FARM-LEVEL FACTORS AFFECTING DAIRY GOAT ARTIFICIAL INSEMINATION IN KENYA

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ABSTRACT

Goats are considered climate smart livestock due to their adaptive nature to adverse climatic conditions. They also play a critical role in the economy of most rural communities in Africa. In Kenya there are about 15 million goats out of which about 400,000 are dairy goats. Goat farming system is faced with a myriad of problems, including uncontrolled breeding methods, feeding mainly based on browsing thus unbalanced, and low uptake of reproductive technologies. This study was carried out to determine factors affecting the uptake of goat artificial insemination in Kenya. A baseline survey was carried out in 200 goat rearing households in Mukurwe-ini sub-County in Nyeri County using a structured questionnaire. Data was stored in MS Excel and analyzed using R software version 4.03. Both descriptive statistics (frequencies and percentages) and Pearson chi-square test were used. Results show that a majority (98%) of farmers used natural mating. Farmers were willing to pay for artificial insemination services at ($P<0.05$), but 71.4% though willing to pay, still perceived artificial insemination as expensive. It is recommended that the government should subsidize artificial insemination services.

Key words: Natural breeding, cost, benefits, challenges

INTRODUCTION

The livestock sector in developing countries account for more than one third of the global Agricultural gross domestic product (GDP). This sector employs more than one billion people world over with 60% being rural households (Ingabire *et al*., 2018). In Kenya, goats form an essential component in the livestock sector (Ndeke *et al.*, 2011) due to its contribution to the production systems of livestock (Kikwatha *et al*., 2020a). The use of technologies in the livestock sector enhances productivity, reduces threats of diseases and ensures environmental sustainability in productive areas (Ingabire *et al.*, 2018)

The world goat population is close to one billion (FAO, 2021) with over 90% found in developing countries, Asia having the highest followed by Africa (Solaiman, 2010). Kenya has over 15 million goats with 400,000 being dairy goats (KNBS, 2019; Kikwatha *et a*l., 2020b) which is an increase from previous reports of 200,000 dairy goats (Mbindyo *et al*., 2017). Dairy goats are climate smart livestock and its farming has gained popularity over the past decades through the sale of milk and meat (Peacock *et al*., 2010) Despite this rise in population, goat farming system today is faced with many problems, key among them being poor breeding methods, poor nutrition and high disease and parasite burden (Kiema *et al*., 2020). However, goat rapid growth translates into faster returns to investment which makes this enterprise attractive among the youth and women.

The breeding method preferred by most goat farmers in Kenya is natural mating. Dairy goat farmers around Mount Kenya use buck rotation (Mbindyo *et al*., 2017) with only less than 1% practicing artificial insemination (AI), a technique which involves buck semen deposition into the doe reproductive tract (Agossou and Koluman, 2018). It plays a key role in breeding of goats and accelerating genetic improvement (Paramio and Izquierdo, 2014) through dissemination of valuable genes (Tsuma *et al*., 2015; Hashemi and Safdarian, 2017) worldwide at a lower cost (Omontese *et al*., 2016).

Although AI is possible in goats with innumerable advantages, its uptake by goat keepers is very low at best only practiced by the elite goat keepers. Low uptake rates of AI has been attributed to factors such as high cost of AI, limited knowledge by farmers and unavailability of trained AI providers (Gunaseelan *et al.*, 2018). However due to the numerous advantages of AI, this challenge can be gaped

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through government intervention to lower the prices. Training of farmers on awareness of AI (Mbindyo *et al*., 2017) and heat detection methods in does is a necessity to this technology (Kifaro *et al*., 2008). Training of sufficient numbers of AI service providers will also facilitate uptake of the technology. The advantages of AI include improved breeds, increased production, reduced venereal disease transmission and reduced hustle of looking for a buck.

This study aimed to determine the factors affecting the uptake of AI technology by testing the null hypothesis that there are no factors affecting the uptake of AI in goat farming.

MATERIALS AND METHODS

Study Area

The survey was conducted in Mukurwe-ini sub-County, Rugi and Mukurwe-ini Central Wards, Nyeri County. Mukurwe-ini sub-County was purposively selected because of its high population of dairy goats. Mukurwe-ini central had 7,726 households and eight locations, while Rugi had 5,806 households and six locations (KNBS, 2019). Figure 1 shows a map of the study area.

This sub-County lies on a latitude 0° 25′12.47”N and longitude 36° 56’ 51.32”E. The climate is warm with annual temperature range of between 12.8 and 20.8 °C. It experiences a bimodal rainfall with long rains in March to May ranging from 1200 -1600 mm and short rains between October and December ranging from 500 -1500 mm. The main cash crops are tea, coffee and pyrethrum. Dairy cattle farming is also a major source of livelihood in Mukurwe-ini sub-County.

Study design and sampling

A cross sectional survey was carried out between February to March 2021. A structured questionnaire was developed and used as a data collection instrument. The questionnaire included farm demographics, goat herd sizes and structure, source of breeding goats, production systems, goat breeds, breeding practices and benefits and challenges accruing from adoption of AI. The questionnaire was pretested and finally administered to 200 selected goat farmers in the two Wards selected through simple random sampling. The sample size for each Ward was computed using Yamane, (1967) formula;

$$n = \frac{N}{1 + N(e)^2}$$

to determine the overall sample for the two targeted Wards.

Where;

n = Sample size

N = Population size

e = Level of precision

The Yamane formula was used to determine the overall sample for the two targeted Wards. The sampling frame for the two Wards was determined from KNBS population census of 2019. Using this formula, a total of 200 farmers were selected from the two wards of Mukurwe-ini sub-County. One hundred (100) households were picked from each Ward and divided among the locations in the respective Ward.

Data Analysis

Data were entered in an excel sheet and descriptive statistics including frequencies, percentages determine using web-based R software version 4.03. and proportions on number coming on heat and pregnancy for those inseminated derived using Pearson chi-square (χ^2) and comparisons for differences in proportions done at $P<0.05$.

Below is the chi-square equation model

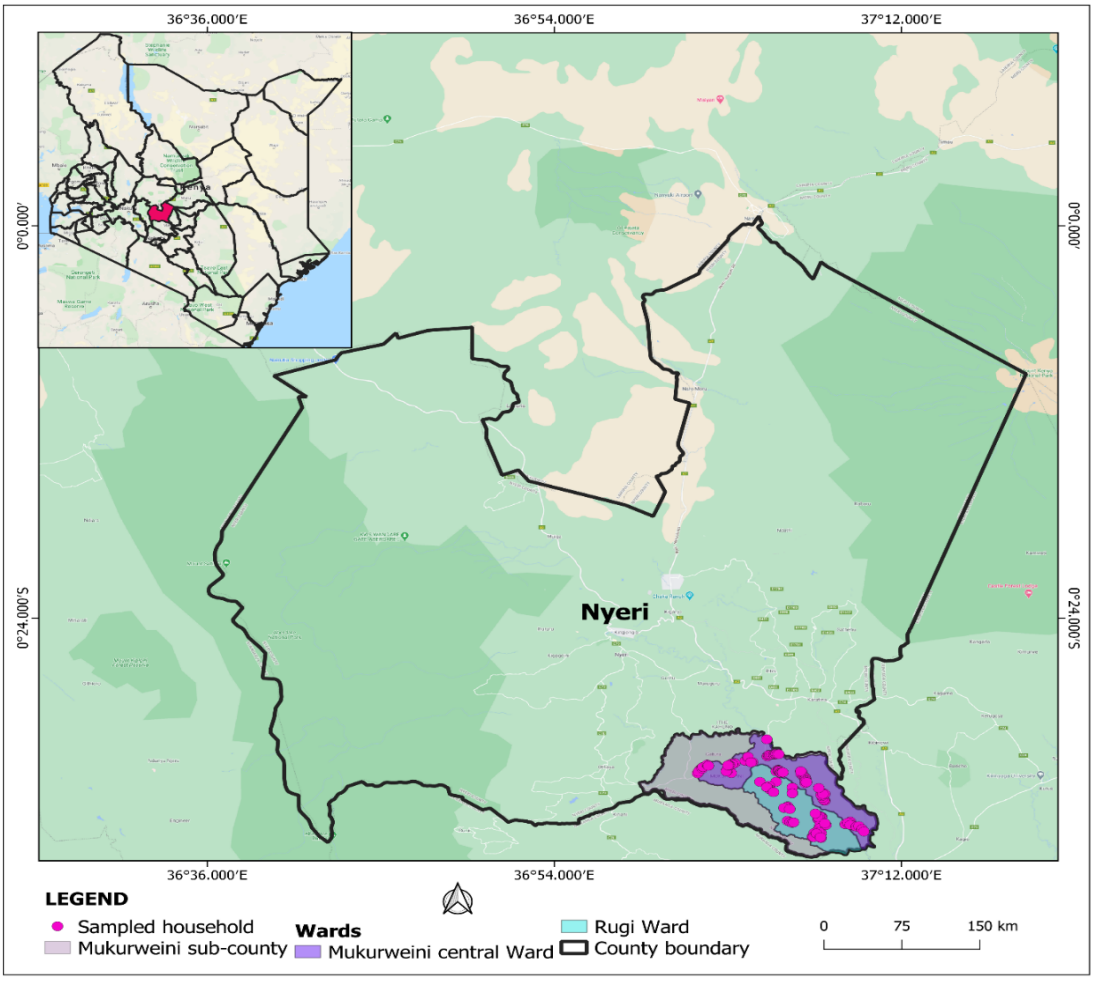
$$x_c^{\,2} = \sum \frac{(O_i - E_i)^2}{E_i}$$

Where O_i is observed value, E_i expected value and c is degree of freedom

RESULTS

Farm Demographic Description

The survey involved 100 farmers from each Ward (Mukurwe-ini central and Rugi). Farmers interviewed in Mukurwe-ini Ward had a mean age of 52.4 (range: 30 – 83) years whereas in Rugi Ward the mean age was 49.1 (range: 22 – 80) years. About half of the farmers interviewed in Mukurwe-ini central Ward and two thirds in Rugi Ward were female (Table I).



In both Wards literacy levels were fairly high with all the interviewees having at least primary level education. In both Wards, farmer affiliation to goat associations was low with about 94% of those interviewed reporting no association with any goat association. The main reasons for not being affiliated to any goat association included lack of awareness about the existence of such associations, having no interest in becoming members and some exited such groups as reasons.

Goat herd size and structure

In both Mukurwe-ini Central and Rugi Wards, farmers interviewed owned on average two goats, majority of which were female goats (Table II.). Farmers in both Wards rarely owned male goats.

Source of breeding goats, production system and goat body condition scores

There were differences ($P<0.05$) in source of breeding goats between the two Wards (Table III.). Farmers sourced goats for breeding from two main places (Market and Local). Farmers from Mukurwe-ini Ward preferring to purchase them from the market (47%) while from the preferred source in Rugi Ward was from local farmers (70%). Other less common sources of breeding goats were goats paid as dowry, sourced from associations or those received as donations.

About 75% of the farmers in Mukurwe-ini Central Ward and 63% in Rugi Ward preferred the semi-intensive production system for raising their goats (Table III.). The intensive production system was practiced by about 24% of the farmers in Mukurwe-ini Ward and about 31% in Rugi Ward. The extensive system was the least preferred.

TABLE I – RESULTS OF FARM DEMOGRAPHICS

Variable	Ward				
	Mukurwe-ini Central		Rugi		
	%	n	%	n	χ2 (p-Value)
Gender					0.719 (0.396)
Female	49.5	47	55.6	55	
Male	50.5	48	44.4	44	
Total	100	95	100	99	
Education					0.172 (0.918)
College	17.9	20	20.2	20	
Primary	48.4	47	47.5	47	
Secondary	33.7	32	32.3	32	
Total	100.0	99	100	99	
Farmers affiliated to any goat association					0.013* (0.911)
No	93.5	87	93.9	93	
Yes	6.5	6	6.1	6	
Total	100	93	100	99	
If no give reason					13.118 (0.157
Unaware	47.1	32	43.5	27	
Not Interested	30.9	21	29.0	18	
Left the group	14.7	10	4.8	3	
No group to join	5.9	4	4.8	3	
Other commitments	1.5	1	6.5	4	
New resident/farmer	0	0	4.8	3	
Too old	0	0	1.6	1	
To join soon	0	0	1.6	1	
Poor Leadership	0	0	1.6	1	
Financial constraints	0	0	1.6	1	
Total	100	68	100	62	

*Different at P<0.05

TABLE II – GOAT HERD SIZE (MEAN±SD) AND STRUCTURE IN MUKURWE-INI CENTRAL AND RUGI WARDS, IN NYERI COUNTY, KENYA 2020

Variable	Mukurwe-ini Central		Rugi	
	Size	n	Size	n
Total goats	2.02.0	94	1.7 ± 1.4	99
Male goats	0.3±0.5	94	0.2 ± 0.5	99
Female goats	1.7±01.8	95	1.5 ± 1.3	99
Milking goats	0.8±1.3	95	0.8 ± 0.9	99

Source: Survey Data

TABLE III – SOURCE OF BREEDING GOATS, PRODUCTION SYSTEM AND BODY CONDITIONS

Variable	Mukurwe-ini Central Ward		Rugi Ward		
	%	n	%	n	χ^2 (p-Value)
Source of goats					
Dowry	7.6	5	2.6	2	
Group association	3.0	2	3.9	3	
Group donation	3.0	2	0.0	0	15.535 (0.04*)
Local farmers	39.4	26	69.7	53	
Market	47.0	31	23.7	18	
Total	100.0	66	100.0	76	
Production system					
Intensive	24.2	16	30.7	23	
Extensive	0.0	0	6.7	5	5.798 (0.055)
Semi intensive	75.8	50	62.7	47	
Total	100.0	66	100.0	75	
Body score					
Thin	22.7	15	26.7	20	
Ideal	62.1	41	53.3	40	1.157 (0.561)
Fat	15.2	10	20.0	15	
Total	100.0	66	100.0	75	

* Different at P<0.05

In both Wards, majority of goats in the farms surveyed had an ideal body condition.

Dairy goat breeds and breeding practices

In both Mukurwe-ini and Rugi Wards, the preferred dairy goat breed was Toggenburg with dairy crosses as the least preferred (Table IV). Other exotic goat breeds reared included the Alpine and Saanen. Goat breeding was predominantly done through natural mating with only one farmer practicing AI. Breeding bucks were obtained from amongst the rotational buck serving a group of farmers on rotational basis and also own bucks. In some instances, dairy goat farmers used both rotational and own bucks for breeding. Awareness about synchronization as a technique to promote breeding in goats was low. Only half of the farmers interviewed at Mukurwe-ini Ward and about a third of those interviewed at Rugi Ward had an idea about the method. Those who knew about synchronization reported that it was done by keeping the buck together with does (male effect). Only four farmers in each Ward knew about hormonal use.

Although AI in dairy goats had not been widely adopted in both study areas, more than two thirds of the farmers interviewed expressed their willingness to adopt and pay for the AI service. Respondents in Mukurwe-ini reported that they paid on average pay KES 288 per insemination while those in Rugi paid KES 168. More than half of the respondents from both counties preferred the County subsidized goat AI scheme with only one person from Mukurwe-ini Central Ward who preferred AI from private practitioners. A fifth of the farmers were undecided on what to use.

TABLE IV – DAIRY GOAT BREEDS AND BREEDING METHODS

Variable	Mukurwe-ini Central		Rugi		χ^2 (p-Value)
	%	n	%	n	
Goat breeds					
Toggenburg	48.3	29	61.6	45	11.481 (0.22)
Alpine	33.3	20	20.5	15	
Saanen	21.7	13	24.7	18	
Crosses	11.7	7	1.4	1	
Total	100.0	60	100.0	73	
Breeding method					
AI	0	0	1.0	1	4.301 (0.231)
Natural mating	100	95	99.0	98	
Total	100.0	95	100.0	99	
Source of buck					
Rotational buck	53.7	51	65.7	65	
Own buck	15.8	15	10.1	10	
Both	30.5	29	23.2	23	
Total	100.0	100.0	99.0	98	
Synchronization awareness					
Yes	54.7	52	40.4	40	3.994 (0.046*)
No	45.3	43	59.6	59	
Total	100.0	95.0	100.0	99	
Synchronization technique used					
Natural (male effect)	50.5	48	36.4	36	4.143 (0.126)
Hormonal	4.2	4	4.0	4	
N/a	45.3	43	59.6	59	
Total	100.0	95	100.0	99	
Willingness to pay for AI					
N/A	22.1	21	14.1	14	8.426 (0.015*)
No	0.0	0	7.1	7	
Yes	77.9	74	78.8	78	
Total	100.0	95	100.0	99	
Preferred source of AI by farmers if AI was adopted					
County subsidized	60.0	57	50.5	50	4.723 (0.317)
Group organization	4.2	4	3.0	3	
Individual	1.1	1	0.0	0	
Undecided	20.0	19	21.2	21	
Private Service	14.7	14	25.3	25	
Total	100.0	95	100.0	99	

*Different at P<0.05

Benefits and challenges of using Artificial insemination in goats

About 70% of the farmers in both Wards perceived that if they adopted AI their goats breeds would improve resulting to increased milk production. Other benefits which can be achieved by adopting AI for breeding include control of reproductive diseases, reduced chances of inbreeding, timely breeding services and reduced cost of production by only keeping and feeding female goats and not bucks.

On the perceived challenges of adopting AI as a breeding method, high cost was cited by about 75% of the respondents in Rugi Ward and 66% in Mukurwe-ini. Other challenges reported included repeat breeding, lack of trained AI providers, poor heat detection and inadequate knowledge.

TABLE V – FARMER PERCEPTIONS ON THE BENEFITS AND CHALLENGES OF ADOPTING THE USE OF ARTIFICIAL INSEMINATION FOR BREEDING GOATS

Variable	Mukurwe-ini Central Ward		Rugi Ward		
	%	n	%	n	χ^2 (p-Value)
Benefits of using AI					
Improved breeds	66.3	53	60.5	49	
Increased milk production	68.8	55	69.1	56	
Disease control	46.3	37	55.6	45	4.690 (0.584)
Control inbreeding	40.0	32	34.6	28	
Timely service	41.3	33	49.4	40	
Reduced cost of production	36.3	29	28.4	23	
Challenges					
High cost	66.3	53	76.5	62	
Poor heat detection	46.3	37	46.9	38	
Limited semen variety	31.3	25	28.4	23	9.565 (0.144)
Repeat breeding	55.0	44	54.3	44	
Lack of trained AI providers	53.8	43	64.2	52	
Inadequate knowledge	46.3	37	28.4	23	
Potential solutions					
Affordable cost	66.3	53	76.5	62	
Train on heat detection	45.0	36	46.9	38	
Gynecology examination	31.3	25	28.4	23	9.213 (0.162)
Farmer sensitization	55.0	44	55.6	45	
Train AI providers	55.0	44	64.2	52	
Avail a variety of semen	46.3	37	28.4	23	

Making AI service accessible and affordable to the small-scale farmers was listed as the most important solution to adoption of AI cited by about 75% of the respondents in Rugi Ward and 66% in Mukurwe-ini Ward. It was also suggested that animal health providers should be trained for them to provide the service and conduct farmer sensitization on use AI in goats. Other solutions cited included training farmers on heat detection, ensuring female goats are regularly examined for reproductive diseases which can compromise conceptions and ensuring availability of a variety of semen.

DISCUSSION

The findings of this study show that farmers aged above 50 years were engaged in goat farming in both Mukurwe-ini and Rugi Wards, lower than the Africa mean farmer age, which stands at 60 (Afande *et al*., 2015). Age is considered a key factor in technology awareness and willingness to adopt. In this study, farmers awareness of AI and synchronization technologies was influenced by age as reported by Ojango *et al*. (2010). The study found that the older the farmer the more reluctant they become in uptake of technology. Despite this, the youth who are not willing to embrace agriculture as a livelihood and the government should find innovative ways to encourage them to embrace agriculture.

Majority of goat keeping farmers in this study were women a finding that agrees well with those of Ndeke *et al*., (2011) but contrasted the findings by Kikwatha *et al.*, (2020b). Other studies have reported a higher involvement of women in agriculture (Karunakaran *et al*., 2015). The fact that women were the most involved in goat rearing can be interpreted to mean many issues. Firstly, goat rearing requires low inputs and is therefore convenient for women with a low resources. Kiema *et al*., (2020) reported that a low initial capital to purchase breeding stock required compared to cattle making it the preferred enterprise for women. The other reason why women in this study were keeping dairy goats might have been due to the nutritional benefits associated with goat milk. Ahuya and Okeyo (2000) and Waithanji *et al*. (2015) in their studies found that women are more likely to be owners of small than large livestock. Although women are responsible for many

livestock husbandry tasks, especially in dairy systems, they also face barriers to adopting improved practices (Polly and Crane, 2018) as they barely get time to go for farmer trainings. Women are risk averse and may therefore be slow in adopting AI and synchronization.

The study shows that a majority of the respondents were not affiliated to any goat association. Farmer groups and other farmer aggregation platforms are commonly encountered in areas where poverty levels are high (Philemon and Maitho, 2017). This was not the case for this study because Nyeri County is considered one of the counties in Kenya with the highest income levels. Farmers with resources at their disposal are able to manage their own affairs without the need to form farmer groups. Another reason is that Nyeri County has a well-developed cooperative movement thus farmers have no reason to form farmer groups for activities and functions the cooperative societies can do. However Waithanji *et al*. (2015) in their study found that farmers who were members of Meru Goat Breeders Association were more knowledgeable than non-members. This was the case in our study as those who had not been members of any association or group had no idea of AI and synchronization techniques. Collapse of these associations may thus necessitate proper sensitization to encourage farmers to join farmer groups (Wainaina *et al*., 2020) and creation of more diverse activities within the groups to make them attractive (Mbindyo *et al*., 2017).

The goat herd sizes per household surveyed was two (2) meaning that this enterprise is practiced on small scale. A study on dairy goats in Embu County (Kiema *et al*., 2020) shows that the herd size was four (4) per household. This difference could have been due to land sizes where Nyeri county is known to have small land sizes (Birch, 2018). When land size is small, farmers tend to intensify their productivity by keeping fewer animals. However lowered production and reproduction due to small land size and lack of utilization of reproductive technologies will ultimately have implications on sustainability of flock productivity (Ojango *et al*., 2010). When land size is small, the practice is to keep more female animals and source for male for natural mating giving room for adoption of AI and synchronization. This was confirmed in this study since it was reported that most males born in their herds were sold to earn income. In some rare cases the males are left in the herd to mature and are slaughtered during festive seasons or for socio-cultural functions (Fafa *et al*., 2021). Males were also sold at a younger age to control inbreeding and cut down on production cost of feeding (Mbuku *et al*., 2015). This shows the urgency to introduce goat AI and synchronization as there are few males for mating and heat detection. Majority of the female goats in the surveyed households were lactating which agreed with results by (Wainaina *et al*., 2020). The milking goats were considered valuable not only for reproduction and milk but because their milk had high nutritional value and fetches a higher prices than cow milk (Waithanji *et al*., 2015).

The main source of breeding bucks was markets. This practice of buying breeding goats from markets was also reported by Wainaina *et al*. (2020). This is disadvantageous since people dispose goats mainly through culling when they are sick, old, have low productivity or with poor breeding traits (Karunakaran *et al*., (2015). Such animals are not appropriate for breeding purposes and may become a risk in terms of disease spread to the healthy animals in the herd. Because dairy goats not easily available, other farmers take advantage of this and act as brokers by selling low quality animal claiming they are pure breeds (Mburu *et al*., 2014) The best solution for these farmers is to embrace AI with synchronization due to the authenticity and the guarantee of the breed type they require.

It is observed from the findings that there were few farmers who practiced extensive production system. This is because in the area studied there is pressure on land with the available land supporting other enterprises mainly tea and coffee; the two main cash crops in the area. Goats were therefore reared under the intensive system and agreed with the study by Wainaina *et al*., 2020. In order to optimize productivity, farmers in the study preferred exotic dairy breeds including the Kenyan Alpine, Toggenburg and Saanen because of their perceived high milk production. This agreed with the other studies (Ndeke *et al*., 2011; Wainaina *et al*., 2020). The Alpine was the preferred breed in the region due to its high milk production and the fact that it adapts well in sub humid to humid climate that has long ,cold and wet seasons (Mburu *et al*., 2014; Wainaina *et al.*, 2020). The Toggenburg was preferred for its resilient, has short inter-kidding intervals and possesses high productive capabilities under local conditions (Ndeke *et al*., 2011; Peacock *et al*., 2010).

Under the intensive production system, livestock feeding is heavily supplemented which may have an effect on their body condition scores. The use of commercial concentrates or feeding animals on high nutrient fodders rich in nutrients is likely to result in animals with good body conditions (Mburu *et al*., 2014). This observation was consistent with the current study findings. It should be noted that body condition important especially for breeding bucks. Breeding buck with less than body condition 2 may not have sufficient stamina and vigor to breed while those with more than 4 lack sexual desire, while in lactating animals a score below 2 can lead to anestrous and low milk production (Ghosh *et al.*, 2019). Goats in the study by Debele *et al*., (2013) had goats with a body score lower than what is recorded in the current study.

In this study breeding of goats was predominantly through natural mating with only one farmer practicing AI. The findings were in agreement with the study by Gore *et al.* (2021). This could be due to the fact that most farmers in Mukurwe-ini Ward were members of the Dairy Goat Association of Kenya hence had been involved in buck rotation (Mbindyo *et al*., 2017). On the contrary, some goat keepers use own bucks for breeding (Wainaina *et al*., 2020). It ought to be noted that natural mating has the disadvantage of increasing the risk of spreading transmissible venereal diseases such *Brucella meltensis*, *Chlamydia abortus* and herpes virus (Underwood *et al.*, 2020) and also encourages in inbreeding particularly from use of own buck (Mbindyo *et al*., 2017; Wainaina *et al*., 2020). Awareness on synchronization technique was low because breeding was mainly through natural mating. However, some farmers were aware that keeping a buck in a herd of female goats resulted in some coming on heat. In the absence of the buck, it is should be noted that the use of hormones is more effective in enhancing reproductive efficiency (Omontese, 2018). Despite the low uptake of AI at the time of the current survey, it is worth noting that many farmers expressed their willingness to not only adopt AI services if availed but pay for the same. The interviewed farmers however quoted comparatively lower insemination prices compared to cattle AI. Perhaps their judgement of cost of insemination in goats was made on the basis of the small size of the goat compared to a cow. The KES 1500 farmers pay for inseminating cows was considered too high (Khainga *et al*., 2018). Generally the high cost of AI in Kenya is mainly attributed to the AI equipment, logistical challenges and the fact that performing AI requires well trained and skilled personnel (Tsuma *et al.*, 2015). This study also revealed that lack of trained AI providers echoed by the key informant posed a challenge in adoption of AI. The key informant were in agreement with the farmers on the need to train AI providers to effectively carry out AI and other activities (Gunaseelan *et al*., 2018; Kharche *et al.*, 2013).

Despite the fact that AI as a breeding method in goats had not be widely adopted, surveyed farmers though it can help them increase milk productivity in their goats if adopted as a breeding method. Mbindyo *et al*. (2017) reported that utilization of genetically proven buck semen and improved breeds resulted in increased milk production. The farmers also perceived that AI in goats was likely to upgrade the existing breeds. This seemed to corroborate findings from other studies that AI is a cheaper way of obtaining good breeds and a much more effective way than importing bucks (Kifaro *et al.*, 2008; Omontese, 2018; Polly and Crane, 2018). Venereal disease control is the other advantage of AI use since semen is collected from quality bucks free from this transmissible venereal disease (Tsuma *et al*., 2015). Similarly timely breeding will be done as time wasted looking for a buck is reduced or transportation from one place to another (Dávila *et al*., 2018).With the ban of importation of live animals (Mburu *et al*., 2014).

Farmers often fail to adopt a new technology because of various barriers. The constraints identified in our study should the farmers take up the technology included high cost of AI which was cited by a majority of farmers, repeat breeding, lack of trained AI providers, poor heat detection and inadequate knowledge on these technologies. Repeat breeding require the input of the farmer and AI providers as management practices at farm level, examination of reproductive health, semen storage, transportation and AI timing are needed. Reproductive health examination, needs trained animal health providers (Arrebola *et al*., 2013). Poor heat detection by farmers necessitates farmer training not only on AI awareness and heat detection but also on hormonal estrous synchronization which will help minimize labor on heat detection (Omontese *et al*., 2016). The farmers interviewed noted that other key barriers to AI use are limited number of trusted providers.

CONCLUSION

Small-scale production of two animals per herd was

largely practiced in Mukurwe-ini sub-County, Nyeri. Natural mating was the main method used for breeding and breeding bucks sourced from market. Farmers were willing to adopt and pay for AI services for dairy goats. They acknowledged the potential benefits of using AI including increased milk production, reduced chances for inbreeding and spread of reproductive diseases. Increased production, efficiency of production and longevity leads to increased productivity. However, the challenges included high cost of AI, lack of trained AI providers, lack of knowledge by farmers, poor heat detection methods, limited semen variety and repeat breeding.

RECOMMENDATIONS

The study recommends dairy goat farmers be discouraged from buying breeding stock from markets as is likely to spread diseases and be a source of inferior genetic material. Capacity building on heat detection methods that are affordable is necessary to increase uptake of goat AI.

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REFERENCES

Afande, D. F. O., Maina, W. N., and Maina, F. M. P. (2015). *Youth Engagement in Agriculture in Kenya : Challenges and Prospects*. *7*(2006), 4–20.

Ahuya C.O. and A. M. Okeyo. (2000). *Sustainable genetic improvement of goat meat and milk production in Kenya: A case of the Meru and Tharaka-Nithi Dairy and Animal Healthcare community-based Breeding Programme*. *Ilri*, 1–19.

Arrebola, F., González, O., Torres, R., and Abecia, J. (2013). *Artificial insemination in Payoya goats : Factors affecting fertility Arti fi cial insemination in Payoya goats : factors affecting fertility*. *January*. https://doi.org/10.1071/AN13138.

Birch, I. (2018). *Agricultural productivity in Kenya : barriers and opportunities*. *December 2018*. Semantic Scholar.

Claire Ingabire, M., Liu, Y., Chrisostom Pesha, J., and Hardi, A. (2018). Factors Affecting Adoption of Artificial Insemination Technology by Small Dairy Farmers in Rwanda: A Case of Rwamagana District. In *Journal of Economics and Sustainable Development www.iiste.org ISSN* (Vol. 9, Issue 12). Online. www.iiste.org.

Dávila, F. S., González, A. S. del B., and Barragán, H. B. (2018). Reproduction in Goats. In *Goat Science*. InTech. https://doi.org/10.5772/intechopen.70003.

Debele, G., Guru, M., Hundessa, F., Duguma, M., Box, H. U. P. O., and Dawa, D. (2013). *Assessment of farmers ' management practices and factors affecting goats ' production system in Adami Tulu Jido kombolcha district of East Shawa Zone , Ethiopia*. 520–526. https://doi.org/10.5251/abjna.2013.4.5.520.526.

Fafa, S., Younouss, C., Traore, E. H., Cabaraux, J.-F., Missohou, A., Antoine-Moussiaux, N., Hornick, J.-L., and Moula, and N. (2021). Characterisation of smallholders ' goat production systems in the Fatick area , Senegal. *Pastorlism* Vol.11, no. 1 pp 1-11.

FAO. (2021). *World Food and Agriculture - Statistical Yearbook 2021*. FAO. https://doi.org/10.4060/cb4477en.

Ghosh, C., Sciences, F., Datta, S., Sciences, F., Mandal, D., Sciences, F., Das, A. K., and Sciences, F. (2019). Body condition scoring in goat : Impact and significance Body condition scoring in goat : Impact and significance. *Journal of Entomology and Zoology Studies* Vol 7; 554-560.

Gore, D. L. M., Okeno, T. O., Muasya, T. K., and Mburu, J. N. (2021). Improved response to selection in dairy goat breeding programme through reproductive technology and genomic selection in the tropics. *Small Ruminant Research*, *200*(August 2020), 106397. https://doi.org/10.1016/j.smallrumres.2021.106397.

Gunaseelan, M., Singh, B. P., Verma, M. R., and Pachaiyappan, K. (2018). Adoption Level of Improved Goat Farming Technologies by Commercial Goat Farmers in Tamil Nadu. *International Journal of Current Microbiology and Applied Sciences*, *7*(05), 3293–3300. https://doi.org/10.20546/ijcmas.2018.705.385.

Hashemi, M., and Safdarian, M. (2017). Efficiency of different methods of estrus synchronization followed

by fixed time artificial insemination in persian downy does. *Animal Reproduction*, *14*(2), 413–417. https://doi.org/10.21451/1984-3143-AR825.

Jerry Agossou, D., and Koluman, N. (2018). The effects of natural mating and artificial insemination using cryopreserved buck semen on reproductive performance in Alpine goats. *Archives Animal Breeding*, *61*(4), 459–461. https://doi.org/10.5194/aab-61-459-2018.

Karunakaran, M., Mandal, A., Mondal, M., Bhakat, C., and Garai, S. (2015). *Semen Preservation and Artificial Insemination in Bengal Goat at Field Level*. *4*(2), 25–28.

Khainga, D. N., Obare, G., and Nyangena, J. (2018). *Estimating pastoralists ' willingness to pay for artificial insemination in arid and semi-arid lands of Kenya*. *10*(August), 262–270. https://doi.org/10.5897/JDAE2018.0920.

Kharche, S. D., Jindal, S. K., Priyadharsini, R., Kumar, S., Goel, A. K., Ramachandran, N., and Rout, P. K. (2013). Fertility following frozen semen artificial insemination in jamunapari goats. *Indian Journal of Animal Sciences*, *83*(10), 1071–1073.

Kiema, M. ., Kitilit, J. ., Nthakanio, P. ., Kios, D. ., and Rachuonyo, H. (2020). The Effect of Upgrading Indigenous Goat Breeds with German Alpine on Milk Yields at Manyatta Division of Embu County. In *African Journal of Education, Science and Technology* (Vol. 6, Issue 1).

Kifaro, G. C., Eik, L. O., Mtenga, L. A., Mush, D. E., Safar, J., Kassuku, A. A., Kimbiti, .E.N., Machang'u, A. D. M.-, Kanuya, N. L., Muhikambele, V. R. M., Ndemanisho, E., and Ulvund, M. J. (2008). *The Potential use of Artificial Insemination in sustainable Breeding of Dairy Goats in Developing countries : A Case Study of Norwegian Dairy Goats 'in Tanzania*. *8*(1), 19–24.

Kikwatha, R. W., Kyalo, D. N., Mulwa, A. S., and Nyonje, R. O. (2020a). Project Design and Sustainability of Dairy Goat Projects for Livelihood Improvement in Kenya. *European Journal of Business and Management Research*, *5*(4). https://doi.org/10.24018/ejbmr.2020.5.4.361.

Kikwatha, R., Dorothy, P., and Kyalo, N. (2020b). *Dairy GoatSectorEnhancementStrategiesforSustainable Livestock Farming Communities*. *1*(2), 27–28.

KNBS. (2019). *2019 KENYA POPULATION AND HOUSING CENSUS VOLUME I : POPULATION BY COUNTY AND SUB-COUNTY: Vol. I* (Issue November).

Mbindyo, C. M., Gitao, C. G., and Peter, S. G. (2017). *Constraints affecting dairy goats milk production in Kenya Constraints affecting dairy goats milk production in Kenya*. *September*. https://doi.org/10.1007/s11250-017-1397-2.

Mbuku, S. M., Okeyo, A. M., Kosgey, I. S., and Kahi, A. K. (2015). Optimum crossbreeding systems for goats in low-input livestock production system in Kenya. *Small Ruminant Research*, *123*(1), 55–61. https://doi.org/10.1016/j.smallrumres.2014.10.001.

Mburu, M., Mugendi, B., Makhoka, A., and Muhoho, S. (2014). *Factors Affecting Kenya Alpine Dairy Goat Milk Production in Nyeri Region Factors Affecting Kenya Alpine Dairy Goat Milk Production in Nyeri Region*. *June 2020*. https://doi.org/10.5539/jfr.v3n6p160

Ndeke, A. N., Mutembei, H. M., Tsuma, V. T., and Mutiga, E. R. (2011). *Reproductive Performance of the Galla and Toggenburg Goats and their Crosses in Mwingi sub-County of Kenya*. http://pearlresearchjournals.org/journals/jmbsr/index.html.

Ojango, J. M. K., Ahuya, C., Okeyo, A. M., and Rege, J. E. O. (2010). The FARM-Africa dairy goat improvement project in Kenya: A case study. *International Livestock Research Institute* (Vol. 30709). www.farmafrica.org.uk.

Omontese, B. O., Rekwot, P. I., Ate, I. U., Ayo, J. O., Kawu, M. U., Rwuaan, J. S., Nwannenna, A. I., Mustapha, R. A. and Bello, A. A. (2016). An update on oestrus synchronisation of goats in Nigeria. In *Asian Pacific Journal of Reproduction* (Vol. 5, Issue 2, pp. 96–101). Elsevier (Singapore) Pte Ltd. https://doi.org/10.1016/j.apjr.2016.01.002.

Omontese,Bobwealth Oakina. (2018). Estrus Synchronization and Artificial Insemination in Goats. In *Goat Science*. InTech. https://doi.org/10.5772/intechopen.74236.

Paramio, M., and Izquierdo, D. (2014). Assisted reproduction technologies in goats. *Small Ruminant Research*, 1–6. https://doi.org/10.1016/j.smallrumres.2014.01.002.

Peacock, C., Ahuya, C. O., Ojango, J. M. K., and Okeyo, A. M. (2010). *Practical crossbreeding for improved livelihoods in developing countries: The FARM Africa goat project*. https://doi.org/10.1016/j.livsci.2010.09.005.

Philemon, B., and Maitho, T. (2017). *Factors Influencing Uptake of Exotic Dairy Goats in Kitui*. *5*(5), 153–166. https://doi.org/10.11648/j.ijsts.20170505.13.

Polly Ericksen, and and Todd Crane. (2018). *The feasibility of low emissions development interventions for the East African livestock sector: Lessons from Kenya and Ethiopia*. ILRI Research Report 46. Nairobi, Kenya: ILRI.

Solaiman, S. G. (2010). *Goat Science and Production* (first). Blackwell.

Tsuma, V. T., Khan, M., Okeyo, A., and Ibrahim, M. (2015). *Agricultural Innovation Program for Pakistan (AIP) A training manual on artificial Insemination in goats*. ILRI Manual 19. Nairobi, Kenya: ILRI.

Underwood, W. J., Blauwiekel, R., Margaret L. Delano, Gillesby, R., Mischler, S. A., and Adam Schoell. (2020). *Biology and Diseases of Ruminants (Sheep, Goats, and Cattle)* (Issue January, pp. 637–638).

Wainaina, A., Maina, J., Maina, N., Muturi, S., and Kimani, F. (2020). Characterisation of productivity and diseases a ff ecting dairy goats in smallholder systems of Greater Thika Region , Kenya. *Journal of Agriculture and Rural Development in the Tropics and Subtropics,* Vol. *121*(2), 243–249.

Waithanji, E., Njuki, J., Mburu, S., Kariuki, J., Waithanji, E., Njuki, J., Mburu, S., Kariuki, J., and Njeru, F. (2015). *Development in Practice A gendered analysis of goat ownership and marketing in Meru , Kenya*. *4524*. https://doi.org/10.1080/09614524.2015.1002453.

Yamane, T. (1967). *Statistics, An Introductory Analysis* (Second). Harper and Row.