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Performance and Genotypes of Dairy Goats in Kenya: Lessons Learnt and the Need to Move beyond Donor Introductions

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Abstract: A study was conducted in three cluster regions in Kenya where the Alpine, Toggenburg and Saanen dairy goat breeds, respectively, were kept. The objective was to determine the breeds' relative performance for use as a basis of their recommendation to farmers. Formal questionnaires were used to obtain information on farm sizes, dairy goat sources, reasons for keeping the dairy goats, goat milk production, amount of feed offered to the goats and the constraints faced. Further information on the actual milk production and live weights of the milking does was collected directly from the farms using hired recorders. Results indicated that the dairy goats were fed between 6 kg/goat/day and 17 kg/goat/day of forage. They had a low production average of 1.4 L milk/goat/day with no clear cut breed differences. Toggenburg milking does were significantly ($p < 0.05$) heavier than the other breeds (48.3 vs. 38.0 and 39.0 kg for the Alpine and Saanen dairy goats, respectively). The milk production and goat live weights were below their reported potential. Feed shortage in the dry season was a major constraint. It was concluded that farmers could keep any of the three breeds. It was recommended that data on the comparative performance from the three breeds be generated to guide on farmer choices. Governments receiving donor support on agricultural endeavours should put in place the technical and policy mechanisms to support the ventures after the donor exits, and also ensure recommendations by different donors on a technical issue are consistent and complementary.

Key words: Dairy goats, goat genotypes, goat milk, goat weights, Kenya.

1. Introduction

Goats (*Capra hircus* Linnaeus) were among the first animals to be domesticated [1, 2], and they are adapted to a wide variety of weather conditions [3]. They are an essential source of meat, milk, skins, fibre [2, 4], and they are also used for social functions. Goat milk is an important source of animal proteins and calcium [5, 6]. The milk is used by more poor people in the world than cow milk [7-9], and especially where cow milk is not available or not affordable to the rural poor [5]. Goat milk has gained attention and has increasing demand in the world due to the health and nutritive benefits to humans, attributed to the milk and its products [6, 7]. With cardiovascular diseases being the leading cause of death in the world [10, 11] while the cancer burden is increasing due to ageing and changing lifestyles [12], goat milk would be of much relief as it has anticarcinogens and other agents useful in preventing coronary heart disease [13]. Despite the recognized benefits of goat milk, its production in the world does not meet the demand. In China for instance, cow milk still dominates the infant formula market due to goat milk shortage [14]. There are over one billion goats in the world, with dairy goats being about 218 million [15].

In Kenya, there are about 28 million goats [16] of which about 502,044 are the dairy type [17]. The dairy goat breeds include the Alpine, Toggenburg, Saanens and Anglo-Nubian while the indigenous breeds are

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mainly the Galla and the Small East African goat [18]. However, the term dairy goat is more frequently used to refer to the dairy goats and their crosses with the indigenous goats [19]. There is currently a rising demand for dairy goats and their products in the country [20], due to their ability to earn income [21] through the sale of breeding stock and milk, and the decreasing farm holdings making it difficult to keep dairy cattle [22]. The dairy goats were first introduced in Kenya in the 1950s by the British settler farmers [23]. Subsequent introductions were through the collaboration between the Government of Kenya (GoK) with donor agencies, or by non-governmental organizations (NGOs), to upgrade the local goats for meat and milk. The agencies included the German Agricultural Team (GTZ/GIZ) in 1992-1999 [24], Farm Africa NGO in 1996-1998 [25], and Heifer Project International-Kenya (HPIK) in 2005, among others. Different dairy goat breeds were introduced by the agencies in the respective areas where the agencies operated. The agencies also targeted different genotype upgrade levels. The increased interest on dairy goats in the country has led to increased enquiries to the Kenya Agricultural and Livestock Research Organization (KALRO), on which breeds are suitable for the various farmers' localities. Milk production levels of less than 1.9 L/goat/day [20, 26] have been reported for dairy goats in Kenya. There has been no study on the relative breed or genotype performance of dairy goats in the country to guide on recommendations to farmers. Therefore, this study was conducted to determine the performance of the dairy goat breeds, and the genotypes kept by farmers in three cluster regions in Kenya, Central, Eastern and Nyanza clusters, as a basis for recommendation and as a part of a wider project to determine the research priorities for dairy goats in Kenya.

2. Materials and Methods

2.1 The Study Area

The study was conducted in the Central, Eastern and Nyanza clusters in Kenya, in high to medium agricultural potential areas [27-29]. Nine agro-ecological zones (AEZs) were covered; four in each of the upper (U) and lower (L) midland (M) zones, and one in the inner lowland (IL) zone. The Central cluster included farmers in Kirinyaga and Embu counties, where Alpine breed of dairy goats was introduced by the GTZ. The cluster area lies at an altitude of 1,090-1,880 masl, longitude of 37°7′-37°41′ East, and latitude of 0°9′-0°47′ South [27, 28]. The mean annual rainfall and temperature ranges were 836-1,800 mm and 16.7-23.4 °C, respectively. The Eastern cluster included farmers in Meru and Kitui counties, where Toggenburg breed of dairy goats was introduced by the Farm Africa NGO. The area has an altitude of 760-1,800 masl, longitude of 37°5′-39°0′ East, and latitude of 0°10′ North to 1°47′ South [28]. The mean annual rainfall and temperature ranges for the area were 471-1,079 mm and 19.2-25.8 °C, respectively. The Nyanza cluster included farmers in Homa Bay and Migori counties, where Saanen breed of dairy goats was introduced by the HPIK NGO. The area has an altitude of 1,135-1,550 masl, longitude of 34°-35° East, and latitude of 0°20′-1°0′ South [29]. The mean annual rainfall and temperature were 800-1,800 mm and 20.4-22.7 °C, respectively.

2.2 Data Collection and Analysis

Three regional clusters were selected in 2013 using stratified systematic sampling [30], based on the predominant dairy goat breed kept. For each cluster, two counties were selected based on their history of having interventions on dairy goats with the subsequent formation of dairy goat farmers' associations. The respective dairy goat associations' officials and the livestock extension staff assisted the researchers in identifying farmers keeping dairy goats. Through face-to-face interviews with the farmers, data were collected on farm sizes, dairy goat numbers and sources, production systems, management, reasons for keeping the goats, and challenges faced by the farmers, using a formal questionnaire. A total of 205 questionnaires were successfully administered. Further data on the amount of feed offered, milk production, live weights of the does and exotic blood level of the milking does were collected from 10 to 16 farmers per county for one month, using two recorders per county. The weights of milking does and feeds offered were estimated using weighing balances. The volume of milk produced was measured using graduated plastic one-litre jags. The exotic blood level of the milking does was derived from the doe record cards. The study was conducted during the wet season.

Data were subjected to analysis of variance (ANOVA), using the general linear model (GLM) procedures of Statistical Analysis System [31]. The model for Nested Design [32] was used to analyze the data collected. Means were separated using the least significant difference (LSD) and Tukey's multiple comparison test.

3. Results

3.1 Respondents

Majority of the farmers (74%) were over 45 years of age, had formal education (90%) and about 58% were women. Farmers owned an average of 1.6 ha/household, mainly under the freehold land tenure (82.4%) system. Farm sizes were largest in the Nyanza cluster (2.4 ha) and smallest in the Central cluster (0.9 ha).

3.2 Livestock Kept

Farmers kept an average of five dairy goats per household, mainly under the zero grazing (82.5%) system. Farmers in the Nyanza cluster kept fewer ($p < 0.05$) dairy goats than in the other two clusters (4.0 vs. 5.8 and 6.2 for the Central and Eastern clusters, respectively).

3.2.1 Sources of Dairy Goats

Majority of the farmers obtained dairy goats through grants by donors or purchasing (Table 1). The main agency that supported dairy goats in the Central cluster was the GTZ, with the aim of upgrading the local goats to 87.5% pure Alpine for milk production. This was to mitigate the decreasing farm holdings for cattle dairying. In the Eastern cluster, the objective of the Farm Africa NGO was to avail nutritious milk and improve living standards of the resource poor farmers, especially women [25], using 75% Toggenburg goats. Dairy goats in the Nyanza cluster were supported by several agencies but HPIK was the main NGO. HPIK aimed to support orphans and widows, and boost their body immunity through goat milk. The donated or purchased dairy goats had exotic blood already, or were local goats that farmers subsequently upgraded using pure bucks originally provided by the donors. The genotypes of the dairy goats kept were therefore the various upgrades (Table 2).

3.2.2 Reasons for Rearing Dairy Goats

Majority of the farmers kept dairy goats to get nutritious milk, but income generation to raise standards of living was also important (Table 3). Improving the health of orphaned children was an important reason unique to the Nyanza cluster. Sale of offspring ranked higher than sale of milk.

3.3 Dairy Goats Feeding

Goats were offered between 6 kg and 17 kg of forage per goat per day, consisting of grasses and/or legumes. Farmers in the Eastern cluster fed more ($p < 0.05$) forage to their goats than those in the Central cluster. Concentrate supplementation was done occasionally, by 83% of the farmers. Piped water was the commonest (34.2%) source of water, and farmers in the Central cluster enjoyed shorter ($p < 0.05$) distances to water source (0.1 km) than in the other two clusters (1.0 km each).

3.4 Milk Production and Goat Weights

About 62% of the farmers milked one or two dairy goats producing 1.4 L milk/goat/day (Table 4). The

Table 1 Sources of dairy goats and percentage of farmers who obtained them in the three clusters.

Goat source	Frequency	Percentage of farmers				
		All clusters	Cluster			
			Central	Eastern	Nyanza	LSD
Provided by donor (through group)	106	53.8[a]	17.2[c]	49.0[b]	95.3[a]	13.69
Bought by farmer	90	42.2[b]	74.0[a]	47.9[b]	4.7[c]	15.50
Provided by farmer group	5	2.6[c]	4.7	3.1	0.0	7.60
Provided by donor and also bought	4	1.9[c]	5.7[a]	0.0[b]	0.0[b]	5.62
LSD		9.27				

LSD = least significant difference between means.
Means bearing different superscript letters (a, b, c) within a row (or within a column for all clusters) are significantly different ($p < 0.05$).

Table 2 Percentage of goats with the various levels of exotic blood for the goats whose milk was recorded at least once.

Cluster (breed)	No. of goats	Percentage of exotic blood						
		100%	96.9%	93.8%	87.5%	75%	50%	Total
Central (Alpine)	37	13.5	13.5	8.1	40.6	13.5	10.8	100
Eastern (Toggenburg)	92*	9.8	-	-	7.6	39.1	43.5	100
Nyanza (Saanen)	38	92.1	-	-	-	7.9	-	100
Total	167	29.4	3.0	1.8	13.2	26.3	26.3	100

* Kitui county had three recorders and additional goats got recruited as the previous ones were dried off.

Table 3 Reasons for rearing dairy goats and percentage of farmers acknowledging each in the Central, Eastern and Nyanza clusters, Kenya.

Reason	Frequency	Percentage of farmers					
		All clusters	Cluster				
			Central	Eastern	Nyanza	LSD	SEM
Nutritious milk for home consumption	146	80.8[a]	51.5[b]	98.4[a]	84.4[a]	15.23	3.66
Raise standards of living	103	58.6[b]	0.0[c]	98.4[a]	60.9[b]	10.64	5.05
Sale of offspring	99	53.3[b]	44.7[b]	98.4[a]	14.1[c]	14.83	4.96
Sale of goat milk	91	48.3[b]	19.6[b]	98.4[a]	18.8[b]	14.61	5.05
Support orphans and boost body immunity	46	27.1[c]	0.0[b]	0.0[b]	81.3[a]	9.62	4.44
Consumes less hence easier to manage than cow	10	5.4[d]	18.1[a]	0.0[b]	1.6[b]	8.05	1.82
Manure	5	2.3[d]	8.7[a]	0.0[b]	0.0[b]	5.34	1.13
MSD		16.89					
SEM		1.86					

MSD = Tukey's minimum significant difference between means; SEM = standard error of the mean.
Means bearing different superscript letters (a, b, c, d) within a row (or within a column for all clusters) are significantly different ($p < 0.05$).

production level agreed well with the recorded data of 1.3 L/goat/day. The milking does weighed 41.4 kg on average. However, the reported and recorded data did not agree on the cluster with the highest goat productivity for milk.

3.5 Goat Survival Rates (Mortality)

The number of dairy goats that died annually per household for the various age groups was 0.36, 0.12 and 0.46 for kids, weaners and adults, respectively. Weaners had higher ($p < 0.05$) survival rates than kids and adults. The number of deaths for the various age groups was not significantly ($p > 0.05$) different across the clusters.

3.6 Goat Breeding

Dairy goats were bred through the natural buck service, by 97.5% of the farmers, with artificial insemination

Table 4 Average daily milk production and weight of milking does by cluster and county, Kenya.

Cluster (breed)	Milk production (L/goat/day)		Recorded doe weight (kg)
	Reported (survey)	Recorded	
Central (Alpine)	1.1[b]	1.6[a]	38.0[b]
Eastern (Toggenburg)	1.2[b]	1.3[b]	43.8[a]
Nyanza (Saanen)	2.1[a]	1.2[b]	39.0[b]
LSD	0.33	0.12	3.42
SEM	0.07	0.03	0.71

Means bearing different superscript letters (a, b, c, d) within a column are significantly different ($p < 0.05$).

(AI) being used mainly in the Central cluster. A buck stayed in one station for an average of 19.5 months, and the buck rotation period was longer ($p < 0.05$) in Nyanza than in the other two clusters (29.4 vs. 16.0 and 17.4 months in the Central and Eastern clusters, respectively).

3.7 Constraints to Dairy Goats Production

The main constraints faced by dairy goat farmers included the inadequate feeds during the dry season (30.7% of the farmers), disease prevalence (30.2%), unorganized goat milk markets (23.1%), irregular market for live goats (17.5%), inadequate breeding bucks (10.4%) and low availability of veterinary officers (9.7%).

4. Discussion

Both the breed and genotype of the dairy goats kept in the respective clusters were influenced by the main donor supporting the goat introduction. The exotic blood level with the highest percentage of milking goats in the Central and the second highest in the Eastern clusters (87.5% and 75%, respectively) was the upgrade level targeted by the respective donors (Table 2). In the Nyanza cluster, where the main objective was to provide the community with goat milk, pure Saanen dominated. However, the dairy goats of all the breeds had lower average milk production (1.4 L/goat/day) than their potential, and milk production did not reflect differences in breed or genotype. The reported daily milk production potential for the Alpine and Toggenburg goats in temperate areas is 4.2-4.5 L and 3.0-3.98 L, respectively [33, 34]. That for Saanen is 3.0-3.9 L [34, 35] in the tropics and 4.9 L [33] in the temperate regions, indicating the superiority of the Saanen in the temperate regions. Milk production levels recorded in Kenya include 3.0 L for the Alpine [36] and 2.0 L for the Toggenburg [25]. The observed weights of mature does of 38.0, 43.8 and 39.0 kg for the Alpine, Toggenburg and Saanen goats, respectively, were lower than the reported potentials of 60, 45-50 and 50-65 kg for these goats, respectively [34, 35]. Both the milk production and growth potentials of the goats in all the clusters were not fully realized, but the Toggenburg breed almost achieved its weight potential and appeared superior, contrary to the expectation. On survivability, the various classes of the goats were similar across the clusters. It was therefore difficult to recommend one breed over the other using the dairy goat performance results.

Several factors could have led to the lower dairy goat performance than their potential. These include the lower acclimatization of dairy goats in the tropics compared to the temperate regions where they originated, the use of cross breeds mainly as opposed to the pure breeds used in the temperate regions, and the likelihood of lower intensity of management in the tropics. The differences in the observed and locally documented milk production levels were most likely due to lower management practices by the farmers. The goats were offered forage on the basis of feed availability without regard to proportion of grass or legume, and feeding was not based on nutrient requirements for milk production or body weight. This calls for development of rations that ensure adequate goat nutrition for high milk production, preferably using the locally available forages. This effort should be supported with capacity building of the extension workers and farmers on the principles of constituting such rations, as well as on forage conservation for use in the dry season. The lack of consistency by the survey and the recorded data on the county or breed with the highest milk production demonstrated that comparison of the three breeds under the same ecological zone and level of management is needed. The evaluation should extend to the suitability of genotypes considering that different donors targeted different genotypes in the Central (87.5% exotic) and Eastern (75% exotic) clusters. This would prevent conflicting messages, and take cognizance of the fact that milk production level of dairy goats is influenced by breed, genotype [6]; environmental management conditions [5]; month of conception [37]; herd, doe, and sire [38]. Indeed, Mburu *et al.* [36] reported interaction between dam grade and region for Alpine upgrades within Nyeri county in Central Kenya.

That the sale of offspring ranked higher than the sale of milk as a reason for rearing dairy goats corroborated the findings by the East African Agricultural Productivity Project's (EAAPP) Regional Dairy Centre of Excellence (RDCoE) [26] that the sale of breeding stock was the main source of income in the dairy goat enterprise. That 38% of the farmers never milked their goats implies that efforts are needed to promote goat milk consumption among the dairy goat keepers and the general public. This could be done by emphasizing the nutritional and health benefits of the milk, that arise from presence in the milk, of agents that: are anticarcinogenic [7, 13, 39-41]; offer cardiovascular protective effects [13, 42]; treat hyperacidity [43]; treat clinical disorders such as malabsorption syndromes, infant malnutrition, and epilepsy [7]. The poor market organization for goat milk could also have discouraged the farmers from feeding the goats for higher milk production or even from milking. During the study, a group of farmers in the Eastern cluster had threatened to abandon the dairy goat enterprise when the regular goat milk buyer gave a notice of stopping milk collection. Indeed, negligence of dairy goats by some farmers in Central Kenya was reported by Mburu *et al.* [36] after the farmers failed to realize the expected benefits. Further, shortage of agricultural extension officers exacerbated the farmers' laxity to the proper rearing of the goats, an observation also made by Mburu *et al.* [36]. Strengthening of farmer groups through availing government officers to oversight on transparency and sound management of the farmer associations by the office bearers could enhance group stability for joint endeavours, such as market negotiations and milk value addition into more premium and storable products for a wider market clientele. Governments could further support goat milk processors and transporters to start businesses on goat milk through such ventures as loans, grants or favourable tax regimes.

The long buck rotation period, especially in the Nyanza cluster (29 months), could be attributed to the scarcity of breeding bucks that also exposed the goats to inbreeding, and the resultant low mature body weights. The inbreeding problem was already reported by Marete *et al.* [44] for the Alpines in Kenya. In this study, it was noted that only a small proportion of farmers (2.5%), mainly in the Central cluster, had benefited from the AI service. The government could target availing breeding bucks in the short term, and fast track the AI service in the long run, which would also widen the genetic base of the dairy goats. Prevalence of diseases and high cost of disease control as a constraint was in agreement with observation by Ademosun [45] for small ruminant production in Africa. Shija *et al.* [46] reported that helminthiasis and pneumonia were the most prevalent in small ruminants. Provision of timely animal health services is necessary, and in an environment of declining government veterinary service support as in Kenya, strengthening of community animal health workers together with legislation support to legalise their practice is required. In addition, more research is needed on incorporating disease resistance traits in breeding programs as suggested by Bett *et al.* [47], to lower the effect of diseases.

While appreciating the donor agencies for their efforts to improve the nutrition, food security and income generation avenues for the communities, there is need for the recipient governments to design long-term strategies that support the targeted sectors for citizens to benefit from such donor endeavors. In the dairy goat subsector that was targeted, it was evident that the government's role was limited to facilitating the donor agencies to access the farmers. There is need for governments to play a bigger role in supporting the enterprises for which there is donor goodwill, for sustainability of the gains following donor exit. In this Kenyan case, such support should be on the development of feeding and disease control strategies to optimize goat production through research, supporting the breeding of goats at community level by availing bucks or the AI service, public capacity building on the beneficial value of goat milk, providing conducive policy environment for investment on goat milk marketing and for operation of animal health workers, and supporting sound management of dairy goat farmer groups. The high involvement of women in the dairy goat enterprise implied its enormous potential to empower them economically. The enterprise further can create employment for the youth and other marginalized or vulnerable groups like the elderly and the sick, as they can easily tend the goats. With the majority of the farmers having free hold land tenure and being more than 45 years of age, the farmers had a free hand in making long-term decisions on farm investments like fodder production, and are also likely to have resources for the dairy goat enterprise.

5. Conclusions

The dairy goat enterprise has the potential of improving food security and income generation in developing countries through milk and meat for consumption, and milk and live goats for sale. However, in Kenya, information available on dairy goat production and survival rates as the determinants of the breeds and genotypes for recommendations to a region, did not favour any breed over the others, hence farmers could keep any of the three breeds. Milk and meat production by the dairy goats was below the potential of the goats and had no breed or genotype differentiation in terms of performance, therefore more research is needed, taking into account the genotype by environment interaction, to generate information for appropriate recommendations on what types of goats to keep, and their expected performance. Donors and NGOs played a leading role in availing the dairy goats to farmers. For such donor-supported livestock improvement ventures in the developing countries, there is need for the recipient governments to put in place the technical and policy measures that support the donor endeavours before or while the donor is in place, for full realization of benefits from projects after donor exit. Also, for a particular agricultural intervention by more than one donor and at different times, the recipient government should ensure harmonization of the recommendations to be used by farmers and extension officers for consistency and complementality with the existing recommendations, to avoid conflict in messages delivered by extension officers.

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