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Research Paper

PRODUCTIVE AND REPRODUCTIVE PERFORMANCE OF DAIRY COWS IN GICUMBI DISTRICT, RWANDA

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To document the productive and reproductive performance of cows owned by beneficiaries of "One cow program" and to compare the same with those owned by non-beneficiaries, data was collected in Gicumbi District, Northern Rwanda. A total of 400 farmers (300 beneficiaries and 100 non-beneficiaries) were randomly selected and interviewed through a structured questionnaire. The information collected included daily milk yields, lactation length, age at first calving, calving interval, conception rate, types of feeds and feeding and the data analysed through SPSS Software. Results showed that the mean daily milk yield per cow and lactation length were 5.8±2.89 and 7.7±3.02 litres and 9.4±1.9 and 10.3±1.6 months for the beneficiaries and non-beneficiaries respectively. The mean age at first calving were 31.6±3.9 and 30.7±3.2 months while the mean calving interval was 18.3±4.5 and 14.3±2.7 months for cows belonging to beneficiaries and non-beneficiaries respectively. Conception rates of cows for first and second services were 57.3 and 76.4% for beneficiaries and 58.6 and 85.9% for non-beneficiaries. Napier grass and crop by products were the preferred cattle feeds by 72% of beneficiaries and 57% non-beneficiaries. Supplementation with concentrate feeds was practiced by 12.7% of beneficiaries and 30% of non-beneficiaries. It was concluded that the productive performance of cows given to beneficiaries was low compared with those of non-beneficiaries within the same locality and this was attributed to poor quality of feeds used by beneficiaries and high cost of supplements. The poor reproductive performance was attributed to inferior feeding and lower knowledge on fertility management by beneficiaries.

Keywords: Calving interval, Conception rate, Feeding, Milk yield, Rwanda

INTRODUCTION

Dairy cattle farming offers to poor households a potential pathway to poverty and hunger alleviation and also in reduction of the prevalence of malnutrition through milk consumption (Kabunga, 2014). In 2006, the government of Rwanda initiated "One cow program" with the aim of using cow transfers to increase productivity in

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agriculture sector, improve household incomes and reduce poverty and malnutrition for poor families (Argent *et al*., 2014). Under this program, beneficiaries are selected based on a number of criteria including: not owning another cow, own less than 0.75 ha of land for pasture production and have a simple cowshed structure. Beneficiaries are then given primary supports including free insemination services, fodder seeds, some veterinary services, vaccinations and training on management of a dairy cow (MINAGRI, 2006). Since the inception of the "One cow program" in 2006, 174,900 cows had been given to poor families either as primary or secondary recipients by June 2012. Similarly milk production in the country had increased from 50,000 MT in 2000 to 450,000 MT in 2012 (MINAGRI, 2013b). The per capita milk consumption also increased from 18 litres in 2006 (MINAGRI, 2006) to 59 in 2014 (NISR, 2015b). Despite the benefits from this program, the assessment of performance parameters of cows given to beneficiaries has not been done. Therefore a study to document and compare productive and reproductive performance of cows owned by beneficiaries and non-beneficiaries of "One cow program" was undertaken.

MATERIALS AND METHODS

Study Site

The study was conducted in Gicumbi District within five administrative sectors namely; Byumba, Kageyo, Mukarange, Rukomo and Shangasha. Gicumbi District is located in the Northern Province of Rwanda and is bordered by Burera and Rulindo Districts to the west, Nyagatare and Gatsibo to the east, Uganda to the north and Kigali city to the south.

The District encompasses 21 administrative sectors and covers an area of 867 km^2, with geographical coordinates; 01°35' South latitude and 30°04' East longitude. The topography is of steep slopes dominated by mountains. It has a temperate tropical highland climate with two rainy seasons, the short rains start in September to mid-December and the long rains in March to May. The average rainfall ranges between 1200 and 1500 mm while annual temperature varies between 13 to 24 ^oC (Gicumbi District Report, 2013).

Data Collection and Analysis

A survey was conducted through a structured questionnaire between December 2016 and January 2017. The interviews were conducted in local language "Kinyarwanda" through face to face interviews with the help of trained enumerators on a total of 400 farmers (300 beneficiaries and 100 non-beneficiaries). Data collected from the selected households included: milk yield, lactation length, number of services per conception, age at calving, calving interval, feeds and feeding, level of knowledge of dairy management and calf management skills. The sample size was determined at 95% confidence level and p = 5% precision according to Yamane (1967:886) simplified formula. The collected data were sorted, checked and then entered and analysed using SPSS (version 21.0). Different models in the SPSS software were used to analyse the data. Descriptive statistics such as means, frequency distribution and percentages were obtained from the beneficiary and non-beneficiary data. Comparisons were then done between beneficiaries and non-beneficiaries for productive and reproductive parameters.

RESULTS AND DISCUSSION

Socio-Economic Characteristics

The family size, age, gender, marital status, education level and land size holding of the respondents is shown in Table 1. The average family size of the respondents was 5.69 for beneficiaries and 6.16 for non-beneficiaries which is higher than the national average of 4.6 persons per family (NISR, 2015a). According to the same report, rural household sizes tended to be larger than those in urban areas though most (51%) lay within 3-5 members. These

Table 1: Socio-Economic Characteristics of the Respondents

	Beneficiaries		**Non-Beneficiaries**	
Family Size	**N**	**Mean**	**N**	**Mean**
	300	5.69	100	6.16
Age Category (Years)	**Frequency**	**Percent**	**Frequency**	**Percent**
18 – 35	52	17.3	17	17
36 – 53	153	51	55	55
> 53	95	31.7	28	28
Total	**300**	**100**	**100**	**100**
Gender	**Frequency**	**Percent**	**Frequency**	**Percent**
Male	169	56.3	71	71
Female	131	43.7	29	29
Total	**300**	**100**	**100**	**100**
Marital Status	**Frequency**	**Percent**	**Frequency**	**Percent**
Single	21	7	7	7
Married	216	72	86	86
Divorced	5	1.7	-	-
Widow	58	19.3	7	7
Total	**300**	**100**	**100**	**100**
Education Level	**Frequency**	**Percent**	**Frequency**	**Percent**
None	68	22.7	5	5
Primary	201	67	60	60
Secondary	29	9.7	27	27
University	2	0.6	8	8
Total	**300**	**100**	**100**	**100**
Land Size in ha	**N**	**Mean ± SD**	**N**	**Mean ± SD**
	300	1.31±1.46	100	2.02±1.72

results may also suggest that dairy cattle farming can support a larger family size. The majority of dairy cattle farmers (both beneficiaries and non-beneficiaries) were below 53 years of age (over 50% being 36-53 years). The proportion of farmers below 35 years for both categories was about 17%, an indicator that the young population has not taken up the practice.

Of the respondents, 56.3% were males and 43.7% females within beneficiaries and 71% males and 29% females within non-beneficiaries. The higher proportion of males for both categories is explained by the fact that most households are male headed in Rwanda (NISR, 2012a). Majority of the respondents were married; 72% (beneficiaries) and 86% (non-beneficiaries), widows were 19.3% (beneficiaries) and 7% (non-beneficiaries). The higher proportion of female headed households and widows amongst beneficiaries is explained by the fact that the "One cow program" targets poor and vulnerable families. A high prevalence of female household heads that are widowed is a common feature in Rwanda as they do not generally remarry (NISR, 2012a).

Among the beneficiaries; 67% had attained primary education while 22.7% had no formal education. The respective rates for the non-beneficiaries were 60 and 5%. Only a small proportion of 0.6 and 8% had attained university education of the beneficiaries and non-beneficiaries respectively. The higher proportion of respondents with lower levels of formal education for the beneficiaries was expected as the targeted group was mostly of the poor who constitute the majority of the non-educated and/or with low levels of education in Rwanda (NISR, 2015). Education has a positive impact on technology adoption (Uematsu and Mishra, 2010). With a higher level of formal education, dairy farmers may thus be expected to be more receptive to information dissemination yielding positive results in terms of better management and improved productivity.

The average land size was 1.31±1.46 and 2.02±1.72 ha for beneficiaries and non-beneficiaries respectively. The average land holding per household for both categories of farmers was higher than the national average of 0.7ha per household (Ayalew *et al*., 2015). Land was primarily used for crops and growing livestock feed.

Milk Yield per Day

The mean milk yield per day was 5.80±2.89 and 7.7±3.02 litres for cows belonging to beneficiaries and non-beneficiaries respectively. There was a significant difference in observed mean milk yields for beneficiaries (P =0.000) and for non-beneficiaries (P = 0.805). Most of beneficiaries (55.8%) milked between 1-5 l/d while 60% of non-beneficiaries milked between 6-10 l/d (Table 2). Differences in milk yields of cows owned by beneficiaries and non-beneficiaries may be linked to variations in the management practices such as; feeding and disease control between the 2 groups. Respondents did not keep records and relied on milk sales data and recall which may result in under-estimating yields.

Additionally, majority of farmers milked the animals with the calf at foot (Table 3) and the reported yields would ignore the milk consumed by the calf. The higher milk yields reported by non-beneficiaries could be explained by the fact that they managed their animals better including providing concentrates supplementation (Table 4). It would also be expected that since non-

Table 2: Estimated Milk Yields in the Study Farms

	N	Mean±SD	SEM	*P* value
Beneficiaries	278	5.80±2.89	0.1734	0
Non-Beneficiaries	100	7.68±3.02	0.31236	0.805
	Beneficiaries		**Non-Beneficiaries**	
Milk (l/day)	**Frequency**	**Percent**	**Frequency**	**Percent**
1 – 5	155	55.8	26	26
6 – 10	105	37.8	60	60
11 – 15	18	6.4	14	14
Total	**278**	**100**	**100**	**100**

beneficiaries had invested more, they are likely to have made a conscious decision to spend more on cows and would manage them better than the beneficiaries.

The observed mean yields were similar to 5.1 and 7.8 l/d reported by Kamanzi and Mapiye (2012) for Friesian crossbreeds kept in Southern and Central Plateau of Gisagara District in

Table 3: Calf Management

	Beneficiaries		**Non-Beneficiaries**	
Calf Ffeeding Methods	**Frequency**	**Percent**	**Frequency**	**Percent**
Suckling	287	100	92	92
Bucket fed	-	-	8	8
Total	**287**	**100**	**100**	**100**
Calf Mortality	**Frequency**	**Percent**	**Frequency**	**Percent**
No	257	85.7	76	76
Yes	43	14.3	24	24
Total	**300**	**100**	**100**	**100**
Weaning Age (in Month)	**Frequency**	**Percent**	**Frequency**	**Percent**
3	10	3.6	3	3
4	56	19.9	22	22.2
5	39	13.9	14	14.1
6	115	40.8	37	37.5
7	29	10.3	12	12.1
≥8	32	11.5	11	11.1
Total	**281**	**100**	**99**	**100**

Table 4: Nutrition and Feeding of Dairy Cows in the Study Area

Feed Source	**Frequency**	**Percent**	**Frequency**	**Percent**
Napier grass only	46	15.3	13	13
Napier grass and crop by products+	216	72	57	57
Napier grass, crop by products and concentrates*	38	12.7	30	30
Total	**300**	**100**	**100**	**100**
Use of Mineral Supplements	**Frequency**	**Percent**	**Frequency**	**Percent**
No	19	6.3	7	7
Yes	281	93.7	93	93
Total	**300**	**100**	**100**	**100**
Types of Minerals Supplements Used	**Frequency**	**Percent**	**Frequency**	**Percent**
Rock salt *"Gikukuri"*	222	79	64	68.8
Commercial licking block	42	14.9	27	29
Table salt	17	6.1	2	2.2
Total	**281**	**100**	**93**	**100**
Water availability	**Frequency**	**Percent**	**Frequency**	**Percent**
Occasional	42	14	13	13
Ad lib	258	86	87	87
Total	**300**	**100**	**100**	**100**
Water Source	**N**	**Mean ± SD**	**N**	**Mean ± SD**
	300	1.78±2.01	100	1.5±1.90

Note: +Crop by-products (Maize stover, bean haulms and banana leaves/pseudo-stems); *Concentrates (maize bran, soybean meal, sunflower cake and mineral mixes).

Rwanda, respectively. However, the yields in the current study were lower than the 16-22 l/d average milk yield for Friesian crossbreeds in Rwanda reported by Kabera *et al*. (2016). From the yields reported in the current study, the dairy cows were producing below their potential, mainly due to feed availability and feeding practices. Over 70% (beneficiaries) and 55% (non-beneficiaries) reported that cows were fed on Napier grass and crop by products with only 12.7% for beneficiaries and 30% non-beneficiaries providing concentrate supplements (Table 4). Feeds quantities may also have been inadequate due to limited land size. In the study area, farmers owned small land parcels of 1.31±1.46 ha for beneficiaries and 2.02±1.72 ha for non-beneficiaries (Table 1) which were used to grow food crops and livestock fodder. None

of the respondents conserved feeds to mitigate against the reported periods of feeds inadequacy which would lead to seasonal fluctuations in amounts of milk produced affecting the overall animal performance. Mean daily milk yield is also affected by stage of lactation. However, the information on the exact lactation stage at the time of data collection was not available at farm level. There is a need for both groups of farmers to improve feeding of the dairy cattle in order to increase daily milk yield.

Lactation Length

The average lactation lengths were similar at 9.4±1.9 for beneficiaries and 10.3±1.6 months for non-beneficiaries' cows (Table 5). The *P* values were 0.061 for beneficiaries and 0.716 for non-beneficiaries indicating that lactation lengths between cows owned by beneficiaries and those of non-beneficiaries are not significantly different (P>0.05). The standard lactation length that would allow a dry period of 60 days for a calving interval of 365 days is 305 days (10 months). Mwabonimana *et al*. (2015) reported an average lactation length of 245 days (8 months) for crossbred cows in Musanze and Nyabihu Districts, Rwanda. However, the current lactation lengths were shorter than the 375-402 days reported by Amasaib *et al*. (2008) for Friesian crossbreds in Sudan.

The observed lactation lengths were closer to the standard lactation of 10 months and with the dry period of 2 months; the cows would have had a calving interval of one year. However, from the present study calving intervals were 18 and 14 months for beneficiaries and non-beneficiaries respectively (Table 6). This may be attributed to longer dry periods which could have been caused by poor nutrition and/or reproductive problems in the study area.

Number of Services per Conception

Of the beneficiaries' farms, 57.3% of cows conceived at first service compared to 58.6% for non-beneficiaries. By the second service 76.4 and 85.9% of cows conceived on beneficiaries and non-beneficiaries' farms respectively (Table 7). The slightly higher conception rates observed for non-beneficiaries' farms could be attributed to differences in the level of education (non-beneficiaries were more educated than beneficiaries Table 1) and these farmers were expected to be better at heat detection and AI timing leading to successful conception rates

Table 5: Lactation Length of Cows among Respondents (in Months)

	N	Mean	SD	SEM	Min	Max	*P* value
Beneficiaries	272	9.42[a]	1.95	0.12	7	16	0.061
Non-Beneficiaries	96	10.38[a]	1.62	0.17	8	14	0.716

Note: [a] Means with no/similar superscript within a row are not significantly different (P>0.05).

Table 6: Calving Interval (CI) (in Months)

	N	Mean	SD	SEM	Min	Max	*P* value
Beneficiaries	227	18.3	4.553	0.307	12	37	0.919
Non-Beneficiaries	95	14.34	2.726	0.289	12	24	0.604

Note: [a] Means with no/similar superscript within a row are not significantly different (P>0.05).

Table 7: Number of Services per Conception

Number of Services	Beneficiaries (n=241)	Non-Beneficiaries (n=99)
	% of Respondents	
1	57.3	58.6
2	19.1	27.3
3	14.5	10.1
4	9.1	4
Total	**100**	**100**

with fewer services. Additionally, the non-beneficiaries fed their cows better compared to beneficiaries (Table 8). Nutrition has been reported as an important factor of animal fertility and conception (Santos, 2008; and Tesfaye *et al*., 2015).

These results are similar with those by Kabera *et al*. (2016) and Semfuko (2013) who reported that the conception rate at first service was over 50% and 56% for Friesian crosses and Friesian/Ayrshire crosses in Kigali peri-urban and in Temeke Municipality, respectively.

Age at First Calving (AFC)

The mean ages at first calvings were similar at 31.6±3.9 and 30.8±3.2 months for heifers belonging to beneficiaries and non-beneficiaries respectively (Table 8). There was no difference in mean AFC for beneficiaries (P = 0.098) and for non-beneficiaries (*P* = 0.0622). The recommended age at first calving for dairy cows is 24 months (Nilforooshan and Edriss, 2004). Non-beneficiaries being more educated were expected to better understand the benefits of an early age at first calving and taken measures to control factors affecting age at first calving such as nutrition and health of heifers than beneficiaries. The advantages of an early age at first calving include reduced rearing costs and a higher productivity per year of herd life (Ettema and Santos, 2004).

The prolonged AFC observed in the current study could partly be attributed to the inaccuracy of recall information during data collection. Failure to conceive and/or low conception rates at first service below 60% (Table 7) could also have led to an extended AFC. Other factors that could delay the AFC are late age at first service and poor calf/heifer management (Gãvan *et al*., 2014).

The observed mean AFC for both beneficiaries and non-beneficiaries were higher than 28.16 and 29.7 months reported by Wanjala and Njehia (2014) and Mugisha *et al*. (2014) for dairy cows under smallholder farms in western Kenya and central Uganda respectively but similar to 31.3 months reported by Mazimpaka (2017) for cross breed cows in Nyagatare, Eastern Rwanda.

In order to reduce AFC observed in the present study, it is necessary to improve calf/ heifer nutrition through the provision of enough and consistent amount of milk to calves before

Table 8: Age at First Calving (AFC) (in Months)

	N	Mean	SD	SEM	Min	Max	*P* value
Beneficiaries	238	31.60[a]	3.989	0.262	26	46	0.098
Non-Beneficiaries	99	30.81[a]	3.275	0.34	27	40	0.622

Note: [a] Means with no/similar superscript within a row are not significantly different (P>0.05).

weaning as well as adequate quality forage and concentrate feeds to ensure good heifer growth.

Calving Interval (CI)

The mean CI was longer at 18.3±4.5 months on beneficiaries' farms compared to 14.3±2.7 months for non-beneficiaries (Table 6). However, no significant difference in CI observed for cows belonging to beneficiaries (P = 0.919) with those of non-beneficiaries (P = 0.604). To attain the target of a calf per breeding cow per year, the ideal calving interval is 12 months. A short calving interval will translate to more calves per cow lifetime and higher average milk yield per day (Kollalpitiya *et al*., 2012).

The long CIs in this study could be attributed to dry periods longer than the ideal of 60days, because lactation lengths were similar to the 305days standard (Table 5). Long dry periods extend the calving interval beyond the normal 13-14 month interval and cause a decrease in lifetime productivity of the dairy cow (M'hamdi *et al*., 2012).

The most important factor affecting CI is the length of days open (Hammoud *et al*., 2002) which is affected by nutrition, reproductive and health management of a dairy cow. Long calving interval in the current study could also be attributed to poor heat detection, semen quality and skills of AI technician and to the reproductive diseases. In order to achieve the average CI of 365 days, the length of days open should be no longer than 90 days which requires that nutrition status of the cow is improved and that it is bred as soon as possible after calving (Gietema, 2005).

The observed CIs in the current study were higher than the 11-13 months reported by Kabera *et al*. (2016) from a similar study in Rwanda but for non-beneficiary farmers this was similar to 445 days (15 months) reported for Holstein Friesian cows in Ethiopia (Tadesse *et al*., 2010). However, for both groups of farmers the CIs observed were shorter than 21.3 months reported by Duguma *et al*. (2012) from another study in Ethiopia for crossbred (Zebu x Holstein-Friesian).

Nutrition and Feeding

Types of feed resources, mineral supplements and water availability is shown in Table 4. The feeding of cattle was largely based on Napier grass and crop by-products. The Napier grass was either home grown, exchanged with other farmers for manure or purchased.

Of the respondents, 72 and 57% of beneficiaries and non-beneficiaries respectively used Napier and crop by products to feed their cows whereas 12.7% (beneficiaries) and 30% (non-beneficiaries) provided concentrates alongside forage. More concentrates were used by non-beneficiaries and suggests that they understood the benefits of supplement than the beneficiaries. These non-beneficiaries may also have been more commercially oriented and financially able to afford the supplementary feeds. The feedstuffs used for supplementation included maize bran, soybean meal, sunflower cake and mineral mixes. Depending on available feedstuffs farmers mixed these in various proportions and many offered the maize bran alone, a common practice to some of dairy farmers in Kenya (Lukuyu *et al*., 2007). Mixed concentrates were relatively expensive (>300 Frw/kg or 0.35US$) compared to milk price (170 Frw per litre or 0.20US$) and were therefore fed in relatively small amounts as most of farmers were unable to purchase them.

The feed types availed to the animals in the study area suggest inadequacy of nutrients necessary for high milk production and may explain the lower than potential milk yields reported by the farmers (Table 2). Kitalyi *et al*. (2005) stated that high yielding dairy animals will not produce optimum milk if they are not offered feeds of the right quality in the right quantities at the appropriate time during all stages of growth, production and maturity. These observations are in agreement with Kamanzi and Mapiye, (2012), Klapwijk *et al*. (2014) and Mutimura *et al*. (2015) who reported that major types of feed resources available in Rwanda; are pasture or grasses, crop residues, improved fodder, roadside grasses and nonconventional feeds like leaves of banana plants and kitchen leftovers.

The majority of the famers (over 93%) gave mineral licks to their cows while water was available *ad libitum* on most farms. Occasional provision of water was due to the long distance between farms and water sources (1.78 and 1.5 km for beneficiaries and non-beneficiaries respectively). About 79% (beneficiaries) and 68.8% (non-beneficiaries) provided mineral supplement in the form of *'Gikukuri'* a local rock block of salt, most probably due to ease of availability and low price (300 Frw/kg or 0.35US$) compared to commercial mineral blocks (1000 Frw/kg or 1.17US$). Musoni *et al*. (2013), also reported that 81.5% dairy cattle farmers in southern province of Rwanda used rock blocks (*Gikukuri*) because of high market price of commercial mineral licks.

Calf Management

Calf feeding methods, calf mortality and weaning age of the calves owned by beneficiaries and non-beneficiaries is shown in Table 3. Most of the respondents suckled the calves except 8% of non-beneficiaries who bucket fed theirs. Suckling of calves appeared to improve calf survival as mortality was lower for beneficiaries, all of whom suckled the calves. This is because suckling ensures calves get colostrum (antibodies) and clean non-contaminated milk from the udder increasing their survival. However, suckling the calves at milking would lead to difficulties of establishing cow milk yield since the amounts consumed by the calf would be overlooked. This may partly explain the lower daily milk yields reported on beneficiaries' farms (Table 2).

The calf mortality reported in this study was 14.3 and 24% for beneficiaries' and non-beneficiaries' farms respectively. The difference of about 10% in mortality rates would reflect differences in calf management between two categories of farmers. Low mortality rate for calves owned by beneficiaries was critical for the success of the "One cow program" and could also be attributed to the regular follow up done by government staffs to ensure that cows given to beneficiaries are always in good health.

Majority of the farmers, 78.2 (beneficiaries) and 76.8% (non-beneficiaries) weaned their calves at between 3 and 6 months of age. Criteria for weaning calves are varied. Generally, calf weaning in the region is done when calves are 3 to 4 months old, at which age they are expected to be double their birth weights (Lukuyu *et al*., 2012). In Rwanda, the average weaning age is 3.8 months (Hirwa *et al*., 2017). Possible reasons to delayed weaning time in the current study, could be the fact that, beneficiaries of "One cow program" have to wean calves when they are at least 6 months of age and pass them to other benefiting farmers (MINAGRI, 2016). Calves were suckled during milking to stimulate

milk let down. This could also be the reason calves were kept for long before weaning them.

CONCLUSION AND RECOMMENDATION

The performance (both productive and reproductive) of cows in Gicumbi District was below the genetic potential of the breeds kept due to inadequate nutrition and lack of fertility management skills. Poor record keeping was also another challenge of the current study.

In order to improve performance of dairy cattle in study area, there is a need for interventions in areas of nutrition, feeding and breeding management of a dairy cow. It is also necessary to train farmers about importance of records and records keeping to facilitate more accurate future production assessment.

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