnancy (All inseminations) (a/d)	2.69	1.9
g) Services per pregnancy (All First Services only) (b/d)	1.1	1.07
h) Services per pregnancy (pregnant cows and heifers only) (c/d)	1.9	1.05
i) First service pregnancy rate (e/b x 100)	31.6%	44.7%

Calves born

From the beginning of the study up to June 2013, a total of 115 improved AI-calves had been born in Rwamagana/Kayonza and another 725 improved AI-calves were born in and around Tanga City, Tanzania. The mean (±SD) gestation lengths for cows/heifers in Rwamagana/Kayonza (Rwanda) and in Tanga (Tanzania) was 275±10.5/275±11.4 days respectively.

Occurrence of other reproductive diseases/disorders

Diseases and other reproductive diseases reported during the study period included mastitis, abortions and calf deaths as shown in Table 4. However, the actual causes of calf deaths were not determined.

Table 4. Frequency of reproductive diseases, disorders and other related events reported between September 2010 and June 2013 in smallholder dairy cattle herds located in Rwamagana/Kayonza (Rwanda) and in Tanga, in Tanzania.

Reproductive disease, disorder or other event	Rwamagana /Kayonza (n/N, %)	Tanga (urban/ peri-urban) (n/N, %)
Abortions	7/131 (5.3)	38/683 (5.6)
Mastitis	-	32/573 (5.6)
Calf deaths	5/17(2.86	60/725 (8.3)
Cow/heifer deaths	-	11/709 (1.6)
Sold for breeding	-	13/709 (1.8)
Stolen	-	8/709 (1.1)

DISCUSSION

The success of the methods used to produce replacements can be assessed by growth of the smallholder dairy sub-sector which can be measured by either the increase in the number of dairy cows population in the smallholder sub-sector or

increase in milk production and/or productivity. Currently, the demand for improved dairy heifers in Rwanda to reach more resource-poor smallholder farmers under the "On Cow to Every Poor Family" and in Tanzania for herd replacement, enterprise expansion or young farmers joining the sub-sector is higher than available supply. This has led to prohibitively high price of the heifers. One way of tackling this problem of shortage of breeding heifers in the smallholder dairy sub-sector is to produce improved off-springs on-farm through the delivery of a reliable and efficient AI field service.

Cattle are not seasonal breeders as they can cycle and breed all year round as long as they are maintained in an optimal status in terms of nutrition and health. The observation in the present study that breeding cows and heifers exhibited a period of increased inseminations (June to October) with a peak around August-September could be a physiological and adaptational phenomenon. This is the rather cool dry period immediately following the long rainy season (March to May) and therefore there are still plenty of natural pastures that are high in DM and nutritive value. Animals inseminated at this time and carry the pregnancy to term are expected to calve between March and July of the following year which again coincides with the period of ready availability of drinking water and natural pastures. This ensures nourishment and survival of the prospective offspring. In a previous study conducted at Magadu dairy farm of the Sokoine University of Agriculture, Morogoro (Kanuya *et al.*, 1997) and among indigenous Zebu cattle in an agro-pastoral production system Gairo district, Morogoro (Kanuya *et al.*, 2006) have also reported a similar phenomenon of peak natural inseminations and conception around the same period of the year.

The observation in the present study of a calving interval of 429± days (Rwamagana/Kayonza) and 518±156 days (Tanga urban and peri-urban) highlights existence of poor reproductive performance in both rural and urban based smallholder dairy units in the East and Central African sub-region. For optimal productive and reproductive performance a short calving interval of $\leq$ 400 days is desirable in tropical dairy production systems (Mujuni *et al.*, 1990). This frequency of calving will ensure that the majority of cows in herd or in a particular area will produce milk at the optimal range of their lactation curves. The results in the present study must also be interpreted in light of small sample size as only a few of the cows had two consecutive dates of calving recorded.

In the present study, the number of services per pregnancy for all cows inseminated (2.7/1.9) and for cows that became pregnant (1.9/1.05) in Rwamagana/Kayonza and Tanga (urban and peri-urban) respectively were also higher than optimal. When artificial insemination is used as the method of reproduction, several factors such as semen handling, semen deposition, timing of service, nutritional status and occurrence of infectious disease(s) can all affect the success or failure of an insemination. Generally if all inseminated cows are considered, services per conception/pregnancy should be less than 2.25. But if only inseminations on pregnant cows are considered, this statistic should be less than 1.8. The best indicator of pregnancy rate within a herd is to calculate services per pregnancy on all cows in the herd which have been bred at least once. However, the findings in the present study should be interpreted taking into consideration the effect of a disproportionately high number of inseminations on a few infertile animals.

The first service pregnancy rate in this study was 31.6% and 44.7% in Rwamagana/Kayonza and Tanga (urban and peri-urban) respectively. This is the proportion of cows and heifers that were confirmed to be pregnant following the first post-partum (cows) or post-pubertal (heifers) insemination. The first service pregnancy rate averages 45%, though 60% is attainable (Williamson, 1987). The population used to calculate the first service pregnancy rate is important in interpreting this reproductive index. If only those cows that are currently pregnant are included, the first service pregnancy rate will be higher (60%) than if first services on all cows inseminated at least once are included (45%). In this study, the latter method of calculating the first service pregnancy rate was used in order to reflect a more realistic success rate of AI service in the smallholder dairy herds.

Previous studies conducted elsewhere have attributed low reproductive performance and efficiency to either delayed first service, missed oestrus, or multiple services per successful conception which in turn is expensive to the dairy producers because of increased breeding expenses, more veterinary services, high reproductive replacement costs and fewer calves being born (Hammond *et al.*, 2010; Duguma *et al.*, 2012). Genetics, management practices including poor nutrition can contribute to this decline in reproductive performance as well.

We conclude that artificially inseminated cows and heifers in smallholder dairy herds in Rwamagana/Kayonza (Rwanda) and in Tanga (urban and peri-urban) in Tanzania exhibit sub-optimal reproductive performance and low AI success rates characterized by long calving intervals (CI), low first service pregnancy rate and need for two or more services per pregnancy. Therefore, the specific causes of the poor reproductive performance in the present study needs to be determined in order for appropriate corrective measures aimed at improving productivity in the smallholder dairy sub-sector in the East and Central African sub-region to be carried out.

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