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Inbreeding depression and simulation of production potential of the communally raised indigenous Xhosa lop eared goats

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ABSTRACT

This study was conducted to determinelevels of inbreeding depression of indigenous Xhosa lop eared goats and their impact on reproduction. Data was obtained through a monitoring study on 100 households with average flock sizes of52 (Bushveld) and 25 (Grassveld) in the Eastern Cape Province of South Africa. The DynaMod model was used to simulate future trends of both current and improved goat production scenarios. Goat class distribution was characterised by few bucks and high doe proportions across all the villages. Breeding ratio (0.1) was above the recommended 0.04 in both areas despite lack of buck ownership in most households. Generally, the goats in both areas had a low reproductive performance. There was low kid survivability of multiple births as higher prolificacyin the Grassveld flockscoincided with increased kid mortality. The improved production simulation of the Grassveld indictated a possibility of genetic unfitness in its flocks. This was validated by high increase in ΔFexceeding the acceptable threshold of 0.063. The $N_e$was below 50 in both areas hence this indicated an endangerment to the existence of indigenous Xhosa lopeared goats. The negative relationship between N_e and fecundity showed that inbreeding depression was reducing flock fertility. The study concluded there were high levels of inbreeding in Xhosa lop eared goats which resulted in low reproductive performance and increased kid mortality.

1. Introduction

Xhosa lop eared goat is an indigenous goat breed from the Eastern Cape Province in South Africa. It was used in the development of the Boer and Kalahari red goats (Du Toit, 2008), which have become prominent commercial breeds. The Xhosa lob eared goat, has however,remained unpopular in the commercial sector. The breed is owned by the majority of communal farmers. In addition to the Xhosa lop ear goats, communal farmersrear Boer goats and their crosses (Slayi et al., 2014). These goats play a pivotal role in the social and economic livelihoods of small-scale farmers.

Most of the communal farmers own small goatflocks of between 2 and 100 goats and do not have breeding management expertise; hence there is high chancein mating of related animals (Mahanjana and Cronjé, 2000). This situation is further worsened by prolonged stay of older breeding males in the flocks and failure to retain young bucks (Masika and Mafu, 2004; Kosgey et al., 2006). Furthermore, the introduction of Boer goats so as to improve productivity in communal goat flocks has increased genetic corrosion of indigenous goat breeds. Accroding to Tada et al. (2013), indiscriminate crossbreeding and increase in inbreeding pose a major threat to the existence of local indigenous breeds. It is crucial to control inbreeding and conserve genetic diversity of the indigenous Xhosa lop eared goat breed (Shrestha and Soysal, 2010; Rashidi et al., 2014). A successful genetic improvement program requires accurate genetic parameter estimates(Moghbeli et al., 2013).An understanding of environmental and genetic factors affecting production traits of farm animals is necessary to design optimal breeding and selection programmes (Zamani et al., 2015).The effects of poor breeding programmes which consequently result to inbreeding depression have caused loss of viability, fertility and disease resistance in locally adapted breeds (Taberlet et al., 2008; FAO, 2011). Some molecular studies to charcterise local goat breeds (Martinez et al., 2004; Hassen et al., 2012; Jnied et al., 2013) have since been conducted however the Xhosa lop eared goats are yet to be investigated.

Research on breeding and genetics of indigenous goat breeds in South Africa is limited hence it is difficult to conduct conservation programmes. Despite some communal goat research studies mentioning the possibility of inbreeding depression in indigenous goats (Webb and Mamabolo, 2004; Masika and Mafu, 2004; Rumosa-Gwaze et al., 2010), no efforts have been done to quantify levels of

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inbreeding depression and their impact on goat productivity. Information regarding productivity of indigenous goats is also scarce while the few available reports are now old and were mostly obtained under controlled environments (Webb and Mamabolo, 2004). Although Rumosa-Gwaze et al. (2010) computed economic indices for indigenous goats, their potential is still not fully understood. The use simulation models could give a basis of comparison between the current and improved production scenarios (Lesnoff, 2007). This would enable precise assessment on impact of the intended mitigation strategies as well as identification of other possible unforeseen constraints which may exist in future production trends. The objective of this study was, therefore, to determine levels of inbreeding depression and their impact on productivity of indigenous Xhosa lob eared goats.

2. Materials and methods

2.1. Study site

The study was conducted in two ecologically different areas in the Eastern Cape Province. Port St. Johns, a Bushveld area, is located under the O.R Tambo District municipality. It is characterised largely by Savanna and Indian Ocean Coastal Belt biomes and some few parts of the grassland (South Africa National Biodiversity Institute SANBI, 2012). It receives mean rainfall of 1250 mm, mainly in summer with a mean summer temperature of 22.5 °C and mean winter temperature of 14.5 °C (South African Explorer, 2014). It is characterised by a moderate, humid and subtropical coastal climate. The villages selected for this study in this municipality were Majola and Bizana. The Umnquma local municipality,a Grassveld area,is located under the Amathole District Municipality. It is characterised largely by Savanna and Grassland biomes and some few patches of the Indian Ocean Coastal Belt and Albany thicket (SANBI, 2012). It receives mean rainfall of 596 mm, mainly in summer with a mean summer temperature of 25.6 °C and mean winter temperature of 19.2 °C (South African Explorer, 2014). The villages selected for this study in this municipality were Izibityolo, Klanisi and Mission.

2.1.1. Animal management

The goats from both Bushveld and Grassveld flocks were penned during the night in kraals. The does were exposed to the buck throughout the year as mating was not controlled. These goats browsed and grazed extensively for approximately 8 h per day with limited monitoring and no supplementation. Farmers made use of both traditional and convectional methods in preventing and controlling diseases. Conventional methods were often used in dipping and dosing of their goats but was sometimes erratic due to shortage of resources to purchase the drugs.

2.2. Data collection

Ethical clearance was granted by the University of Fort Hare ethics committee and a certificate (Reference number: MUC201SDUB01) was issued. All ethical considerations were observed during and after the data collection period.

A detailed data template was used to collect information on flock inventory. A total of 100 goat farmers were randomly selected to participate in this study. The Bushveld had 50 farmers from two villages (Majola and Bizana) while the Grassland had a similar number farmers from three villages (Izibityolo,Mission and Klanisi). The farmers were trained in filling out the template with assistance from the agricultural extension staff. Each of the selected farmers captured monthly inflows and outflows in and from their flocks. The goat flocks were monitored for a period of 12 months. The non-Fisherian sex-ratio effective population size (N_e) was calculated using a formula by Wright (1931) (Eq. (1)) and the levels of inbreeding per generation(ΔF) were calculated using the formula by Wright (1977) (Eq. (2)).

$$Ne = 4 * N_m * N_f / N_m + N_f \quad (1)$$

Where N_m and N_f are the number of breeding males and females; respectively.

$$\Delta F = 1/(2 * N_e) \quad (2)$$

2.2.1. The simulation model

The DynMod model (Lesnoff, 2007) was used to simulate goat population sizes inorder to assess their production potential. This model is a Microsoft Excel spreadsheet that simulates livestock population dynamics over a given time period based on parameters such as reproduction rates or mortality rates. The model parameters used for this study were flock sizes at the beginning of the observation period and reproduction rates (parturition, prolificacy) as inflows and mortality rates as outflows during the 12 month observation period.

A simulation of goat population sizes in both the current and improved productivity scenirios was conducted to determine the goat production potential within a 20 year period. The assumptions of the improved productivity scenario were that mortality was to reduce by 5% through practicing good husbandry techniques e.g. routine dipping and dosing, improved housing structures.

2.3. Data analysis

All the data were tested for normality using PROC UNIVARIATE of SAS (2003). To establish goat productivity the following parameters were computed; prolificacy, fecundity, weaning and mortality. PROC FREQ of SAS (2003) was used to generate frequencies for these productivity parameters.

The general linear model (GLM) procedure of SAS (SAS, 2003) was used to determine the goat class distribution and small population genetics parameters across five villages. The following model was computed:

$$Y_{ij} = \mu + \alpha_i + e_{ij}$$

Where;

Y_{ij} = (number of goats in different classes; Breeding ratio, N_e, ΔF)

μ = the common mean,

α_i = the ecological area effect (1,2)

e_{ij} = the random error.

Differences between means were separated using the Least Significance Difference (LSD) test of SAS. Correlations were used to establish the relationship between $N_e$and the productivity indicators.

3. Results and discussion

3.1. Goatflock class distribution

Flock class distribution (Table 1) in both areas was characterised by high breeding and non-breeding does, followed by kids, castrates and the least numbers being breeding and non-breeding bucks. The breeding males were fewer as compared to castrates as observed by other authors (Jaitner et al., 2001;Kosgey, 2004; Nigussie et al., 2015). This could be attributed to the fact that farmers prefer to sell castrates and this places a lower priority to male breeding animals. This result further supports the fact that extensive goat farming has a huge reliance on community bucks (Webb and Mamabolo, 2004; Gizaw et al., 2010). The high proportion of does observed