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Review

Indigenous Pig Genetic Resources in Southern Africa: Progress and Prospects

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Abstract: Pig genetic resources in Africa originate from different regions. Genetic analysis has shown a strong phylogeographic pattern with the pigs on the eastern parts showing a high frequency of alleles from the Far East while the ones on the western parts show a strong European influence. This highlights the influence of trade routes on the genetic legacy of African pigs. They have, however, since adapted to the local environments to produce unique populations with unique attributes. Most of the pigs are now reared in resource-constrained smallholdings under free-range conditions. They are largely owned by women who spread ownership of the resource through kinship networks. Very little work has been done to characterize, conserve and sustainably utilize pig genetic resources in Southern Africa. The risk status of the breeds together with population numbers, distribution and other attributes are largely unknown. This paper proposes several strategies for the sustainable utilization of the pig genetic resources: a market-driven *in situ* conservation program and two complementary *ex situ* strategies. In addition, the possibility of community-based breed improvement programs is discussed.

Keywords: diversity; conservation; animal genetic resources; indigenous pigs; southern Africa

1. Introduction

There are several breeds and populations of pigs in Southern Africa including commercial, indigenous (or local), nondescript and feral which have been introduced to the region through various pathways [1]. According to DAD – IS [1] all the Southern African Development Community (SADC) countries, except the Comoros Islands, have the three major international breeds (Large White, Landrace and Duroc). The region's pig genetic resources are also composed of several local or indigenous pig breeds with various names and attributes [2,3]. The main attributes of these local breeds are hardiness, foraging ability, heat tolerance, high fertility, good mothering ability, good quality meat, tolerance to endemic diseases and parasites and adapted to low management levels [4]. They are well adaptable to local harsh conditions and this makes them important genetic resources which can be conserved by utilization during the current era of climate change [5]. Threats to these genetic resources are well documented. According to Pilling [6] these threats can be classified into: disasters and emergencies that lead to livestock mortality and restocking; disease epidemics and their control measures [4]; inappropriate breeding management, strategies and policies which may lead to breed substitution and inadvertent loss of animal genetic resources; changing production systems and livelihoods including economic growth, changes in culture and, cross-cutting issues such as

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climate change which influence changes in feed and water availability as well as emerging diseases. Additional threats also relate to inadequate policy and legal frameworks. For example, only 24.4 % of African countries have reported the risk status of their animal genetic resources (AnGR) with even fewer countries supplying information on gene banks. It should be noted here that these two statistics are important indicators that constitute tier 1 (or core statistics) for Sustainable Development Goals (SDG 2; indicators 2.5.1 and 2.5.2). Available literature shows that 32 out of 71 breeds with known risk status are at risk. Applying this proportion to the remaining 703 reported livestock breeds would mean approximately 218 additional breeds are at risk. Lack of knowledge about the status of a breed is also a threat since it, concomitantly, includes lack of breed characterization and inventory information.

Very little work has been carried out to characterize indigenous pigs in southern Africa. The little work shows inadequate coverage of the populations and countries and the work is largely fragmentary and not well coordinated [1,3,5]. Therefore, poor characterization of indigenous pigs in in southern Africa could hamper the possibility of mapping the distributions, population status and diversity [1,5] and more importantly the role of these animals in human livelihoods [4,7]. In addition, little effort has been made to take advantage of more advanced techniques that are increasingly becoming cheaper such as single nucleotide polymorphism (SNP) arrays [8]. Work has shown that pigs in Africa originated from several regions with the ones on the eastern parts showing a strong genetic relationship with Far Eastern pigs while those on the west shown more relationship with European breeds [9].

One of the major constraints in conserving pig genetic resources in southern Africa is the lack of market participation of the majority of pig farmers [3] who keep small herds mainly for subsistence [4]. The major barriers to market participation are production constraints, information asymmetry, underdeveloped markets and support infrastructure, limited finance and other resources and inadequate knowledge [4]. In addition, '…marketing systems [that serve smallholder farmers] are generally exploitative, collusive and economically inefficient' [10]. It is important to note that attaching a market value to a genetic resource is one of the easiest ways of conserving it. There are, however, certain breeds that do not have an immediate market value but are important as a store of option value which is the benefit derived from safeguarding an asset for the option of using it at a future date – especially in response to changes in production environment (changes in consumer taste, new diseases and climate change among others [11] . This is not new as there is evidence of such use of genetic resources to respond to adverse climate change in the past.

2. Status of pig production in Southern Africa

Pig ownership in Southern Africa is inclusive of all genders with a slightly higher number of female owners [4,5]. The dominance of female owners and the spread of pigs within the gender is based on kinship networks that lead to assistance in the care of pigs and sharing of the genetic resource [3]. In addition, women may be default keepers of livestock since they care for families in the rural communities while men seek wage labor in urban areas [12]. Also, this could be because many indigenous pigs are small sized compared to other animals like cattle and are kept in the backyards hence they are relatively easy to look after [5]. Women's selection criteria are different from those of men and may ultimately determine if the families remain livestock keepers or not. They

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choose animals that are easy to manage and are generally disease tolerant which is not likely to increase their workload given that most of their time is taken up by the 'reproductive economy' which usually does not feature in economic analysis and agricultural policy. While the number of people employed in agriculture is decreasing overall, the proportion of women in agriculture is increasing [12]. The role of women in the maintenance and sustainable use of pig genetic resources needs to be recognized (and rewarded) in any strategies regarding the conservation of this resource.

3. Constraints to smallholder pig production

Smallholder pig owners who hold most of the genetic diversity face the following constraints.

1. Production constraints: Indigenous pig farmers tend to keep small numbers of pigs [3]. This allows them to match the animals to the available resources [7]. The farmers are vulnerable to shocks and lack access to modern production technology. The low numbers may lead to inbreeding [13] and vulnerability to disasters. Interestingly the resource-constrained production systems seem better and more resilient than intensive pig production systems in Africa. Lekule and Kyvsgaard [14] cite three reasons for this apparent contradiction: lower fixed costs and inputs compared to intensive production, access to kitchen waste that can be used to supplement a few scavenging pigs and, pigs having other functions in traditional systems that make their production worthwhile. Unfortunately, the factors that contribute to resilience of these production systems also act as buffers that keep the systems in a low-level equilibrium that is difficult to upscale. In addition, there is a food-versus-feed conflict as a result of pigs sharing the same major feed ingredients that are used by humans for food.
2. Lack of access to information: Farmers usually do not have access to information about production, markets, feeds etc. that would improve production. Pigs are also single-product animals unlike cattle and goats.
3. Poverty: Scarcity of natural, physical, financial, human and social assets impacts the farmer's decision-making process [15]. Obviously, poverty will impact many aspects of production including access to loans, information, drugs and other resources.
4. Lack of farmer organisations and institutions [16]: Collective action is a useful tool for any activity including management of animal genetic resources [17]. Smallholders are not involved in structured selection of pigs neither do they have concrete breeding programmes.
5. Policy gaps: The only SADC country with a complete plan for the management of AnGR as of 2019 is South Africa [18]. While the African Union Inter-African Bureau for Animal Resources (AU-IBAR) has developed a tool and a portal for characterisation of the continent's animal genetic resources there has been very little effort by governments to allocate resources for that exercise.
6. Weak production systems and diseases: Free range production systems offer limited disease surveillance, monitoring and biosecurity options. There are several studies [14,19,20] that demonstrate this. Free ranging also increases contact with feral pigs which may be a contributing factor to the outbreaks of African swine fever [21].

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7. Absence of genetic improvement programmes for the smallholder pigs: The indigenous pigs in Southern Africa have a slower growth rate than exotics, their major strength being adaptive traits that give them an advantage in low-intensity management smallholder systems [7]. Invariably the genetic heritage of indigenous pig is constantly threated by genetic erosion caused by some indiscriminate crossbreeding with exotic breeds [22].
8. Other constraints: There are overarching constraints that are external to the production system which include conflicts, globalisation, population growth, changing consumer tastes, religious taboos, developments in science and technology and climate change. These will obviously impact conservation and use of AnGR in some way [23].

There are a few pig genetic and phenotypic characterization studies. The populations, genetic structure, attributes and risk status have not been fully studied. The studies themselves lack coordination. What is particularly important is the near absence of government and private organizations in these efforts. FAOs animal genetic resource database DAD – IS does not present information on numbers and genetic structure.

3. Sustainable utilization and conservation of pig genetic resources in Southern Africa

The Convention on Biological Diversity (CBD) defines sustainable use as the use of components of biological diversity in a way and at a rate that does not lead to the long-term decline in biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations [24]. The CBD also recognizes, '…the vital role that women play in the conservation and sustainable use of biological diversity and affirming the need for the full participation of women at all levels of policy-making and implementation for biological diversity conservation.'

The easiest route to conservation and sustainable use is development of markets for the pig genetic resources. This will enable *in situ* conservation while directly benefitting the smallholder farmers. *In situ* conservation is the most preferred approach as it allows the animals to keep adapting to changes in their environment while performing other important roles such as ecosystem services. Market development can be done in the following ways:

1. Investing in infrastructure and institutions: According to Barrett [25] market access is both a cause and a consequence of development. There is need for public investment in institutional and physical infrastructure necessary to ensure broad-based, low-cost access to competitive and well-functioning markets.
2. Farmer organisation: Collective action enables farmers to access markets while reducing transaction costs of purchasing inputs, market information and new technologies [17]. Farmer organisations also provide an opportunity for recording and breed improvement since records can be kept and breeding objectives can be set. Barrett [25] states that market participation is the same as adoption of new technologies and should be evaluated as such. Organising farmers helps in adoption of this 'technology' *en masse*. Besides, farmers keep relatively small herds so organisation will help aggregate the excess stock for sale.
3. Policy interventions: Several workers [17,26,27] emphasise the importance of policy intervention in promoting both conservation and market access by smallholder farmers. There is need to develop a set of policies that incentivise farmers to produce local pigs. In

addition, the public sector needs to build institutions that support the conservation, utilisation and improvement of the indigenous breeds. There should be an effort to harmonise policy on conservation and marketing in the region. These policies should recognise the role played by women in maintaining these resources.

4. Development of products and markets: Köhler-Rollefson [28] reported 8 cases of marketing indigenous livestock products in different communities, countries and circumstances. In all cases there were interventions of different nature (ranging from policy to development of new products) along the value chain. There is need to explore ways of either developing niche markets, new products or contract farming to enable the introduction of neglected genetic resources into the market.

Breed improvement is closely linked to marketing. However, development of breeding programs should consider the fact that the breeding goals of smallholders are much more multifaceted compared to the commercial pig farmers who focus on a few traits of economic importance such as fast growth rates, larger carcasses, disease tolerance etc. Goals for smallholders include aesthetic (color and patterning), behavioral aspects (temperament, mothering ability, foraging behavior, herdability and any other aspects that minimize labor on livestock), adaptability and the ability to survive on low management levels [28]. Rege et al. [23] highlight the need '…to improve, produce, deliver and sustain genotypes appropriate for the objectives of the target poor livestock keeper/producer.' This will obviously incorporate indigenous knowledge in the breeding programs. Several possible schemes have been proposed including sire rotation or loan schemes, nucleus-based programs run by the public sector and linked to community-level multipliers and other community-based programs where selection is done at community level [23]. There is an opportunity to use recent advances in technology, especially assisted reproductive technologies and genomics, to quicken the process without loss of diversity [8,29]. There is also need to build breeding societies around the neglected breeds.

The next best strategy is to use *ex situ* conservation either *in vivo* or *in vitro*. *In vivo ex situ* conservation will still require a market for the animals. This will entail use of public research stations and farms (and any other breeders) to maintain conservation and commercial herds. There is need to establish a gene bank for AnGR to preserve species that are threatened with loss of genetic diversity to allow for repopulation, expanding the genetic base of a breed as well as research. This also has the additional benefit of protecting the resources from disasters and disease outbreaks [30]. The objective is to maintain maximum genetic diversity using few individuals. In the United States of America, cluster analysis is used to evaluate pedigree data to identify 'families' of animals within a breed to be sample for conservation [30]. Table 1 below summarizes the likely interventions and timelines to achieve sustainable conservation and utilization of pig genetic resources in Southern Africa.

204 Table 1: Identification of the key activities, actors and needs for sustainable utilization and conservation of pig genetic resources.

Objective	Activities	How	When	Who
Food and nutrition security	Increase the number of pig growers	To conduct a needs assessment study followed by various awareness campaigns Facilitate information dissemination among farmers and between farmers and extension through ICTs	2020-2025	Researchers, Extension, Government, Farmers NGOs
	Reduced mortality (Better reproductive efficiency)	Improve animal health and housing management. Farmer capacity building programmes	2020-2025	Researchers, Extension, Government, Farmers NGOs
	Improve environmental and public health	Farmer training Establishing biosecurity structures to control zoonotic diseases	2020-2025	Researchers, Extension, Government, Farmers NGOs
Income generation	Identification of current market	Improve product quality and quantity and timing as well as addressing price and policy issues Conducting a qualitative and quantitative value chain analysis Create niche market Constructing processing facilities	2020-2025	Researchers, Extension, Government, Farmers NGOs
	Farmer organisation for collective resource mobilisation	Incentive group farming and contract farming Facilitate credit support for the farmer groups in production Creating small farmer abattoirs	2020-2025	Researchers, Extension, Government, Farmers NGOs

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4. Conclusions

The review shows that indigenous pigs have remained an important resource to rural people in Southern Africa. However, characterization and inventorying on the animals' genetic resources are still incomplete and the available information is fragmentary and not coordinated. Even, the uses of these indigenous pig genetic resources are not well documented across the region. Production of the animals is low, and this is largely constrained by limited resources. However, smallholder free-range systems seem to be more resilient and sustainable despite the lower inputs and biosecurity measures. Most indigenous pigs are owned and looked after by women. This makes women an important stakeholder in any policy intervention around sustainable utilization and conservation of indigenous pig resources.

Future market development complemented by well-planned *ex situ* conservation programmes could be effective strategies towards *in situ* conservation of pig genetic resources. This has the added benefit that the pigs will continue to serve other functions depending on farmer objectives. Also, to meet markets demand and elevate productivity of the farmers, there is need for breed improvement without loss of genetic diversity. Thus, suggested programmes should always incorporate indigenous knowledge systems and smallholder farmer breeding objectives. The farmers have much more multifaceted breeding objectives that include aesthetic, behavioral, suitability for religious or cultural roles and adaptive traits. Therefore, to improve characterization, genetic utilization and conservation of the local pig resources, there is need for a coordinated Southern Africa regional policy framework that is backed by adequate resources.

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