Small Ruminant Research 144 (2016) 176–183

Contents lists available at ScienceDirect

Small Ruminant Research

journal homepage: www.elsevier.com/locate/smallrumres

Breeding systems for genetic improvement of dairy goats in smallholder production systems in Kenya

A.A. Amayi[a,*], T.O. Okeno[a,b], M.G. Gicheha[c], A.K. Kahi[a]

[a] Animal Breeding and Genomics Group, Department of Animal Science, Egerton University, P.O. Box 536, 20115 Egerton, Kenya
[b] Center for Quantitative Genetics and Genomics, Department of Molecular Biology and Genetics, Aarhus University, P.O. Box 50, 8830 Tjele, Denmark
[c] Department of Animal Sciences, Jomo Kenyatta University of Agriculture and Technology, P.O. Box 62000, 00200 Nairobi, Kenya

ARTICLE INFO

Article history:
Received 17 September 2015
Received in revised form 8 April 2016
Accepted 21 September 2016
Available online 22 September 2016

Keywords:
Breeding systems
Dairy goats
Smallholder systems

ABSTRACT

A deterministic simulation model was used to test the hypothesis that utilization of untested juvenile bucks could be an alternative to old buck strategy in dissemination of superior genetic materials in dairy goats breeding program. We compared the genetic and economic gains realised when the untested juvenile and old bucks were used to disseminate genetic materials in a two-tier closed and open nucleus breeding systems. In the untested juvenile buck strategy, 95 and 70% of nucleus and commercial does, respectively, were mated to the untested juvenile bucks. In the old buck strategy, all the females in the nucleus and 70% of commercial does were mated by old bucks from the nucleus. In the open nucleus system, 20% of the does born in the commercial sector were recruited into the nucleus to produce nucleus does of does. Utilization of untested juvenile bucks realised 5.92 and 7.30% more annual returns and profitability per doe, respectively compared to old buck strategy. The old buck strategy, however, outperformed untested juvenile buck strategy by 23.37 and 14.85% in total annual genetic gain in closed and open nucleus breeding systems, respectively. Comparison between closed and open nucleus breeding systems demonstrated that open nucleus systems are superior to closed nucleus systems both in genetic and economic response. These findings therefore demonstrate that untested juvenile bucks could be an alternative to old buck strategy when economic viability of the breeding program is the main focus. There is, however, need to strike a balance between economic and genetic gains in the breeding program.

1. Introduction

The potential of dairy goats to uplift the living standards of the resource poor rural households in developing countries has been recognised. In Kenya for instance, both government and non-governmental organizations have been actively involved in promotion of dairy goat production in medium-high potential agricultural areas (Bett 2009; Ogola et al., 2010). These areas have been the main focus due to favourable climatic conditions and increasing human population resulting in frequent land divisions. The land parcels in these areas are currently too small to support meaningful dairy cattle or crop production. The increasing human population, however, is an important market base for goat products. To supply this expanding human population with goat products, exotic breeds have been used for dairy goat production (Bett et al., 2009).

The current dairy goats population in Kenya has been estimated at 175 000 (Shivairo et al., 2013). This population mainly consist of exotic dairy goat breeds such as the German Alpines, Toggenberg, Anglo-Nubian, Saanen, Boer and their crosses with indigenous goats (Ahuya et al., 2005; Krause, 2005; Bett et al., 2007). These breeds are raised under three production systems defined based on agro-ecological zones and management regimes. They include smallholder low-potential (SLP), smallholder medium-potential (SMP) and smallholder high-potential (SHP) (Bett et al., 2007; Shivairo et al., 2013). These production systems are characterised by extensive, semi-intensive and intensive management systems, respectively. The SLP and SMP production systems mainly rely on SHP as source of breeding and replacement stocks. The SHP on the other hand, produce their own replacement stock either within their own flocks or collaborate with non-governmental organizations to import pure or crossbred exotic dairy goat breeds (Ahuya et al., 2005; Bett et al., 2009; Ogola et al., 2010). This implies that, the SHP has the elite flocks and therefore determines the genetic progress realised in SLP and SMP production systems. The SLP and

* Corresponding author.
E-mail address: amayi.alex@gmail.com (T.O. Okeno).

http://dx.doi.org/10.1016/j.smallrumres.2016.09.017
0921-4488/

SMP production systems mainly purchase culled bucks from SHP to use for breeding in their flocks. Conversely, the females are rarely traded between the three production systems as they are raised as replacement stock within each system. This makes sense due to small population of dairy goats in Kenya (Shivairo et al., 2013). The dissemination of genetic materials from SHP to SLP and SMP depicts a closed nucleus breeding program as SHP do not import genetic materials from SLP or SMP.

Designing a structured nucleus breeding program involves description of production systems, definition of breeding objectives, choice of breeding systems and breeds, evaluation system and dissemination of superior genetic materials (Harris et al., 1984). Such programs are scarce in developing countries (Kahi et al., 2010; Rege et al., 2011; Bett et al., 2012). Fortunately, in Kenya the dairy goat production systems have been described, breeding objectives developed and systems designed (Bett, 2009). The appropriate strategy to disseminate the superior genetic materials, however, has not been developed. Currently, culled old bucks from SHP are used for breeding in the SLP and SMP production systems. The genetic and economic merit of using these old bucks has however not been established. Therefore, there is need to investigate the genetic and economic worth of old buck strategy in comparison with alternative strategies utilising untested juvenile bucks.

We believe that use of untested juvenile bucks could result in higher genetic and economic gains in smallholder dairy goats production systems compared to the culled old bucks in dissemination of genetic materials from the nucleus to the commercial population for two reasons. First, the untested juvenile bucks could be ranked based on a *priori* information from relatives and high ranking candidates selected for breeding at early age. This will reduce the long generation interval associated with waiting for bucks to be culled from SHP besides waiting for information from their offspring to select them. Secondly, there would be high return to investment as it has been demonstrated that the genetic gains obtained in the early years of a genetic improvement can provide more rapid return to invested capital than gains realised in later years (Gicheha et al., 2007). Following this reasoning, we used deterministic simulation to test our hypothesis. We simulated a two-tier nucleus breeding system resembling that practiced by dairy goat producers in Kenya. We assumed that SHP is the elite flock (nucleus) and SLP and SMP are commercial flocks. The economic and genetic efficiencies of the system were evaluated based on the use of old and untested juvenile bucks to disseminate genetic materials from the elite to commercial population. The two strategies were compared assuming closed and open nucleus breeding systems.

2. Material and methods

2.1. Procedure

We used deterministic simulation model to evaluate economic and genetic efficiencies of utilizing either old or untested juvenile buck strategies to disseminate genetic materials in two-tier closed and open nucleus systems. A two-tier closed nucleus breeding system using old bucks to disseminate genetic materials from the nucleus to commercial population was considered as the reference system. The alternative systems considered were two-tier closed and open nucleus systems utilizing untested juvenile bucks to disseminate genetic materials from the nucleus to commercial populations. The economic and genetic gain per doe per year of each system was used as indicators of response to selection upon which systems were compared.

Table 1
Phenotypic standard deviations (σ_p), economic values (V, KSh.), heritabilities (along diagonal), genetic (above diagonal) and residual (below diagonal) of traits in the breeding goal.

Trait[a]	σ_p	h2	V (KSh)	MY	LW	DMW	NKW	SR	DWG
MY	3.01	0.38	20.90	–	0.34	0.09	0.38	0.00	0.07
LW	2.93	0.26	71.61	0.08	–	0.40	0.29	0.00	0.40
DMW	4.08	0.58	2.12	0.16	0.40	–	0.33	0.00	0.44
NKW	0.94	0.15	13.68	0.08	0.10	0.09	–	0.00	0.09
SR	0.29	0.05	22.96	0.00	0.10	0.20	0.12	–	0.00
DWG	0.11	0.10	–	0.06	0.44	0.45	0.10	0.00	–

[a] MY, milk yield; LW, live weight; DMW, doe mature weight; NKW, number of kids weaned; SR, doe survival rate; DWG, daily weight gain.

2.2. Breeding goal

Maximization of returns to investment is the aim of every livestock breeding program and its first step is the definition of the breeding goal (Ponzoni, 1986). Development of breeding goal involves identification of production systems, traits of economic importance and estimation of their economic values. The breeding goals for dairy goats in Kenya have been defined under different smallholder production systems (Bett et al., 2007, 2011, 2012). The production systems included smallholder low-, medium- and high-potential. These systems represent typical dairy goat farming practices in Kenya. In the current study, the smallholder-high potential production system was considered as the elite unit, while the smallholder low-and medium-potential represented the commercial populations. The traits in the breeding goal in the three production systems considered included milk yield (MY), daily weight gain (DWG), live weight (LW), does mature weight (DMW), number of kids weaned per doe (NKW) and survival rate of the does (SR) (Bett et al., 2007). These traits had similar definitions in both production systems and subsequently, they have been adopted for the nucleus and commercial populations in this study. The MY was defined as average milk yield per doe per day; DWG the average daily weight gain from kidding to weaning. The LW and DMW were defined as the weight of the males and females at weaning and does weight at first service, respectively. The NKW was the number of kids weaned per doe per year and SR as the percentage of does serviced after the previous kidding. The economic values (EVs) for traits in the index were derived based on market dynamics implying that they were objectively defined (Bett et al., 2007). These EVs are expressed in Kenya shillings (KSh.), where KSh.100 is equal to 1US$. The traits in the breeding goal and their corresponding EVs are presented in Table 1.

2.3. Breeding systems, selection groups and information sources

A two-tier closed nucleus breeding system utilizing old bucks to produce offspring in the nucleus and commercial tiers was considered as the reference system against which the other systems were compared. This system assumed single directional flow of genetic materials from the nucleus to the commercial tier. The two-tier closed system was justifiable for two reasons. Firstly, it depicted the single direction flow of genetic materials from SHP to SLP and SMP production systems observed under Kenyan production systems. Secondly, it represents breeding systems in many tropical countries (Gicheha et al., 2006), where big farms (nucleus) act as closed elite populations, while the smallholder and pastoral systems form the lower tier. In the current study therefore the SHP population was considered to be the closed nucleus. The main activities in the nucleus included performance and pedigree recording, genetic evaluation, selection and mating decisions. The genetic gain was therefore generated within the nucleus. Although, there is no selection in the commercial sector, genetic progress realised was