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Review article

Addressing production challenges in goat production systems of South Africa: The genomics approach

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ABSTRACT

Functional traits have become increasingly important for efficient breeding schemes in the goat industry due to rising costs of production relative to product prices and consumers demanding healthy and nutritious food in addition to abiding to animal welfare standards. The challenges facing South African and other developing countries' goat industries is in the implementation of cost-effective production systems for high quality meat and milk which is safe to the consumer from communal farming regions riddled by many production challenges. Genetic improvement for economically important traits such as growth, reproduction, health and product quality is currently based on convectional estimated breeding values. These methods have been practiced for several decades for breeds benefiting from efficient breeding schemes. South Africa is one of the few countries in the world that have successfully developed high producing commercialised goat breeds some of which have been adopted in other regions. Genetic progress using conventional genetic evaluations is however lengthy and based on a few traits. Molecular and genomic tools are increasingly being used for the detection and mapping of genes of economic importance in goats. Attention is turning to the simultaneous identification of genes for production and functional traits using whole genome sequence and genome-wide SNP data. South Africa has a rich genetic pool of feral, commercial, and indigenous non-descript goat populations to select from. Preliminary studies using the Illumina Goat SNP60K bead chip have revealed high genetic diversity and uniqueness of the South African goat breeds. The unique genomes of the different breeds and populations are a potential source of genetic variation, which could be useful for genetic improvement programs. Next generation sequencing and genotyping technologies present opportunities for genomic breeding schemes in the near future. This paper reviews current challenges faced by the goat industry in South Africa and worldwide. The feasibility of using second-generation genomic tools to improve traits of economic importance in the goat industry is discussed.

1. Introduction

South Africa has a vibrant goat (*Capra hircus*) industry with over 6 million goats (DAFF, 2014) that comprise approximately 55% of the total goats found in southern Africa (FAOSTAT, 2013). Among the few countries in the world, South Africa has also successfully developed highly producing commercialised goat breeds. The Boer, Kalahari Red and Savanna goats are good examples of breeds locally developed in South Africa that have turned out to be internationally relevant. These breeds are well known for their fast growth rate and good carcass traits (Casey and Webb, 2010). The South African goat industry benefited from efficient selection for production and reproductive traits. The traditional hand and eye method employed in the development of the Boer and other commercial meat breeds is still widely used by most goat farmers in South Africa in the meat, dairy and mohair industry as well as for other livestock species (Casey and Webb, 2010). Slow genetic progress as evident in the Saanen milk composition (Muller, 2005), inconsistencies in performance throughout the year, mostly observed in mohair and dairy production (Norris et al., 2011) as well as the meat industry (DAFF, 2012) have been the main limitations of conventional selection programs. Subjectivity in phenotyping and the overall selection process result in inconsistencies in production. Recent

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advances in next generation sequencing and genotyping technologies have opened up new possibilities of addressing these problems using genomic tools.

The South African Boer, Savanna and Kalahari Red goats although having desirable production traits, are limited to commercial farming systems, and cannot perform optimally in the smallholder farms where there is scarce nutrition and harsh production environments (Casey and Webb, 2010). With ever-changing climate and scarcity of resources, there is a need to fully utilise resources in order to maximise profits. Development of a breed that can produce optimally under the harsh smallholder farming systems in South Africa and other developing countries is therefore a priority. Apart from the established commercial breeds, 63% of South Africa's goats are uncharacterised and raised under smallholder farming systems. In addition, South Africa has a Tankwa breed which is a feral goat isolated from those farmed by commercial and smallholder farmers. There is potential for selecting for production and robustness in these untapped village and feral goats. Breeds that can produce optimally under resource limited and harsh production environments will find application in smallholder and emerging commercial farming systems of South Africa and other developing countries. The smallholder sector of the South African goat industry is still lagging behind in terms of improvement of traits such as growth, reproduction and health particularly for the indigenous veld ecotypes (Morrison, 2007). The Tankwa and some uncharacterised village goats have qualities that are lacking in the commercialised breeds that could be used for development of breeds to optimise production even when faced with challenges such as poor nutrition and adverse climatic conditions.

Improvement of production traits in cattle breeding is well defined and better than that of goats (Van Marle-Köster et al., 2013), making the South African beef and dairy cattle industries more competitive than the goat industry. The reason for slow progress in the goat industry has in a way been attributed to the lack of information on the genetics of the key and economically important traits (Van Marle-Koster and Nel, 2003). Research on goat breeding and genetics has been limited to some quantitative genetic studies and diversity analysis using microsatellite markers (Snyman and Olivier, 1999; Visser et al., 2009).

Current advances in genomics have allowed massive scale genome wide screening of genetic variants in a number of livestock species (Nielsen et al., 2011), including goats (Bai et al., 2012). The genomes of the Tankwa feral goat and the non-descripts breeds have not been fully exploited. There is an untapped diversity found in the village and feral goat populations, which first needs to be characterised and then harnessed. Whilst SA has done well with conventional selection tools and produced successful breeds, there is need to integrate advanced genomics tools and use them in breed improvement and development with particular focus on smallholder and emerging farmers. Genotyping technologies such as next generation sequencing (NGS) and SNP Beadchips (Dong et al., 2013; Tosser-Klopp et al., 2014) have opened new doors to selection and breed improvement programs in goats and other livestock species.

This review gives an overview of South African goat production systems and how they have evolved over the years with an emphasis on breeds and traits of economic importance. The review also looks at the challenges facing this industry particularly in terms of disease management and the smallholder, emerging and commercial farming systems. Current methods used in selection of the important traits and disease control and the efficiency of these methods will be discussed. The feasibility and potential benefits of genomics in SA goat improvement is discussed.

Table 1
Food and Agricultural Organisation (FAO) goat statistics of top producing African countries in 2012 (FAOSTAT, 2013)

Country	Number of goats (million)
Nigeria	57.60
Sudan (former)	44.00
Kenya	29.41
Ethiopia	24.06
Mali	18.22
Tanzania	15.09
Uganda	14.01
Niger	13.76
Burkina Faso	13.09
Somalia	11.60
Chad	6.78
South Africa	6.14

2. The South African goat industry

South Africa is one of the top countries with the largest number of goats in Africa that are estimated at 6.14 million goats (Table 1). South Africa stocks about 55% of the goats in southern Africa (FAOSTAT, 2013). The South African goat industry has three main end products which are meat (chevon), milk and fibre raised under commercial, smallholder and emerging farming systems. Commercial goat producers operate on a large-scale production of meat, milk and mohair. Production is aimed for sales and generation of profits. This type of farming usually involves the use of modern technology to maximise production and increase profits (Fraser, 2001).

The Boer, Savanna and the Kalahari Red goats are kept for chevon production in the commercial sector. About one third of the goats are slaughtered by the meat industry annually, and about 90% of the goats dedicated to meat production are indigenous to South Africa (FAOSTAT, 2013). Between the year 2001 and 2011, goat production in South Africa contributed R3.6 billion to the economy through chevon production (DAFF, 2012). Although some of the chevon produced is consumed locally, South Africa also exports chevon to countries such as Angola, Congo, Democratic Republic of Congo and Nigeria (DAFF, 2013). In addition, the production of hides was estimated at 600 tons per annum in 2012 (FAOSTAT, 2013). The Angora breed is used for mohair production whilst the dairy industry is mainly comprised of imported Saanen, Toggenburg and Alpine breeds.

The smallholder sector is comprised of goat farmers that produce for family consumptions and are usually found in the communal areas of the country. Herd numbers are usually small, and the goats are often left to fend for themselves and are occasionally supplemented with household leftovers. This kind of practice is popular in most developing countries and is less intensive with any income generated basically low (Salami et al., 2010). The South African smallholder sector predominantly keeps the multipurpose and uncharacterised veld type indigenous goat ecotypes.

In South Africa, goats are the main livestock species kept under the communal or smallholder farming systems. These farming systems are characterised by low input production systems with limited and poor quality feeding resources and management. They are mainly composed of the indigenous uncharacterised veld-type goats which have small body frames and low meat yield (DAFF, 2012). Although commonly kept as multipurpose breeds, these breeds are mainly used for meat production. South Africa contributes only 1 % to the total world chevon production because a larger proportion of the goats are kept in smallholder farms where productivity and offtake is low (Simela and Merkel, 2008). Goats, unlike other livestock species such as cattle, sheep, pigs and poultry, have been less supported by research or as an industry (Morand-Fehr et al., 2004) resulting in less genetic progress in