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Artificial Insemination in Nyagatare District: Level of Adoption and the Factors determining its Adoption

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ABSTRACT

This study was undertaken to characterize and to estimate the level of adoption of artificial insemination (AI) as well as to identify factors determining its adoption by communal farmers of Nyagatare, Rwanda. This followed the launching of the official Government AI programme in the district several years earlier. A questionnaire was used to carry out a survey of the breeding methods used for small scale dairy cows by farmers from five selected sectors of Nyagatare district of the Eastern Province of Rwanda. Of the 360 respondents, 16.9% primarily used AI, 63.1% used natural service and 20.0% used both methods for breeding. A significant percentage of respondents residing within 5km of the AI centres (79.2%; P<0.05) adopted AI whilst a significant percentage of respondents residing more than 15km from AI centres (92.5%; P<0.05) preferred natural service. A significant percentage of respondents from big families with 6-7 members were using AI (54.1%; P<0.05), whilst all the respondents from small families with up to 3 members opted for natural service (100% P<0.05). A significant percentage of respondents with secondary education (76.9%; P<0.05) opted for AI whilst a significant percentage of respondents with no formal education (98.5%; P < 0.05) opted for natural service alone. A significant percentage of respondents working in both agriculture and animal husbandry (93.1%; P<0.05) opted for AI whilst a significant percentage of respondents working in crop production and other none animal husbandry related sectors (93.2%; P<0.05) opted for natural service alone. Land size in excess of 5 hectares did not significantly influence adoption of AI. The study showed that there were several underlying factors that had the potential to influence farmers' choice of breeding methods. Chief among these factors are level of education of farmer, family size, distance to AI station and occupation in agriculture or animal husbandry.

1. INTRODUCTION

Rwanda is the most densely populated African country with 415 inhabitants per km^2 and around 60% of the households living on land holdings of less than 0.5ha (Abbott et al., 2015). With a population growth rate of 3% per annum, there is considerable pressure on agricultural land as family farms are continuously divided into increasingly smaller plots (Westoff, 2013; Abbott et al., 2015). The livestock sector which provides employment at family and village level uses the agro-pastoral production system contributing 40% to agricultural GDP and around 8% of Rwanda's total GDP (Ntanyoma, 2010; Karenzi et al., 2013; Malyon, 2014; Nishimwe et al., 2015). From 2008 to 2015 milk and meat production have significantly increased; however, it has not yet reached levels required to satisfy both local, regional and/or international markets (Abbott et al., 2015).

The major challenge faced by the livestock sector and the dairy sub-sector, in particular, is to satisfy the rise in general demand for livestock products using technology at a level that the natural resource base can sustain without destroying the environment (Roe, 2009; Amede et al., 2011). Other challenges include spread of reproductive diseases, poor conception rates, 'social' problems arising from ‘sharing’ bulls, lack of control over quality of progeny, poor feed quality, feed insufficiency, poor financial resources, insufficient veterinary support and poor dairy breed performance (Roe, 2009; Amede et al., 2011; Gahakwa et al., 2014). The implementation of AI using good quality semen from exotic bulls of reputable pedigree was initiated in Rwanda in the 1960’s but has only been recently made widespread.

Several authors agree that small holder dairy farming is an important agricultural sector providing livelihoods to a big proportion of the community and producing the bulk of milk in many developing countries (Howley et al., 2012; Martinez-Garcia et al., 2015; Rathod et al., 2017). In Rwanda, the smallholder dairy sector provides a unique development strategy as a source of livelihood through providing income, home consumption, manure and as a reserve for cash for investment (Lukuyu et al., 2009).

It is well known that AI is the quickest reliable way of disseminating advances in genetic resources undertaken in different parts of the world for the benefit of mankind (Howley et al., 2012; Mugisha et al., 2014; Galina et al., 2016). Advantages of AI include genetic improvement of milk production, control of venereal and other diseases, reduction in lethal genes, simplicity and low cost (Howley et al., 2012). Other advantages include increased breeding frequency, improved conception rates thus reducing the incidence of repeat breeders. In light of the foregoing, one would naturally expect every farmer to have, by now, gone high-tech and adopted AI as a method of breeding. Although many farmers are aware of the advantages of AI and would prefer to use the technology, studies from Africa reveal that few farmers actually use AI (Teferal, 2013; Mugisha et al., 2014; Tebug et al., 2014). Thus the technology is poorly adopted in Africa as well as in other regions of the world (Howley et al., 2012; Sanjabi and Javanmardi, 2014; Martinez-Garcia et al., 2015). According to Rhinehart and Thompson (2016) AI remains underutilised in the world.

The factors that affect adoption of precision agricultural technologies (Tey and Brindal, 2012) and, in particular, AI are many and varied and can be divided into demographic, socio-economic and location factors (Tebug et al., 2014). Simply stated there are farm and farmer factors influencing the adoption of AI (Howley et al., 2012). Factors affecting AI adoption may also be separated into fixed and modifiable factors (Galina et al., 2016). AI adoption is influenced by education level of the farmer, age of farmer, gender of the famer, ethnicity, family size, experience with farming, contact with extension personnel, membership of dairy cooperatives, access to credit, on-farm and off farm income, availability of labour, availability of feed and water and distance to veterinary institution (Mugisha et al., 2014; Martinez-Garcia et al., 2015; Galina et al., 2016; Rathod et al., 2017).

In order to support and accelerate increased productivity within the smallholder dairy sector, the Rwandan government established AI centres in sectors within districts run by state veterinarians and AI-trained Animal Health Workers (Paul et al., 2017). The efficiency of the AI programs established in Rwanda and the level of its adoption by farmers, to the best of our knowledge, has not been evaluated and reported on in scientific studies. However, empirical evidence from informal discussions with AI service providers suggests that the adoption of this technology is actually declining. AI technology aims to improve the breed of dairy cows and thus level of milk production without the extra spatial, veterinary and financial pressures of rearing and keeping bulls on land already under huge demographic pressure. The objective of this study was to determine the level of adoption of AI and to identify the major socio-economic factors affecting farmers’ choices in adopting AI or natural service in their small scale dairy enterprises. In addition, this study also aimed to identify the various breeding practices in Rwanda by sampling sectors in Nyagatare district in the Eastern Province.

2. MATERIALS METHODS

2.1. Study area

The study was conducted in Nyagatare, one of the seven districts of the Eastern Province of Rwanda. The district is located between1°18'0.00"S and 30°19'30.00"E. The average altitude is at 1400 m above sea level and receives annual rainfall of 827 mm. The annual average temperature ranges between 25.3 and 27.7°C. Nyagatare district has the highest number of cattle in Rwanda (Abbot et al., 2015). The District of Nyagatare consists of gently sloping hills separated by low granite valleys. The vegetation type is largely savannah and some gallery forestry. The semi-intensive farming method is the most practiced in the district since land size is small.

2.2. Sample size and sampling technique

A total of 360 small scale dairy farmers were purposively selected from 5175 farmers. The sample size was calculated according to Krejcie and Morgan's table as described by Krejcie and Morgan (1970). The purposive sampling technique was used to select sub-locations where smallholder dairy farmers were more clustered and areas where natural service and AI services were practiced. Non-proportional sampling was employed within the sub-locations.

2.3. Data collection

Self-administered structured questionnaires were used to collect primary data from the sample units. Ethical considerations were taken into account when designing the questionnaire.

Information gathered by the questionnaire included among others; land holding size, demographic data (personal information, gender, age, occupation family size, educational level, herd size), type of breeding (natural or AI) reason for adoption of a particular service system, distance from the nearest AI centre, way of accessing the nearest AI centre, sire breeds used, identity of inseminating personnel, methods and time of heat detection and number of inseminations per conception.

2.4. Statistical analysis

Quantitative data was analysed using SPSS version 21 (IBM, 2010). Descriptive statistics and Z test for comparison of two or more proportions was used and a p-value <0.05 was considered significant. Content analysis was used to analyse open-ended questionnaires i.e. qualitative data.

3. RESULTS

Table 1: Effect of land size on farmer' choice of AI or natural service

Land size	Total number of farmers	Number using AI	Proportion using AI (%)	Number using natural service	Proportion using natural service (%)
No land	11	4	36.4 [a]	7	63.6 [b]
< 2 hectares	191	79	41.4 [a]	112	58.6 [b]
2 – 5 hectares	126	36	28.6 [a]	90	71.4 [a]
> 5 hectares	32	14	43.8 [a]	18	56.3 [b]
Total	**360**	**133**	**-**	**227**	**-**

[ab]Values within a row which share a common superscript are significantly different (P<0.05)

Statistical analysis using the Z test showed that land size up to 2 hectares and over 5 hectares was not a significant factor for choice of AI or natural service (P>0.05). Except for respondents with no land, choice of AI increased with an increase in land size (P<0.05). More respondents owning land between 2-5 hectares in size significantly chose natural service over AI (P<0.05).

Table 2: Effect of distance from AI centre on farmers' choice of AI or natural service

Distance from AI centre (km)	Total number of farmers	Number using AI	Proportion (%)	Number using natural service	Proportion (%)
<5	120	95	79.2 [a]	25	20.8 [a]
5 to 10	67	24	35.8 [a]	43	64.2 [b]
10 to 15	65	11	16.9 [a]	54	83.1 [a]
>15	108	3	2.8 [a]	105	92.5 [a]
Total	**360**	**133**	**-**	**227**	**-**

[ab]Values within a row which share a common superscript are significantly different (P<0.05)

Statistical analysis showed that respondents located within 5km of AI centres significantly chose AI over natural service (P<0.05). There was no significant difference in the choices made by respondents located 5-10km from AI centres (P>0.05). Respondents located more than 10km from AI centres significantly chose natural service over AI (P<0.05).

Table 3: Effect of family size on adoption of AI

Family size	Total number of farmers	Number using AI	Proportion using AI (%)	Number using natural service	Proportion using natural service (%)
Up to 3	90	0	0.0 [a]	90	100 [a]
4 to 5	133	50	37.6 [a]	83	62.4 [b]
6 to 7	115	72	62.6 [a]	43	37.4 [a]

>7	22	11	50.0 [a]	11	50.0 [b]
Total	**360**	**133**	**-**	**227**	**-**

[ab]Values within a row which share a common superscript are significantly different (P<0.05).

Statistical analysis showed that respondents with up to 3 members per family significantly chose natural service over AI (P<0.05). There was no significant difference in the choices over AI/natural service made by recipients from families with 4-5 members and those with over 7 members (P>0.05). Respondents whose families had 6-7 members significantly chose AI over natural service (P<0.05). Choice of AI increased with an increase in family size up to a seven-member family.

Table 4: Level of education effects on choice of service method

Educational Qualification	Total number of farmers	Number adopting AI	Proportion using AI (%)	Natural service	Proportion using natural service (%)
None	134	2	1.5 [a]	132	98.5 [a]
Primary	96	24	25.0 [a]	72	75.0 [a]
Secondary	122	105	76.9 [a]	17	13.9 [a]
Tertiary	8	2	25.0 [a]	6	75.0 [b]
Total	**360**	**133**	**-**	**227**	**-**

[ab]Values within a row which share a common superscript are significantly different (P<0.05).

Statistical analysis showed that respondents with no education and primary education significantly chose natural service over AI (P<0.05). Respondents with secondary education significantly chose AI over natural service (P<0.05). There was no significant difference in the choice of AI/natural service by respondents with tertiary education (P>0.05). Adoption of AI increased with an increase in the level of education.

Table 5: Farmers using AI or natural service according to main occupation

Occupation	Total number of farmers	Number using AI	Proportion using AI (%)	Number using natural service	Proportion using natural service (%)
Agric	75	24	32.0 [a]	51	68.0 [b]
Anihus	80	34	42.5 [a]	46	57.5 [b]
Agric/anihus	58	54	93.1 [a]	4	6.9 [a]
Agric/other	118	8	6.8 [a]	110	93.2 [a]
Anihus/other	29	13	44.8 [a]	16	55.2 [b]
Total	**360**	**133**	**-**	**227**	**-**

Agric = Agriculture (crop production); Anihus = animal husbandry

[ab]Values within a row which share a common superscript are significantly different (P<0.05)

Statistical analysis showed that respondents employed in both agriculture and animal husbandry significantly chose AI over natural service (P<0.05). There was no significant difference in the choice of AI/natural service in respondents employed in either agriculture only or animal husbandry only (P>0.05). Respondents employed in both agriculture and another sector (other than animal husbandry) significantly chose natural service over AI (P<0.05). There was no significant difference in the choice of AI/natural service by respondents employed in both animal husbandry and another sector other than animal husbandry (P>0.05).

4. DISCUSSION

The survey on the five sectors of Nyagatare district revealed that the overall level of adoption of AI was 36.9%. These results were similar to the 36.1% AI adoption level reported by Kaaya et al. (2008) in Uganda. The figure is much higher than the 2.5% reported by Sanjabi and Javanmardi (2014) in India and, at the same time, much lower than the 54 % reported by Devi (2013) from the same country. Howley et al. (2012) reported an adoption level of more than 80% on a specialised dairy farm, more than 60% on a mixed dairy farm and about 30% on beef cattle farms in Ireland and Elliott et al. (2013), reported a less than 10% adoption in beef cattle in the US. From the foregoing discussion, it can be concluded that AI is adopted better in developed countries than in developing countries. In addition, literature also shows that AI is also better adopted on specialized dairy farms than on less specialized dairy farms and beef cattle in that order. The adoption level of 36.9% is actually a fair level for a developing country with only a small holder dairy enterprise. The notion from AI practitioners that AI adoption in Rwanda is decreasing cannot be arrived at without previous hard data to compare with the present situation. Our findings therefore provide the baseline information for future studies

In the current study, land size over 5 hectares did not have a significant (P>0.05) effect on AI adoption. These findings are in agreement with the conclusions from some studies (Rezvanfar, 2007) which did not show any significant relationship with overall adoption behaviour of AI on dairy farms. Some authors, however, reported a negative correlation between farm size and level of adoption of AI (Murage and Ilatsia, 2011; Devi, 2013). According to Murage and Ilatsia (2011), farmers with smaller hectares tend to adopt AI more as they do not have extra space on which to raise bulls. It is therefore reasonable to find out that farmers in Nyagatare to have adopted IA to the level shown by our results. However, the results contradict the findings other studies which reported a positive correlation between AI adoption and farm size (Martinez-Garcia et al., 2015) adoption of AI.

The study shows that AI adoption by small scale farmers was greatly influenced by accessibility of AI centres, i.e. most farmers within walking distance adopted AI, whereas those more than 15km away from AI centres preferred natural service. This could be possibly because of the costs involved in the movement of personnel and equipment for the AI procedure. Similar observations were also reported by other scholars (Teferal, 2013; Tebug et al., 2014; Galina et al., 2016; Rathod et al., 2017). Distance was related to increase in costs, which is essentially a hindrance for farmers to use AI.

Most of the farmers with 6 to 7 family members showed a significant preference to AI whereas those with small families (up to 3 members) and those with very large families (with over 7 members) preferred to use natural service for breeding ($p < 0.05$). Our results are consistent with those of some workers (Howley et al., 2012; Dehinenet et al., 2014; Galina et al., 2016) who reported a positive relationship between family size and AI adoption. The results, however, contradict with other reports (Teferal, 2013) who reported that family size was negatively correlated with AI adoption. According to Galina et al. (2016) AI is a labour intensive activity and hence larger families tend to adopt it. Thus small families possibly used natural service due to unavailability of manpower to escort animals to AI centres for insemination.

Education level had a profound effect on the choice of type of service by the farmers. Farmers from families where at least one member had attained secondary education opted for AI. This may possibly be due to the fact that these individuals are better equipped to understand the technical information provided by the extension workers on the practical aspects and advantages of using AI in dairy farming. About 62.8% (226/360) of respondents had some form of formal education and of these 54 % claimed to have attained secondary education. The lack of formal education in other farmers obviously resulted in their ignorance of the benefits and ease of AI resulting in them showing apathy towards AI. Results from this study agree with those of several workers who reported that education level positively influenced the adoption of AI (Howley et al., 2012; Tey and Brindal, 2012; Devi, 2013; Martinez-Garcia et al., 2015; Rathod et al., 2017). However, other authors found no relationship between the level of education and the probability of adopting AI (Mugisha et al., 2014; Tebug et al., 2014). This implies that secondary and tertiary-educated farmers are able to recognize the importance of AI in improving dairy farming unlike when the illiteracy level was high.

When questioned on their reasons for adopting AI, the survey revealed that most of the farmers who chose AI did so for the right reasons (use of good breeds, increased milk production, ease of practice) rather than for the lack of male breeding animals. It was noted however, that very few farmers appreciated the range of advantages that come with use of AI (shortening of calving interval and thus increase in reproductive efficiency of dairy cows and eradication of reproductive diseases). The farmers that opted for natural service possibly did so because they owned a bull or they had access to a neighbour's bull. Due to the extensive grazing forms of animal husbandry, some farmers left the service of their cows unsupervised out on pastures.

The occupation of family members was shown to have a significant effect on the decision by farmers in adopting AI or natural service. The study showed that families with members working in both the agriculture and animal husbandry sectors opted for AI possibly due to increased exposure and thus awareness to AI information. Families with members working primarily in the agriculture sector and other sectors (other than animal husbandry) had the least interest in adopting AI possibly due to lack of exposure to information on the advantages of AI. It was also possible that these same farmers were deeply involved in other innovative technologies in their relevant sector of employment to find time or resources to adequately consider adopting AI. (Ghosh et al., 2005) reported a similar trend in the effect of occupation on the behaviour of smallholder dairy farmers in the adoption of AI.

The survey further revealed that though the principal heat detectors were personnel with no obvious formal training in the practice, their proficiency of heat detection did not significantly differ from that of formally trained personnel. The signs of oestrus and the time of detection were correct and reliable. Further queries revealed that an unusually high number of animals had to be returned for service (unquantified), citing possible technical problems encountered during inseminations. The fact that most of the inseminations (63%) were performed by AI-trained animal health workers who were not veterinarians may be responsible for such failures of AI. AI-trained animal health workers possible had insufficient experience unless they had been attached to an AI centre handling high volumes of inseminations. These personnel may have lacked the full knowledge of how semen is handled prior to inseminations leading to the use of damaged semen (Ballester et al., 2007).

Of grave concern to the researchers in this study was an apparent lack of regard for veterinary diagnosis of pregnancies in dairy cows. Only one respondent cited the engagement of a veterinarian for pregnancy diagnosis. Pregnancy diagnosis is a practice that compliments and assures the success of AI. Possible reasons for the absence of veterinary engagement in pregnancy diagnosis may be the scarcity of veterinary personnel at village level, difficulty in getting a veterinarian to leave the office, lack of financial resources for acquiring such services and the obvious difficulty of organising personnel and time to escort animals to the AI centre for pregnancy diagnosis.

5. CONCLUSION

This study has shown that the level of adoption of AI for breeding cows in smallholder dairy farming systems in Nyagatare district of Eastern Rwanda is 36.9%. This figure is quite high for a developing country. The study has also shown that there are several underlying factors that have the potential to influence farmers' choice of breeding methods. Chief among these factors are level of education of farmer, family size, distance to AI station and occupation in agriculture or animal husbandry. Some of these factors may be mitigated to improve on service access and delivery to rural farmers if their nature is studied in more detail.

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