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Review

Sustainable Utilization of Indigenous Goats in Southern Africa

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Abstract: Goats have a key role in ensuring food security and economic livelihood to smallholder farmers in rural areas. Women play a vital role in goat rearing, promoting economic autonomy within households. Indigenous goats dominate and are of high significance due to their adaptive traits that are relevant for climate change and low maintenance. However, lack of emphasis on farmer-centered technology development and proper breed characterization remains a hitch to sustainable utilization and breed development of indigenous goats. This can be over come through proper linkage between market and production, workable regional and national agricultural policies, community breeding programs, collaborative research work within the region, and consistent government support.

Keywords: food security; goats; climate change; Southern Africa

1. Introduction

The Southern African region is a host to approximately 38 million goats [1]. About 70% of the goats are kept under traditional management systems where the farm structure comprises of about twenty (±20) goats. Goat productivity in this system is relatively low due to minimal inputs, poor infrastructure, undefined marketing channels and multiple breeding objectives [2,3]. Indigenous goatsare, however, the most popular breed due to their ability to cope with a range of climatic conditions including disease challenges, inadequate feed resources and low management [4]. These genetic resources are more crucial to livelihoods as climate change progresses and environmental changes arise. They provide nutrition and financial stability to poor resource households and play a vital role in the African culture.

Due to their adaptability, indigenous goats are found in a wide range of production environments in Southern Africa. Although goats as a strategic resource have contributed to sustainable utilization of the environment, they have been blamed of causing environmental degradation in other areas [5]. If managed well, due to their smaller size (low maintenance) and their ability to browse in poor and dry areas where other ruminants cannot, goats can contribute significantly to sustainable rangeland utilization. While most of the environmentally harmful effects of goat grazing arise from improper management practices particularly at very high grazing pressures, if managed adequately, goat grazing can be a useful tool for environmental conservation [5]. For example, it has been found that mixed grazing of indigenous cattle and goats at a ratio of 2:1 had a complementary advantage for improved utilization of pasture resources and animal performance compared to when either of the species was kept [6].

The Southern African indigenous goat population is comprised of a mixture of large (e.g., Nguni, Tswana, Matebele) and smaller East African (e.g., Landim, Mashona, Malawian) indigenous goats (Figure 1). These goats are generally characterized by small body size, slow growth rate, low milk yield and low carcass weight. In order to improve productivity of these goats, cross-breeding with exotic breeds was initiated around the 1980s [7]. Unfortunately, this did not yield any positive results to the farmer's livelihood as it was not coordinatedproperly. There was a mismatch of breeding goals, a failure to capture tangible values and improve the existing management of low input production systems [2]. The most concerning factor included continuation of haphazard crossbreeding and breed replacement practiced by the farmers, which has a negative impact on the existing population of indigenous goats as genetic resources.

Sustainable utilization of indigenous goats is the key for efficient conservation, breed improvement, management, and marketing. This entails comprehensive information on breed identity and their unique eccentrics, as well as their environments. Such information can be attained through characterization studies. In southern Africa, characterization studies have been conducted on production systems [3,8,9], phenotypic characterization [10–13] and genetic characterization [13–16]. Initiatives have been made to conserve indigenous goats as purebred flocks in different countries of the region. Programs, structures and modalities to implement conservation with sustainable utilization are, however, still lacking, and this remains a challenge to food security. The aim of this article is to give perspectives on the alternative approaches towards conservation, development and sustainable utilization of indigenous goats in the Southern African region.

Figure 1. Some of the indigenous goats of Southern African region.

2. Characterization of Indigenous Goats

Phenotypic characterization is the primary phase for documentation of qualitative and quantitative traits of the indigenous goats [17]. Goats in the region are locally named according to different ethnic names and geographical habitats but show similar phenotypes. They are mostly multi-colored,

bearded, horned, with medium to broad lopped ears, short hair and can be small to medium size [18]. Most variations observed in phenotypic characterization studies were due to environmental factors, resulting in different ecotypes. These variations have caused some discrepancies with regard to breed and ecotype identification. Although further studies are needed in this regard, genetic characterization is also needed to guide the final decisions on breed improvement and sustainable utilization programs.

Molecular technologies such as mitochondrial DNA, microsatellite markers and single nucleotide polymorphism (SNPs) are important for genetic characterizations [19]. Table 1 shows studies on genetic characterization of indigenous goats in different countries in Southern Africa. These studies have provided information on genetic diversity, genetic structure and genetic relationship within and between populations, which is relevant for breed monitoring and development and for the general improvement of goats. The scarcity of knowledge, however, still remains with genetic linkage of Southern African indigenous goats and adaptive traits that can be exploited for sustainable utilization to improve productivity and contribute to food security.

Table 1. Genetic diversity of Southern African indigenous goats based on different markers.

Country	Population	H_o	H_e	Markers	References
Mozambique	Pafuri, Tete, Maputo, Cabo Delgado	0.553	0.620	microsatellites	[14]
Tanzania	Sukuma, Gogo, Sonjo, Pare	0.620	0.714	microsatellites	[20]
Namibia	Kunene, Kavango, Caprivi, Ovambo	-	0.623	microsatellites	[21]
South Africa	Boer, Kalahari red, Savanna Nguni, Tswana, Venda, Xhosa, Zulu and Tankwa	0.35–0.41	0.33–0.40	SNPs	[15]
Zimbabwe	Binga, Chipinge, Matopo, Shurugwi, Tsholotsho and MatopoResearch Station	0.61	0.60	SNPs	[16]
Botswana	Tswana	0.419	0.423	SNPs	[13]

H_o = observed heterozygosity, H_e = expected heterozygosity, SNP = single nucleotide polymorphism.

3. Sustainable Utilization

Derivation of significant benefits from goats as a strategic genetic resource in Southern Africa is still to be experienced. This is despite the existence of the Global Plan of Action [22] and national plans for management and utilization of genetic resources. While these plans are commendable, their implementation at the rural community level remains a challenge due to a variety of reasons. Therefore, a paradigm shift is required especially with regard to the way we view indigenous goats. Currently, governments, Non-Governmental Organizations (NGOs), markets and development agencies continue to promote exotic goat breeds and crossbreds at the expense of indigenous ones, despite the previous failures. A change of attitude by researchers, policy makers and extension workers towards traditional goat keepers and their breeds is very important. In Southern Africa, the majority (90%) of farmers are categorized as smallholders and own 75 percent of farm animals comprised mainly of indigenous breeds [23]. Consequently, for any production improvement strategies, the need for goat owners to be involved in decision-making and ownership of such initiatives is important. No matter how much effort is put into financial and technological support, the eventual survival of improvement programs depends on whether the farmers understand and agree with the objectives of the projects [24]. With that in mind, farmers' knowledge, innovations and practices must be integrated into research and extension. Community based programs have been found to be integral to the success of sustainable management and utilization of animal genetic resources (AnGR) [25].

3.1. Community Based Breeding Program

While indigenous goats have a competitive edge under prevailing climatic and environmental conditions, they are still generally viewed as less productive than exotic breeds. Therefore, practical selection programs are needed to improve productivity and add more value to indigenous goats. Community based breeding program (CBBP) is perceived as a strategy that can support breeding and conservation efforts in rural communities where flock sizes are small, and implementation of recording schemes are almost impossible. Setting up a CBBP usually follows these important steps: Definition of breeding objectives, development of selection criteria, genetic evaluations, selection of animals, design of appropriate mating systems and strategies for dissemination of superior genetics [26], and establishing a monitoring and evaluation framework [27]. Through capacity building and in order to integrate community knowledge in breed identification, farmers are involved in identifying relevant breeding objectives and selection criteria for their animals. Apart from increased production, breeding objectives should be aligned with market requirements in order to improve competitiveness of indigenous goat products as well as to challenges due to climate change by selecting for improved health, functional and other fitness traits. However, in other communities, preferences such as color, behavior and mothering ability can be considered as important [28].

CBBPs rely on the principle of establishing a communally owned open nucleus breeding system from which top breeding males are selected and disseminated to breeding flocks within the community. These males undergo rotational exchange while new ones are continuously selected to replace old ones. The concept has so far, been successfully implemented in sheep and goats in Ethiopia, and out scaled to goats in Uganda and Malawi through projects from the United States Agency for International Development and the United States Department of Agriculture. Other practices include castration of undesirable males, pedigree recording and progeny testing [25,29] and genomic characterization. Genetic progress and economic evaluation of CBBP has been undertaken in Ethiopia [30] and is underway in Uganda and Malawi through various postgraduate studies. Preliminary results show phenotypic increase in growth rates of offspring born from selected bucks. It has been concluded on one site that goats from CBBP sites have higher carcass yields than from non-CBBP sites [31].

Genetic improvement programs can only be implemented where accurate performance and pedigree recording is possible, which has proven unsuccessful in most indigenous goat production systems due to a lack of structures for record-keeping. Therefore, simple and easy to understand data collection tools should be formulated for indigenous goat keepers. Local management of recording schemes should be encouraged through the promotion of farmer groups and cooperative projects [24]. It is advisable to back up the localized recording scheme with an effective extension service with a view of finally mainstreaming the smallholder breeding activities into existing national livestock recording and performance testing schemes.

Since most smallholder farmers keep small flocks, formation of clusters or groups would enable them to acquire improved economies of scale. As a block, they can easily lobby government, undertake group funding or solicit private sector funding for the much needed infrastructure that includes breeding and reproductive technology centers, roads, milk collection facilities etc. Furthermore, they can collectively negotiate better prices from input suppliers, transport providers and at the market. An example is that of a well-detailed CBBP for West African goat in Liberia. The objectives of this CBBP entailed increasing productivity and income of resource-constrained farmers—by providing access to improved animals that respond well to feeding and management—while facilitating and targeting specific market opportunities [32].

Finally, for sustainability and success of these communities based programs, specialized communication strategies should be established, coupled with program monitoring and evaluation. This entails dialogue and feedback as well as review, implementation and revision of the developed programs.

3.2. Production Related Issues

Goat keepers in rural communities are faced with challenges at different phases of the goat production value chain. One such constraint is unavailability and high cost of input supplies such as medicine, vaccines and feed to mitigate effects of diseases, internal and external parasites, and seasonal fluctuations in feed quality and quantity [3]. In some cases, due to erratic rainfall and climate change, communities have encountered shortage of drinking water and feed for their animals. Possible interventions to these shortcomings include government incentives through subsidies on veterinary and feed supplies to the resource constrained farmers. Development of a one stop supply center at a strategic location within a community cluster would bring resources closer to farmers. Farmers belonging to a cluster could benefit from resource-sharing such as use of communal boreholes funded through government, donor agencies or cooperatives. The continued existence and success of these clusters relies on the ability of a cluster to source out their funds and not over-rely on donations which is more sustainable, in the long run. Furthermore, crop residue and other locally available feed materials could be used together with commercial feed ingredients to develop more palatable and nutrient balanced mixed rations. This could alleviate malnutrition and mortality in goat production.

Interventions to production constraints should integrate indigenous knowledge from the communities and scientific evaluation from research and academic institutions, with extension services provided by different sectors such as government and NGOs. Inclusion of existing knowledge in indigenous goat production provides an opportunity to better improve community knowledge and encourage participation. Rural communities continue to rely on several indigenous knowledge practices such as breeding practices [23], anthelmintic properties of some fodder crops that can be used to control internal parasites [25] and the ability to recognize changes in their climate and local environment using natural indicators [33]. However, for relevance, broad adoption and competitiveness, indigenous knowledge needs to be enhanced and well packaged for marketing and dissemination purposes.

Information and knowledge has become an important factor in timely decision making for effective livestock production. With advancements in technology, many rural communities have gained access to communication networks especially through mobile telephones and call centers. Therefore, efficient and fast dissemination of information between research, extension, and farmers can be made possible by exploiting such telecommunication facilities. This can be in the form of a mobile phone application (app) on routine goat health and management, or basic telemedicine where a veterinarian may discuss a case with a farmer over the telephone.

3.3. Marketing of Indigenous Goats and their Products

Indigenous goats are usually sold live on produce markets, mostly by middlemen who aggregate from farmers in rural areas. Formal channels exist in some countries, however, sales based on dressed weight attract lower gross margins unless sold at premium prices. Indigenous goats have unique characteristics which can be exploited and translated into niche products. These products range from colored hides, extra-fine fiber to meat or milk with special taste [34]. Niche products can be appealing and are generally more expensive than standard products hence they can motivate farmers through increased economic profitability. Therefore, niche products seem to present prospects to conserve indigenous goat breeds in a favorable economic context. Furthermore, due to their unique features, indigenous goats and their products can also play an important role in agrotourism, whereby local and international tourists visit communities where they are kept for viewing, photography and exploration. Traditional processing techniques (those involved in producing handicrafts or garments with distinctive designs) and strong local ties (breeds that are found only in certain localities and are raised by certain ethnic groups) could form the basis of marketing indigenous breeds and their products [34] including for tourism purposes. Markets should be well profiled and production objectives must be geared towards that. This should be consistent and sustainable as it will help in commercializing the small ruminant sector and in changing farmers' mind-set to be market oriented. Moreover, CBBP centers

offer market convenience to sell surplus breeding stock to neighboring communities, and non-selected goats to middlemen and butcher men who subsequently take them to a commodity market.

3.4. Gender Aspects and Marginalized Groups in Goat Production

Women play a key role in goat value chains by providing much of the needed labor—especially more in goat rearing than other livestock. However, women face greater constraints than men, including economical/financial, social and institutional barriers, which can affect their participation in livestock value chains and the benefits that can be gained from them [35]. These challenges are mainly a consequence of their poor access to land, little involvement in decision-making, credit, markets, assets and technical information and to their stereotyped role within households and communities, particularly in rural settings [36,37]. However, through participatory approaches women can be represented better in community-based AnGR conservation and sustainable utilization programs. Furthermore, there is a need to reduce continued male dominance by developing gender sensitive policy initiatives to ensure that women and men have equal access to land, research and extension services, credit and other facilities [38]. There are marginalized ethnic groups who also play a pivotal role in keeping indigenous goat resources and have ensured their continued existence. However, these groups also suffer the same fate as women. Empowerment and increased involvement from women and marginalized groups will result in input from diverse experiences, household security, cultural backgrounds, strategies and knowledge that can enrich the community based programs.

3.5. Regional Policy and Legal Framework

Despite individual country efforts in conservation and management of indigenous goats, more could still be achieved at the regional level. This is advanced by the fact that some goat breeds are common across several countries or at least have common ancestry. However, due to the absence of regional data integration, the genetic relationship of these goat breeds remains largely unknown. In any case, exploration of genetic resources across countries compared to within countries presents an opportunity to access a large pool of genetic diversity with potential for an enormous selection response. Availability and use of AnGR across the countries and beyond, harmonization of common policy, and creation of a user-friendly and accessible regional database haven't really been achieved as previously suggested [39]. Hence, a legal framework to accelerate and enforce implementation of these noble policy aspects is needed. This will also guide important issues such as exchange of genetic resources and samples between countries especially with the advent of shared facilities like regional gene banks and genetic analysis laboratories.

3.6. Future Research and Development

Some of the research that could be carried out in future to enhance conservation, utilization and management of indigenous goats include: (1) Determination of risk status of indigenous goat breeds to inform whether a conservation program is necessary or not. Demographic data collection should be carried across the region to obtain information such as genetic distinctiveness and adaptive traits of the goat breeds. (2) The establishment of effective breeding population sizes since they are not known for most indigenous goat breeds. These can be determined by carrying out breed surveys or on the basis of experience or previous census/surveys or by analyzing data stored by countries in the Domestic Animal Diversity Information System (DAD-IS). (3) More data collection in extensive farming systems so that these can be genotyped, analyzed and documented. Genetic diversity analyses and selective signals/sweeps can be identified and association studies can be conducted for various traits including adaptation and disease resistance traits. (4) Meta-analyses of genomic data which has already been collected on different goat breeds within the region [13,15,16]. (5) Establishment, out-scaling and evaluation of community based breeding and development programs for indigenous goats with the aim of improving and conserving the local breeds.

4. Conclusions

Indigenous goats are important genetic resources kept under resource-poor farming systems with potential for increased productivity to enhance food security and the nation's welfare. Compared to cattle, these genetic resources have become even more important under changing climates.

Sustainable utilization and conservation of these genetic resources should be linked to the market. This will assist in supporting and exploiting niche products efficiently. In each country, there should be regulatory policies that will protect and regulate sustainable utilization of indigenous goats and developmental policies that will provide rules and regulations to facilitate marketing process of indigenous goat products.

The use of genomic tools has the potential to be explored in low-input farming systems by identifying SNPs associated with different traits e.g., disease resistance and adaptation, and these can be used to develop 'customized' chips for the low-input farming systems.

Farmer participation, informed policies and ring-fenced budget allocation to national indigenous genetic resources will promote and ensure sustainable utilization of indigenous goats in the region.

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