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Optimum crossbreeding systems for goats in low-input livestock production system in Kenya

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ABSTRACT

The aim of the current simulation study was to maximize the amount (kg) of high value meat arising from surplus males and females per kilogram of the goat population and, maximize weight gains to turnoff age. Subsequently, the study aimed to decrease turnoff age, maximization of reproduction rates and minimization of the mature weight of does in the low-input livestock production system in Kenya. Three crossbreeding systems and a synthetic breed development were evaluated, namely; (a) straight breeding system that utilized pure Small East African goat (SEAG) where parental lines were maintained to generate the desired terminal crosses, (b) three-breed crossbreeding system that utilized SEAG as pure breed, Galla goat (GG) as the first cross sire breed, and Improved Boer goat (IBG) as the terminal sire, (c) two-breed rotational crossbreeding system where the SEAG and IBG were purebreds, and (d) synthetic breed development system utilizing SEAG × IBG. The HotCross crossbreeding simulation software was used to assess the predicted performance of the different goat breed crosses under conditions of agro ecological zones (AEZ) V and VI. A model was developed to compare these crossbreeding systems, and showed the optimum numbers required in each stage of a cross to maximize production. In the AEZ V, it was found that the three-breed terminal system gave 18.2 kg (76%) improvement over straightbreds per doe mated per year. The multi-breed composite realized 20.4 kg (86%) improvement over pure SEAG. In the AEZ VI, it was found that the three-breed terminal system gave 10 kg (64%) improvement over straightbreds per doe mated per year. The multi-breed composite realized 14.6 kg (94%) improvement straightbreds per doe mated per year. The two-breed rotation was worse than the multi-breed composite in both environments. This implies that in low-input livestock production system, a multi-breed composite may be the crossbreeding system of choice, so long as supportive infrastructure is put in place.

1. Introduction

Crossbreeding has been widely used to improve productivity of various goat breeds in low-input smallholder production system (Peacock et al., 2011; Sousa et al., 2011; Mohamed et al., 2012; Buckley et al., 2014). Desirable effects of crossbreeding are heterosis and the utilization of differences between breeds to optimize genetic

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merit of different traits under various environmental conditions (e.g., Mohammed et al., 2013; Mestawet et al., 2014). Genetic variation that exists between and within breeds can be harnessed to produce genotypes that are better suited to the specific production environment and, for existing and future markets. Distantly related breed groups, for examples one which is tolerant to environmental stresses and the other, with high productive attributes can be crossed to produce a well adapted and productive animal (e.g., Haile et al., 2011; Rege et al., 2011).

In smallholder production systems in Kenya, crossbreeding programmes have been used as means of improving the production efficiency of goat breeds and have resulted in crossbred genotypes with different proportions of genes from the foundation breeds (Ahuya et al., 2009; Peacock et al., 2011). Several development agencies have implemented projects aimed at improving production and productivity of local goats using the exotic goat breeds as sires (Bett et al., 2011; Peacock et al., 2011). For example, the Small Ruminant Collaborative Research Support Programme (SR-CRSP) funded by the United States Agency for International Development which aimed at developing a dual purpose goat that would produce milk and meat (Bett et al., 2009). The purpose of which was to improve the on the nutritional and economic welfare of the small-scale farmers. FARM Africa introduced the Toggenburg goats for crossing with indigenous breeds to maximize on its growth, reproductive and milk traits (Ahuya et al., 2009).

In general, use of 2 breeds, 3 and 4 breeds to produce 2-way, 4-way breed and different proportions of the contributing breeds have been attempted (i.e., $1-(1/2)^n$) (Bett et al., 2009). However, most commonly practiced crossbreeding system has been the “upgrading” of indigenous breeds to higher exotic grades, because it is logistically simpler and easier to implement.

In Kenya, the majority of indigenous goats are predominantly kept under pastoral production systems in the arid and semi-arid lands (ASALs), which are classified within agro ecological zones (AEZ) IV, V and VI (Otte and Chilonda, 2003). Livestock genetic improvement programmes in pastoral systems are uncommon for good reasons, more so those involving crossbreeding. However, examples exist in other areas where crossbreeding have been attempted, but most of which disastrously failed (see e.g., Rege et al., 2011). A notable successful example of a crossbreeding programme is however that of Small East African goat (SEAG) × Galla goat (GG) in the eastern ASALs of Kenya (Njoro, 2003). The farmers in Kathekani location formed breeder groups and targeted the GG buck rather than the doe for crossbreeding with the SEAG. The motivation behind the success was the incomes realized where the SEAG of 25 kg live weight fetched US$ 20 whereas the SEAG × GG of 45 kg live weight attracted US$ 67 (Njoro, 2003). However, it will be important to evaluate this programme and establish whether, indeed, the 20 additional kg live weight among the crossbreds was sustained over the generations or was just the superiority of the F1s.

Generally, the consideration of basic aspects connected with the design and success of breeding programmes could be helpful. These include; the production environment and systems, the available local genotypes, market demand and environmental potentials that define breeding objectives. Additionally, suitable approaches for establishing sustainable and pragmatic site specific breeding programmes for goats, which allow a permanent evaluation of the improvement process, are important (Visser and van Marle-Köster, 2014). The traditionally well-established community organizations are seen as suitable candidates to handle breeding schemes, provided that a sound market-oriented research and technical assistance integrates management, nutrition, health and transformation.

The aim of the current simulation study was to maximize the amount (kg) of high value meat arising from surplus males and females per kilogram of the goat population and maximize weight gains to turnoff age. Subsequently, the study aimed to decrease turnoff age, maximization of reproduction rates and minimization of the mature weight of does in the low-input livestock production system. The study adopted simulated alternative crossbreeding systems with a view to recommending the most appropriate breeding system.

2. Materials and methods

2.1. The agro-ecological climate

The study was set out to evaluate through simulation, a goat crossbreeding programme in Kenya's ASALs using the HotCross model (Newman et al., 2000). Kenya has a total area of about 582,646 km^2, with about 1.9% under water. The dry land mass is commonly divided into six AEZs based on food crop growing period, temperature regime and soil mapping unit (Otte and Chilonda, 2003; Republic of Kenya, 2010). Over 80% of the country comprises the ASALs that are predominantly inhabited by the pastoralists and agro-pastoralists. Kenya's ASALs support about seven million people and more than 50% of the country's current livestock population (Republic of Kenya, 2010). These areas, also classified as rangelands, are unsuitable for rain-fed agriculture due to inadequate precipitation and land degradation. This study targeted two distinct AEZs (i.e., zones V and VI) among the predominant Rendille pastoral community in northern Kenya.

2.1.1. The agro ecological zones (AEZ) V

The AEZ V is drier and experiences annual rainfall of between 300 and 600 mm. The short trees and shrubs found here that form goat feed include *Acacia mellifera*, *Acacia tortilis*, *Acacia horrida*, *Acacia reficiens*, *Acacia nubica*, *Acacia paslii*, *Acacia zanzibarica*, *Adansonia digitata*, *Terminalia prunioides*, *Dobea* spp., *Dioppspyros* spp. and *Commiphora* spp. (Roba and Oba, 2009). The common grasses found in this zone include *Eragrostis superba*, *Cenchrus ciliaris*, *Cymbopogon* spp., *Bothriochloa* spp. and *Heteropogon contortus.* These browse trees and shrubs are highly nutritious and provide valuable crude protein and digestible organic matter thus supplementing the nutrient-deficient rangeland grasses to the animals on a continuous basis.

2.1.2. The agro ecological zones (AEZ) VI

The AEZ VI is considered as semi desert and forms the driest part of Kenya. It experiences an annual rainfall of 200–400 mm, which is quite unreliable. This area experiences uneven rainfall distribution leading to wide fluctuations in the quantity and quality of herbage material available to animals. In this zone *Acacia* and *Commiphora* shrubs are dominant. Other important taller shrubs found in this zone include *Delonix elata*, *A. tortilis* and *A. digitata*. *Balanites eagyptica*, *Boscia coriacea*, Salvadora persica, *A. mellifera* and *A. reficiens* (Roba and Oba, 2009). Common and important dwarf shrubs found in this zone are *Indigofera spinosa* and *Sansevieria* spp. Shrubs e.g., *Sericocomopsis*, *Barberia* and *Duosperma eromophylum* are found in this area. Grasses that may occur as annuals or perennials include *Aristida adoensis* and *Stipagrostis hirtigluma* (Roba and Oba, 2009). Quality of herbage material decreases considerably during the dry season and, consequently, rumen dry-matter digestibility of forages by goats is reduced (Guerrero-Cervantes et al., 2009).