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Evaluation of Dairy Cattle Productivity in Smallholder Farms in Nyeri County, Kenya

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Abstract
Dairy cattle production contributes approximately 4.5% of the Kenyan National Gross Domestic Product, creates jobs along the value chain and plays a key role in food security. However, average milk yield per cow is still low under smallholder dairy production system despite concerted efforts to improve productivity. The purpose of this study was to evaluate the productivity of smallholder dairy farms in 2 sub-counties of Nyeri County. A semi structured questionnaire was administered to collect data on feed resources and feeding systems, breeds and breeding systems, calf management, age at first service (AFS), age at first calving (AFC), calving interval (CI), milk yield (MY) and lactation length (LL) in smallholder dairy farms. Data was analysed using Statistical Package for Social Sciences (SPSS). The dominant feed resources and feeding system were roughages (mostly Napier grass), concentrates and mineral supplements (87.2%) and stall feeding (74.2%). Majority of the farmers kept Friesians (82.2%) with (94.5%) using artificial insemination. Most of the farmers (83.5%) fed 2-4 litres of colostrum to the calves and the method of feeding was majorly bucket feeding (93.0%). High proportion of farmers (97.7%) fed the colostrum from 0-6 hours after calving and (59.6%) weaned calves at 3 months. The AFS was mainly 18-20 months and above, while the mean AFC, CI, and LL were 28.7±2.84, 15.2±5.11 and 10.0±4.90 months, respectively. The mean milk yield was 10.7±5.85 litres/cow/day. The main challenges to dairy cattle production were feed shortages (30.6%), low farmgate milk prices (28.3%) and high cost of concentrate feeds (17.8%). It was concluded that performance of dairy cattle in the study area was poor attributed mostly to feed shortages and low milk prices. To improve productivity, feed availability and cost together with farmgate price of milk should be addressed.

Keywords: *Dairy Cattle; Feeding; Milk yield; Reproductive Performance, Kenya*

Introduction

Livestock plays a major role in the Kenyan economy contributing approximately 4.5% of the Kenya National Gross Domestic Product (GDP), 12% of Agricultural GDP (KDB, 2016) with dairy contributing approximately 3% (FAO, 2011; Bingi and Tondel, 2015). The livestock population comprises of a dairy herd of about 3.5 million exotic cattle, 14.1 million indigenous cattle, 27.7 million goats and 2.97 million camels according to 2009 census (MoALF, 2013). Cattle account for approximately 88% of milk produced while the rest comes from camels and goats (MoALF, 2013). Smallholder dairy production accounts for 80-90% of milk produced in Kenya (KNBS, 2017). Dairy production is a principal

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Farming activity which contributes to the livelihood of 1.5 million smallholder dairy farmers (KDB, 2016). It provides employment by creating 750,000 direct jobs and 500,000 indirect jobs in addition to supporting other service industries such as animal feed processing, breeding and animal healthcare among others (KDB, 2016). Kenya is among the countries with the highest annual per capita consumption of milk in Africa (of approximately 100 kg) compared to an average of 25 kg annual per capita for Sub-Saharan Africa (MoALF, 2013). However, this remains below the global annual per capita milk consumption requirement of about 220 kg per capita (MoALF, 2013).

Bebe *et al*., (2003) in Kenya highlands, reported that 43%, 19%, 16%, and 22% of farmers kept the Friesian, Ayrshire, Guernsey/Jersey and *Bos indicus* cows (East African Zebu, Boran, Sahiwal) respectively. On the other hand, 75% of the farmers in Mirangine of Nyandarua County kept Friesian and the rest kept Ayrshire, crosses, Guernsey and Jersey in that order (Gitau, 2013).

Artificial insemination is the predominant breeding method in dairy producing areas. In Mirangine (Nyandarua County), 72.3% of the respondents used AI, while 27.7% used natural mating (Gitau, 2013). According to Karanja (2002), good genetics is one way of improving milk production. The imported semen is estimated to have a market share of 22 % (Karanja, 2002). However, Muia *et al.,* (2011) reported improved AI usage at 44% in smallholder farms. However, this has also decreased genetic progress of the dairy cattle because of inbreeding and poor coordinated breeding (Odero-Waitituh, (2017).

Reproductive performance in smallholder dairy farms in Kenya has been described as poor (Bebe *et al.,* 2000; Owen *et al.,* 2005; Gitonga, 2010), characterized by long calving intervals. For example, Bebe *et al.,* (2003) reported a calving interval of about 633 days. The poor reproductive performance in smallholder systems is attributed to inadequate and poor-quality feed, prolonged anoestrus periods, poor oestrus detection skills, lack of proper breeding records and poor breeding techniques (Bebe *et al.,* 2000; Owen *et al.,* 2005).

However, the study conducted in Kenya by Mungube *et al*., (2014) revealed calving intervals (CI) as 13.6 ± 2.9 in per-urban areas of Eastern Kenya. Poor detection of heat lowers conception rates because of wrong insemination timing which leads into conception failure. This result to long calving intervals (CI) with negative impacts on the productive and reproductive performance of dairy cattle (Mungube *et al*., 2014).

The milk yield per cow according to MoLD (2010), had remained at only 6 kg/day for a period of more than thirty years whereas South African average was 19 kg/day (KDB, 2016). The low productivity has been attributed to inadequate quantities and poor-quality feeds, inadequate and inefficient breeding services, poor animal husbandry, inadequate extension and advisory services, ineffective disease control and veterinary services (MoALF, 2013). Poor access to output markets also contributes to low incentive to increased dairy production (MoALF, 2013).

Animal diseases have a massive impact on dairy productivity by changing the rates of reproduction, weight gain, decreased yield, and quality of milk (Wangila, 2016). Tick-borne diseases inflict an enormous impact in the tropical and subtropical parts of the developing world (Wangila, 2016). The common tick - borne diseases are babesiosis, bovine anaplasmosis and East Coast fever (ECF) (Young, *et al.,* 1988). Animals that survive an acute attack often show a slow recovery, resulting in losses in both milk and meat production. Usually, mortality is between 5 and 40%, but may increase to 70% during a severe outbreak (Merck Veterinary Manual, 3rd Edition ,1997). The effects of diseases like diarrhoea, mastitis, and milk fever are associated with a significant decline in milk production (Bareille *et al*., 2003). The costly disease in milk production is mastitis (Seegers *et al*., 2003). It leads to reduction in milk yield, public health risk due to consumption of unsafe milk, and less efficient processing of milk (FAO, 2014).

In the recent past, there has been a change in land holdings, educational and age characteristics of the dairy farmers and improved government and private extension services. This cross sectional survey therefore, examined the current level of feeding systems, breeding systems, reproductive and productive performance in smallholder dairy farms in Nyeri County.

Materials and Methods

The study Site

This study was done in Nyeri County which comprises eight sub-counties including Mathira East, Mathira West, Kieni East, Kieni West, Nyeri Town, Tetu, Othaya and Mukurweini. Based on number of dairy farmers in a Sub-County, two Sub-Counties were selected for the study namely; Mathira East and Othaya (Fig 1). Nyeri County population was 759,164 based on Kenya National Bureau of Statistics (KNBS) (2019) census result and a population density of 207.8/km² (CGN, 2013). It is a leading innovative agricultural hub that has common boundaries with five Counties including; Meru to the north east, Laikipia to the north, Nyandarua to the west, Murang'a to the south and Kirinyaga to the east. The County is about 150 kilometres north of Nairobi and lies between latitude: 0°25′12″ S and longitude: 36°56′51″ E with altitude ranging from 3,076 meters and 5,199 meters above sea level (CGN, 2013).

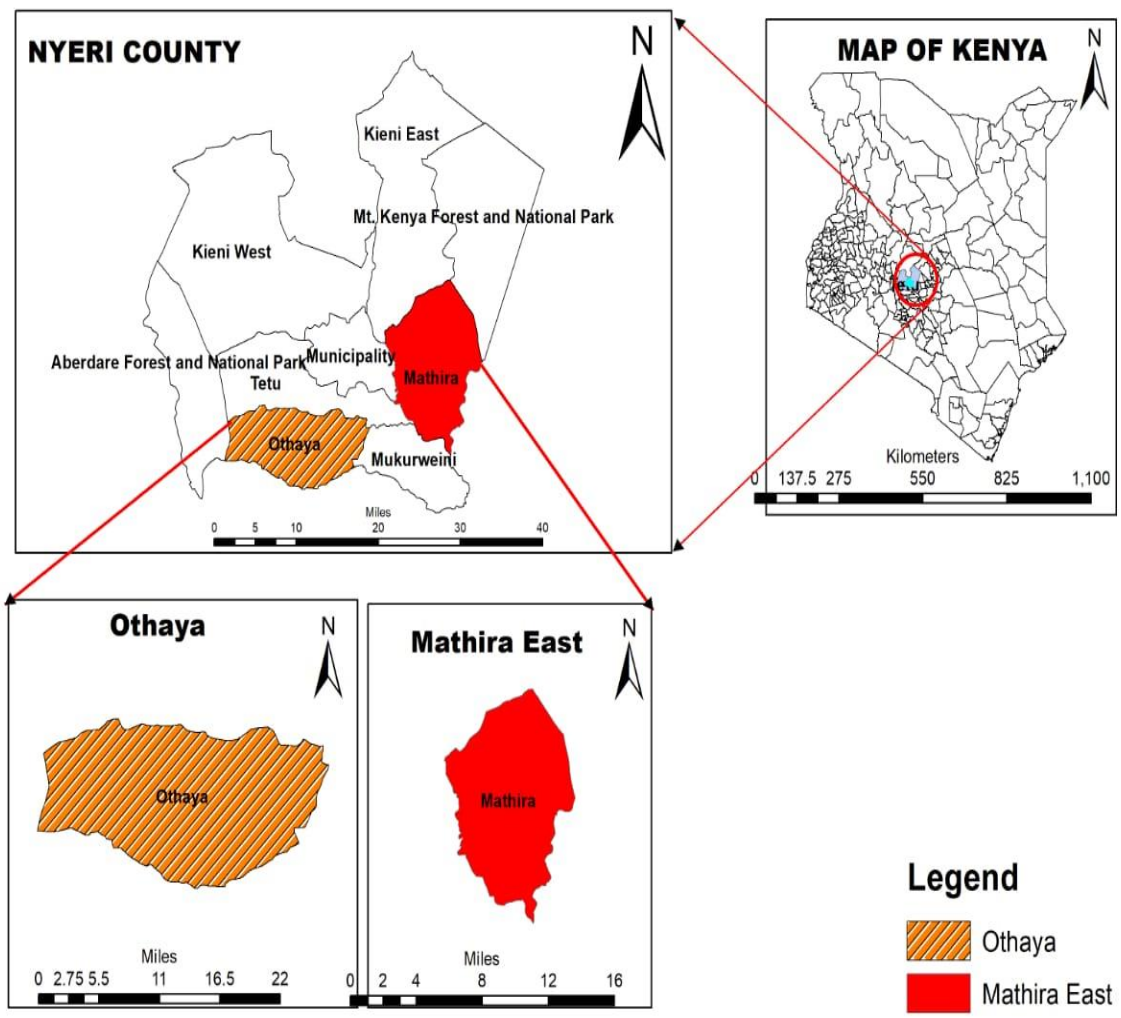

Figure 1: Location of study sites

The county experiences both cold and warm temperatures with an average of 12.8 ^{0}C in the cold months (June and July) and 20.8 ^{0}C in the hot months (January-March and September-October). The rainfall varies between 500 mm and 1600 mm per annum with high precipitation from April to May. The study was conducted in 2 sub counties of Nyeri County namely Mathira East and Othaya which were chosen based on high number of smallholder dairy farmers and high intensification. Two wards were purposively selected from each of the sub-counties: Iria-ini and Magutu in Mathira East and Chinga and Karima in Othaya for data collection. The main selection criteria were based on a farmer having at least one milking dairy cow.

Data collection and management

The estimated number (9000) of smallholder dairy farms in Mathira East and Othaya sub-counties was provided by County Department of Livestock. Yamane (1967:886) method was used to determine sample size of 400 farms. Then collection of primary data was done using a pre-tested semi-structured questionnaire administered to 400 (100 each from the 4 wards) purposively selected smallholder dairy farms by trained enumerators. Questionnaire was administered in both English and Kikuyu language. Data collected included socio-economic, feed resources, feeding systems, Calf and heifer management, breeding systems, reproductive and productive performance. The data collection was conducted from January to February 2019.

Data Analysis and software used

Descriptive statistics were calculated using different tools of SPSS and Microsoft Excel Software; frequencies, percentages, means, standard deviations and cross tabulations. Chi Square test was used to test for similarities and differences. Interactions of variables was determined using linear regression model.

Results

Production Systems and Feed Resources

The dairy cattle production systems and feed resources in the study area are shown in Table 1. Majority of farmers kept their cows under the intensive system of production (74.2%) with the rest (25.8%) practicing the semi intensive system. The production systems practiced by farmers in both sub-counties were not significantly difference (p>0.05) between the Wards.

Feed resources in the small-scale dairy farms in the study consisted of roughages concentrates and mineral supplements (87.2%), roughages and mineral supplement (5.5%), roughages and concentrates (4.8%) and roughages alone (2.5%). The roughages consisted of mainly Napier grass (100% of farms), maize fodder and desmodium whereas concentrates were dairy meal (both commercial and homemade) and milling by-products (maize bran, wheat pollard, maize germ) and oil seed cakes (cotton seed cake and sunflower cake). There was no significant difference (p>0.05) between the Wards with Chi Square test.

Cattle Breeds and Breeding Systems

Table 2, revealed dairy cattle breeds and breeding systems in the study area. The dairy cattle breeds found in the smallholder dairy farms were Friesians (82.2%), Ayrshires (8.0%), Guernsey (4.0%), Jerseys (0.8%) and Crosses (5.0%). Breeds did not differ significantly (p>0.05) between the wards at 95% confidence level using Chi Square test. The breeding systems practiced in the study area were artificial insemination (AI) and natural mating. Majority of farmers used AI (94.5%), 3.5% applied natural mating with only 2% using both. Breeding systems did not differ significantly (p>0.05) between the wards when tested using Chi Square test.

Artificial Insemination services were mostly provided by private practitioners (70.7%), government (18.8%) and dairy cooperatives (2.5%) with some using more than one provider. There was no significant difference (p>0.05) between the wards in AI provision in the study area.

Table 1: Dairy cattle production systems and feed resources in the study area

Subcounty	Mathira East		Othaya		
	Wards				
Systems %	Iria-ini	Magutu	Chinga	Karima	Mean
	(N=100)	(N=100)	(N=99)	(N=100)	
Semi intensive	23	33	22.2	25	25.8
Intensive	77	67	77.8	75	74.2
Feed Resources of the Dairy Cattle (%)					
Roughages (mostly Napier grass) alone	7.0	3.0	0.0	0.0	2.5
Roughages and minerals	6.0	9.0	3.0	4.0	5.5
Roughages and concentrates	5.0	7.0	4.0	3.0	4.8
Roughages, concentrates and minerals	82.0	81.0	92.9	93.0	87.2

Table 2: Cattle Breeds, Breeding Methods and AI Provision in the study area

Subcounty	Mathira East		Othaya		
		Wards			
Breeds (%)	Iria-ini	Magutu	Chinga	Karima	Mean
	(N=100)	(N=100)	(N=99)	(N=100)	
Friesians	83.0	70.0	84.8	91.0	82.2
Ayrshires	4.0	9.0	14.1	5.0	8.0
Guernsey	9.0	7.0	0.0	0.0	4.0
Jerseys	2.0	0.0	0.0	1.0	0.8
Crosses	2.0	14.0	1.0	3.0	5.0
Breeding Methods (%)					
Artificial insemination (AI)	98.0	94.0	94.0	92.0	94.5
Natural mating	2.0	3.0	6.1	3.0	3.5
Artificial insemination (AI) + Natural mating	0.0	3.0	0.0	5.0	2.0
Artificial Insemination (AI) providers (%)					
Government	30.0	22.0	6.1	17.0	18.8
Private institution	61.0	70.0	80.8	71.0	70.7
Cooperatives	1.0	4.0	1.0	4.0	2.5
More than one provider	8.0	4.0	12.1	8.0	8.0

Calf Management

Colostrum feeding, calf feeding methods, feeding time and weaning of calves in smallholder dairy farms are shown in Table 3. Majority of the farmers (83.5%) fed 2-4 litres of colostrum and the method of feeding was mainly bucket feeding (93.0%) which is expected for exotic dairy cows. Colostrum feeding time was investigated in study area and majority of smallholder dairy farmers (97.7%) fed the colostrum from 0-6 hours after calving. Colostrum feeding, feeding methods and feeding time were not significantly different at 0.05 confidence level using Chi Square test.

Time, criteria and method of calf weaning in the study area were assessed and majority of farmers (59.6%) weaned calves at 3 months and 36.6% from 3-6 months. The criteria for weaning were mainly age of the calf (86.0%) and ability of the calf to consume a large amount of forages (9.8%). Sex of the calf was also a criterion used by 1.8% of the farms whereby male calves were sold off as early as 1 week of age when the milk is usually suitable for sale after calving while the rest of the farmers raised male calves to weaning. An average 94.75% of the farmers used intermittent weaning while 7.8% used the process where they abruptly stop feeding the calf with milk. The time, criteria and methods of calf weaning did not differ significantly (p>0.05) within and between the Wards.

Table 3: Colostrum feeding, methods, weaning, weaning criteria and weaning process of calves in study area

Subcounty	Mathira East		Othaya		
		Wards			
Litres of Milk/day	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
1-2 litres	4.0	4.0	2.0	4.0	3.5
2-4 litres	86.0	89.0	79.8	79.0	83.5
Unknown amount (Suckling)	10.0	7.0	18.2	17.0	13.0
Feeding Methods (%)					
Suckling	7.0	8.0	3.0	5.0	5.8
Bucket feeding	92.0	91.0	97.0	92.0	93.0
Both	1.0	1.0	0.0	3.0	1.2
Weaning Time (%)					
<3 Months	2.0	1.0	1.0	2.0	1.5
3 months	48.0	42.0	67.7	81.0	59.6
3-6 Months	48.0	55.0	27.3	16.0	36.6
6-9 Months	2.0	2.0	4.0	1.0	2.3
Weaning Criteria (%)					
Age of the calf	71	94.0	93.9	85.0	86.0
Sex of the calf	2	4.0	1.0	0.0	1.8
Ability to consume large amount of forage	23	2.0	3.0	11.0	9.8
Weight estimation	4	0.0	2.0	4.0	2.5
Weaning Process (%)					
Immediate cessation	3	7.0	0.0	11.0	5.3
Intermittent cessation	97	93.0	100.0	89.0	94.8

Reproductive performance of heifers

The age of heifers at first service (AFS) and first calving are shown in Table 4. The heifers were served at different ages in all the wards with 37.8% at 15-18, 32.1% at 18-20 and 24.1% above 20 months. Majority of farmers in Chinga and Karima served heifers between 18-20 months compared to Iria-ini and Magutu where they were served at <18months which could be due to different heifer feeding and management practices in Othaya and Mathira East sub counties.

Table 4: Age at first service, first calving, monitoring of growth and monitoring criteria of heifers in the study area

Subcounty	Mathira East		Othaya		
	Wards				
Age at first service %	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
15-18 months	54.0	52.0	26.3	19.0	37.8
18-20 months	24.0	31.0	39.4	34.0	32.1
>20 months	20.0	17.0	27.3	32.0	24.1
Did not come on heat	2.0	0.0	7.1	15.0	6.0
Age at first calving(months)					
Wards	N	Mean±SD			
Iria-ini	100	28.5a ± 2.43			
Magutu	100	28.0a ±2.30			
Chinga	99	28.4a ±3.30			
Karima	100	29.7a±3.27			
Mean		28.7±2.84			
SEM		0.294			
Monitoring of heifer %					
No	41.0	42.0	5.1	12.0	25.1
Yes	59.0	58.0	94.9	88.0	74.9
Monitoring Criteria (%)					
Weight and height estimation	44.0	55.0	81.8	88.0	67.2
No monitoring	56.0	45.0	18.2	12.0	32.8

[a]Means with the same superscripts between wards are not significantly difference (P>0.05)
Monitoring of Heifer Growth (%)

The age at first calving (AFC) ranged from 25 to 36 months in the study area with average of 28.7 months and was not significantly different in all the wards (p>0.05). In the current study, 74.9% of respondents monitored heifer growth mainly through weight and height estimation (67.2%). Monitoring heifer growth did not differ significantly (p>0.05) across the wards.

Reproductive Performance of the dairy cows

The number of services per conception (SPC) and calving interval (CI) of dairy cows in the study area are shown in Table 5. The proportion of smallholder dairy farmers who had their cows inseminated once, twice, thrice and four times were 58.6%, 33.3%, 6.0% and 2.0% respectively. Number of services per conception is dependent on several factors which include heat detection, insemination practice, nutrition and health status of the cow. Dairy farmers in Karima ward of Othaya sub-county reported the highest conception (66%) after first service. The mean of calving interval in the study area was 15.22±5.11 months (456.6 days) (Table 5). There was no significant difference in the mean between the Wards (*p*>0.05).

Table 5: Reproductive Performance of dairy cows in the study area

Subcounty	Mathira East		Othaya		
	Wards				
	Iria-ini	Magutu	Chinga	Karima	Mean
Number of services per conception (%)	(N=100)	(N=100)	(N=99)	(N=100)	
1	57	57	54.5	66	58.6
2	38	33	36.4	26	33.3
3	5	7	6.1	6	6
4	0	3	3	2	2
Calving Interval (months)					
Wards		N	[a]Mean±SD		
Iria-ini		100	15.71±5.80a		
Magutu		100	14.14±3.36a		
Chinga		99	15.62±5.08a		
Karima		100	15.41±5.74a		
Mean			15.22±5.11		
SEM			0.5002		

[a]Mean with the same superscripts between the wards are not significantly different (*P*>0.05)

Productive Performance of lactating cows

The mean daily milk yield (MY) and lactation length (LL) in the study farms is shown in Table 6. Of the study dairy farms, 37.4% of the cows produced 5-10 litres, 24.6% 10-15 litres and 15.8% 15-20 litres of milk per day. In the current study, the average milk yield was 10.7±5.9 litres/day. Calculations from the mean daily milk yields from the different locations showed that the 305 days lactation yield would range from 3040 to 3739 litres/year and an average of 3389 litres/year. The milk yields were significantly different between the wards (*p*<0.05). The lactation length ranged from 6 to 26 months with the average of 10.0±4.9 months. Lactation length was significantly different (*p*<0.05) between the wards in the study area.

Factors associated with reproductive and productive performance in the study area

Factors affecting milk production, calving interval and age at first service in the study area are shown in Table 7. Milk production was positively associated (coefficient .247) with quantity of concentrate fed at early lactation. Breeds of cattle and diseases were negatively associated (-.059 and -.081) with milk production level. Milk production and quantity of concentrate fed during early lactation were significantly (*p*<0.05) related. Good feeding of heifers was positively correlated (.254) with age at first service then breeds and diseases which were negatively associated. There was significant (*p*<0.05) association between feeding heifers and age at first service. Calving interval was positively correlated (.018) with quantity of concentrate fed at mid and late lactation and negatively associated with other factors. Association between calving interval and quantity of concentrate fed during the mid and late lactation was non-significant (*p*>0.05).

Table 6: Productive Performance of dairy cows in the study farms

Milk yields l/day and Lactation length Wards	N	[a]Mean±SD	[a]Mean±SD
Iria-ini	100	9.77±4.99[a]	8.09±2.69a
Magutu	100	9.82±5.92[a]	7.48±1.79a
Chinga	99	12.25±6.16[c]	11.98±5.78b
Karima	100	10.94±5.97[b]	12.48±5.73c
Mean		10.7±5.9	10.0±4.9
SE		0.5803	0.4005

[a]Means with different superscripts between the Wards are significantly different ($P<0.05$)

Table 7: Linear Regression Model Results of Factors Affecting Reproductive and Productive Performance in Nyeri County.

Variables	Std. Error	Coefficient	*P*-Value
Milk Production			
Breeds of Cattle	.143	-.059	.230
Quantity of concentrate at early lactation	.410	.247	.001
Quantity of concentrate at mid and late lactation	.401	.032	.663
Diseases Control Measures	.251	-.081	.095
Age at first service			
Breeds of Cattle	.023	-.068	.171
Diseases Control Measures	.040	-.041	.399
Feeding of Heifers	.046	.254	.000
Calving Interval			
Breeds of Cattle	.129	-.064	.203
Quantity of concentrate at early lactation	.372	-.032	.674
Quantity of concentrate at mid and late lactation	.365	.018	.817
Diseases Control Measures	.227	-.042	.399
Number of observations	399		
Confidence Level	.05		

Challenges to dairying and coping mechanisms in study area.

The challenges of dairying and coping mechanisms by smallholder dairy farmers in the study area are shown in Table 8. The major challenges were feed related and included fodder/feeds shortages (30.6%) and related to this, the high cost (17.8%) as well as low quality of feeds (7.3%). Low prices of milk (28.3%) and diseases were also important. Challenges do not differ significantly (p>0.05) between the wards.

To overcome these challenges, farmers came up with various coping mechanisms which included purchase of fodder and crop residues (42.1%), renting land for fodder production (21.1%), selling milk to neighbours, middlemen and shops (11.3%) and consulting veterinarians (10.8%). Coping strategies were not significantly different (p>0.05) across the wards in the study area.

Table 8: Challenges and coping mechanism in smallholder dairy farms in the study area

	Mathira East		Othaya		
	Wards				
Challenges (%)	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Fodder and feeds shortages	26	37	39.4	20	30.6
High cost of feeds	18	25	22.2	6	17.8
Silent heat and infertility	0	2	5.1	8	3.8
Low quality feeds	6	2	5.1	16	7.3
Low farm gate milk prices	30	22	17.2	44	28.3
Livestock diseases	18	10	9.1	3	10
Lack of training in dairy management	2	2	2	3	2.3
Coping mechanisms %					
Renting land for fodder production	14	28	27.3	15	21.1
Supplementation with mineral salts	1	0	4	0	1.3
Homemade dairy meal	7	1	4	1	3.3
Substitution of commercial feeds with fodder	8	6	2	3	4.8
Purchase of fodder	38	37	32.3	61	42.1
Provide less feeds and crop residues	4	6	2	0	3
Consult Veterinarian (Vet)	11	12	15.2	5	10.8
Selling milk to neighbours, middlemen and shops	11	9	11.1	14	11.3
Selling stock, culling and changing AI provider	6	1	2	1	2.5

Discussion

In the study area, most of smallholder dairy farmers practiced intensive system of production. Bebe *et al*., (2003) reported that in the Kenyan highlands, the households practiced intensive, semi-intensive and extensive dairy farming systems in the proportion of 44%, 33% and 23% respectively. Extensive system was not practiced in the current study site due to small land holdings. Njarui *et al*., (2016) reported that in Kenyan highlands, where population densities are high, the intensive dairy farming system is practiced where forages and crop residues are stall fed to cattle.

Feed resources in the farms consisted of roughages, concentrates and mineral supplements (87.2%) mainly in the study area. Napier grass was a common feed resource in all the farms. The roughages consisted of mainly Napier grass (100% of farms), maize fodder and desmodium, whereas concentrates were dairy meal (both commercial and homemade) and milling by-products (maize bran, wheat pollard, maize germ) and oil seed cakes (cotton seed cake and sunflower cake). Napier grass was reported as a main forage for dairy cattle in intensive and semi intensive systems and grown by more than 70% of small-scale dairy farmers in Kenya (Orodho 2006; Mulaa *et al*., 2013). Napier grass is a preferred fodder crop as it produces enormous biomass and tolerates frequent cuttings (Nyambati *et al*., 2011) thus representing between 40 to 80% of the fodder for the small-scale dairy farms (Staal *et al*., 1998). With good management practices, Napier grass can produce 40t/ha/year in areas of high rainfall (1200 mm to 2400 mm of rainfall) and 1 acre of Napier grass planted by the Tumbukiza (mico-catchments) method can produce enough feed for 2 to 3 dairy cows for a year (Kabirizi *et al*., 2015).

The dairy cattle breeds found in the study area were mainly Friesians. Friesian cattle were preferred due to high milk yield though of low butter fat. Milk payment was based on volume rather than composition in the study area, thus the preference. Although the Friesian is known for higher milk production, it also requires large quantities of feed to realise its potential. Due to feed shortages (quantity and quality) in the study area, the anticipated high milk yield may not have been realised. Bebe *et al*., (2003) reported 43% of farmers in the Kenyan highlands kept Friesians while 19% and 16% kept Ayrshire and Guernsey/Jersey respectively. Gitau, (2013) reported that in the same area, 75% of the farmers kept Friesian. Market-oriented dairying where exotic cattle dominate is found in the crop-dairy systems of Kenya high potential areas (Muriuki, 2003). Over 50 % of the total herd are crosses while the pure breeds are dominated by Friesian–Holstein and Ayrshire (MoALD, 2001; Muriuki, 2009).

Artificial Insemination was mainly used in the study area. This is an indication that most of the smallholder dairy farmers knew the importance of AI and were able to access artificial insemination services. AI was introduced in the Kenya highlands over 50 years ago (MoALDM, 1998) and most of the farmers have known its benefits such as superior semen, reduction in reproductive diseases and the cost of maintaining a bull. Muraya *et al*., (2018) observed that in Meru County where AI services were readily available, majority of smallholder farmers used the service. Recent study in Mirangine (Nyandarua County), 72.3% of the respondents used AI, while 27.7% used natural mating (Gitau, 2013).

Artificial Insemination services were mostly provided by private practitioners. The higher usage of private AI technicians was attributed to ease of accessibility by the farmers when their cows were on heat. Similarly, Muraya *et al*., (2018), reported that AI services were mainly provided by private AI technicians in Meru County. According to Baltenweck *et al*., (2004), private AI services increased after the liberalization of breeding services in 1990s by the Government of Kenya. In Kirinyaga and Nakuru Districts, private AI increased from 14% to 59% and 37% to 64% ten years ago respectively (Baltenweck *et al*., 2004).

Majority of the farmers in the study site fed 2-4 litres of colostrum to the calves which are within the recommended amount (Sweeney *et al*., 2010; Lukuyu *et al*., 2012). The method of feeding was mainly bucket feeding (93.0%) which is expected for exotic dairy cows. According to Nafula, (2013), 97.1% of farmers used bucket feeding in Mukurweini Subcounty. It has been reported that bucket feeding is the most commonly used method in commercial dairy farms in Kenya (SNV, 2017).

Majority of farmers fed the colostrum from 0-6 hours after calving. This implied that most calves were provided with colostrum during the period of maximum absorption of immunoglobulins through the intestinal wall prior to the closure of pores (SNV, 2017). Nafula (2013) in a study conducted in Kenya also reported that majority of farmers (97.7%) fed colostrum in the first six hours of calf 's life. There was similarity in feeding colostrum in all the wards in Mathira East and Othaya sub-counties. A calf should have fed at least 10% of their body weight of colostrum as a common rule, in its first 24 hours of life, preferably half of this within 6-12 hours of birth (SNV, 2017). Good calf rearing depends on adequate intake of high-quality colostrum within the first day of life and feeding management to encourage early rumen development (Goopy and Gakige, 2016).

Weaning of calves was mainly at 3 months in the smallholder dairy farms. This implied that most of the farmers used age instead of weaning weight, a good indicator of proper management. The recommended average weight at weaning for larger breeds (Friesians and Ayrshire) is 80 kg (Lukuyu *et al*., 2012). Majority of the calves are weaned from 12 - 16 weeks (3-4 months) in Kenya (SNV, 2017).

The criteria for weaning were mainly age of the calf. Sex of the calf was also a criterion used by small proportion of the farms whereby male calves were sold off as early as 1 week of age when the milk is usually suitable for sale after calving while the rest of the farmers raised male calves to weaning. This is a common practice on commercial dairy farms where AI is used, thus male calves are not required for breeding. The recommended weaning criteria in Kenya are based on the ability of the calf to consume 1.5% of its body weight of dry feeds, attains twice the birth weight and age of the calf (Lukuyu *et al*., 2012; SNV, 2017). In a study conducted in Meru, average daily weight gain of calves was 0.50±0.45 kg/day and mean body weight of 85.2±32.8 kg at weaning time (Kathambi *et al*., 2018). In this study, the weight at weaning was unavailable and thus the growth rate could not be estimated.

An average 94.75% farmers used intermittent weaning in the study site. Majority of farmers chose intermittent weaning to avoid stress that affects the calf after abrupt weaning. Abrupt weaning was practiced mainly in Karima ward of Othaya sub-county compared to other wards probably due to insufficient training of farmers on good calf management practices. According to Sweeney *et al*., (2010), calves fed large amounts of milk and weaned at 6th week of age, by gradually decreasing the milk allowance over a period of 10 days, resulted in the best general weight gains.

The age at first service was mainly 18-20 months and above. Majority of farmers in Chinga and Karima served heifers between 18-20 months compared to Iria-ini and Magutu where they were served at <18months which could be due to heifer feeding and management practices in the sub counties. The age at first service (AFS) in peri-urban areas of Eastern Kenya was reported as 25.1 months (Mungube *et al*., 2014). In Malawi, Watanabe *et al*., (2017) reported mean age at first service as 25.2 months in small scale dairy farms. The age at first service is not always related to age at first calving as the first service may not result in a conception. Heifers are expected to be first inseminated at 14 to 15 months at body weight of more than 350 kg for larger breeds (Friesians and Ayrshire) to attain first calving of about 24 months (Antov *et al*., 1998). The age at first service was longer in the study area compared to the recommended 14-15 months (Novakovic *et al*., 2011). The long AFS was attributed to insufficient feeding and poor monitoring of heifer growth.

The age at first calving (AFC) was longer than expected in the study area. Nonetheless, AFC in the current study was lower than the 36 months reported in Kenya Highlands (Lanyasunya *et al*., 1999; Bebe *et al*., 2003). A study in Malawi reported an even later age at first calving of 43.4 ± 13.8 months (Watanabe *et al*., 2017).

Monitoring heifer growth is a good strategy to evaluate adequacy or otherwise of management and especially the feeding. In the current study, majority of respondents monitored heifer growth. In order to avoid late first calving, heifer growth should be monitored to allow adjustment in feeding program so as to achieve an average AFC of 24 months (Wathes *et al*., 2014).

The proportion of farmers who had their cows inseminated once was slightly higher in the study area. Number of services per conception (SPC) is dependent on several factors which include heat detection, insemination practice and the nutrition and health status of the cow. Good nutrition reduces number of services per conception and increase chances of conception (Tesfaye *et al*., 2015). According to Diskin (2008), heat detection efficiency relies on the ability and commitment of the person responsible in identifying the signs of heat before artificial insemination. It is also affected by breeding method being higher in free natural breeding and lower in places in which artificial insemination is utilized (Melaku *et al*., 2011). Farmers in Karima ward of Othaya sub-county reported the highest conception rate (66%) after first service. This high performance could be attributed to the age of farmers as majority were over 50 years. The older farmers were reported to be more accurate in heat detection and AI timing, resulting into successful conception compared to younger farmers (Gitau, 2013; Mutavi and Amwata, 2018). Similarly, the results in the current study agree with Rukundo, (2018), who reported a 58.6% first service conception rate for small scale farmers in Rwanda. More farmers in Karima ward fed their cattle on forages, concentrates and mineral salts which may explain high conception per service compared to other wards in the study area. Nutrition has been shown to be a vital factor affecting fertility and conception in dairy cattle (Santos, 2008; Tesfaye *et al*., 2015).

The mean of calving interval in the study area was 15.22±5.11 months which was longer than expected (Kollalpitiya *et al.,* 2012). The length of CI measures the productivity of dairy cow in term of calf crops and milk yield in a lifetime. Shorter CI (365 days) leads to more calves and milk yield in the lifetime of dairy cow compared to long CI. It is affected by factors such as nutrition, quality of semen, knowledge of farmer and AI technicians and reproductive health of the cow. The current findings concurred with the results by Wondossen *et al*., (2018) who reported an average calving interval of 469.2 ± 7.9 days (15.64±0.26 months) in Ethiopia. However, CI in the current study was shorter than calving intervals of 21.1 months reported in Kenya (Bebe *et al.,* 2003). A more recent study reported a lower CI of 13.6 ± 2.9 months in peri-urban areas of Eastern Kenya (Mungube *et al*., 2014) compared to 15.22±5.11 months in the current study. The recommended CI of 12 months (365 days) would ensure that a cow gives a calf every year (Kollalpitiya *et al.,* 2012). Calving interval in the current study was longer than 12 months and could be explained by inadequate feeding due to feeds scarcity, inadequate knowledge of farmers in heat detection, diseases and poor management practices in the study area.

Of the study farms, majority of the cows produced 5-15 litres of milk per day. Njonge (2017), in a similar study on smallholder dairy farms in Kirinyaga County, reported that 25% of farmers recorded yields of > 8 litres per day, 22% 4- 8 litres and 60% 1-4 litres per day. In the current study, the average milk yield was 10.7±5.9 litres/day. Calculations from the mean daily milk yields from the different locations showed that the 305 days lactation yield would range from 3040 to 3739 litres/year and an average of 3389 litres/year. The milk yields were significantly different between the wards (P<0.05). A larger proportion of farmers from the 2 wards in Othaya had higher milk per yield per cow than Mathira East. This difference was attributed to good feeding regimes in Othaya where more farmers fed combination of roughages, concentrates and minerals. There were also more Friesian cows and better trained farmers in Othaya. Average milk production in Kenya has been reported to range from 7-9 litres/cow/day compared to 19 litres of milk/cow/day in South Africa (KDB, 2016). The milk production in the study area is much lower than expected as there were many Friesians and Ayrshires breeds that are known for high milk production.

The average lactation length was recorded as 10.0±4.9 months in the current study. The longer lactation length would be expected to lead to longer calving interval. The ideal lactation length should be 305 days in order to achieve a calving interval of 365 days. The average lactation length realized in this study was about 300 days which would be expected to achieve the 365 days CI. The calving interval of 365 days was not achieved in the present study because of poor feeding which leads to delayed heat and infertility sometimes. Short lactation lengths can be explained by poor feeding of dairy cows during early lactation and probably during last two months of gestation, dry period, when the cow builds up body reserves to support high milk production in subsequent lactation (Wafula, 2018). The resulting low milk production prompted some farmers to dry their cows within 5 months of lactation. Wafula, (2018) reported a similar average lactation length of 300 days in Meru County. He further observed that milk yield and lactation length were influenced by good management, feeding, herd fertility management, calf rearing and health of the cows. Performance of dairy cows including lactation yield in Kenya is influenced by type of breeds, short lactation period, quantity and quality of feeds (Wanjala and Njehia, 2014).

The major challenges were feed related and included fodder/feeds shortages and the high cost of feeds. The shortage of feeds was especially acute during the dry season as was noted at the time of data collection resulting in low milk production. More farmers in Karima ward of Othaya sub-county mentioned milk prices as a major constraint compared to others as prices were low at the time of data collection and buyers (mostly processors) took long to pay. Njonge (2017), listed the challenges of dairy farmers in Kirinyaga County, Kenya, as feed shortages (77 %), land availability (10 %), diseases (6.3%) and worms (5.4%). A study conducted in Nyandarua and Nakuru Counties in Kenya reported lack of milk coolers, inadequate training, poor breeds, insufficient credit institutions and inbreeding due to poor breeding (Gitau, 2013).

The losses through diseases could have been through infertility, involuntary culling, a reduced feed intake thus lower milk production, treatment costs and mortality in heavily parasitized animals (Mceod, 1995). The effects of these infections, even when the worm load is low, can be aggravated by other factors which cause stress, such as frequent drought or concurrent infections which may be present in such areas. Low levels of infection in Uganda was described as the most economically important form of infection that may lead to unthrifty animals which become more susceptible to other infections (Ocaido *et al.,* 1996).

To overcome these challenges, farmers came up with various coping mechanisms which included purchase of fodder and crop residues among others. Rukundo (2018) reported that farmers fed crop by products, reduced amount of feeds, purchased fodder and crop residues during the periods of feeds shortages to cope with the challenge.

Conclusion

The main dairy production system in the study site was intensive system where cattle were stall fed through the cut and carry method and the dominant fodder was Napier grass. The common breed of dairy cattle was Friesian and breeding method was mainly artificial insemination. Majority of dairy calves were fed colostrum within 0-6 hours after calving and calves weaning was mainly at three months in the study area. Age at first service and first calving were longer than expected in the study area. The reproductive and productive performance of dairy cattle was poor than expected and this was attributed mainly to feed shortages. This was confirmed by linear regression model, with positive association between milk production and quantity of concentrate fed to dairy cow during early lactation. It implied that increased concentrate (4-6 kg per cow/day) increased litres of milk produced in the study area. With linear regression model, milk production, AFS, CI and reproductive have shown positive interaction with proper feeding and negative association with the other factors such as breeds and diseases. To improve age at first service, age at first calving, reproductive and productive performance of dairy cattle, stakeholders should consider training smallholder dairy farmers in dairy calves, heifers, cows management and feeding practices. Feed availability and cost together with farmgate prices of milk should be addressed.

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