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Review article

Crossbreeding and genetic loss in domestic animal resources in rural communities in Africa

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ABSTRACT

Africa is abundantly graced with an excess of domestic animal genetic resources that have adapted to the continent's existing stressful conditions (Scholtz, 2005). Now, most momentous concern is the impending loss of domestic animal genetic resources that are threatened by increased uncontrolled crossbreeding with exotic genotypes. The resource poor rural animal agriculture systems in Africa has relied on these domestic animal genetic resources and they have proved beyond doubt their resilience under local prevailing conditions. Due to pressure of modern trends in livestock and poultry production systems and practices, there has been a mismatch on domestic animal genetic resources utilization and conservation sustainability. The imposition of highly intensified animal production practices has been associated with dominance of very high producing exotic animal genetic resources facilitating indiscriminate crossbreeding with domestic animal genetic resources in rural Africa. This has been implemented without taking into account that predicted changes in climate will impose selection pressures on traits significant for biological fitness (and production) and adaptability. The new focus has downplayed the contribution of domestic animal biodiversity has yet to be properly integrated into strategies for adaptation to and mitigation of climate change and variability consequences. It is imperative that domestic animal genetic resources' role in the resilience of rural animal production systems in Africa still need to be promoted. Domestic livestock and

poultry species in Africa are unique animal genetic resources which need to be safeguarded under the pending unpredictable climate change and variability and the rapid changing world. The modern trends which emphasize on productivity undermines the element of genetic adaptation enshrined in domestic animal genetic resources which is vital for future of Africa's animal agriculture. As a consequence, domestic animal genetic diversity is diminishing drastically due to indiscriminate crossing of exotic with the domestic animal genetic population. To arrest this erosion or population decline focus should be to promote domestic animal genetic resources in situ avoiding the replacement approach and include maintaining adaptation as part of any animal breeding strategies on domestic animal genetic resources utilization practices in Africa. The review looks at the influence of crossbreeding exotic animal genetic resources with domestic animal genetic resources as the major driver of animal genetic loss in Africa.

1. Introduction

Africa has a magnificent reservoir of domestic animal genetic resources diversity which are much more superior than those found in other segments of the world. However, the significance of domestic livestock and poultry genetic resources of Africa in support of rural economies has always been underestimated. Straight breeding of domestic animal genetic resources has been the basis of viable rural resources poor animal production systems. It should be appreciated that the mode of production strategy employed in Africa is dependent on first and foremost on the environment and extent of management. The introduction of high level production livestock and poultry species through crossbreeding has increased animals to environmental challenges apart from genetic loss of domestic animal genetic diversity. Indiscriminate crossbreeding or extensive use of exotic germplasms has resulted into genetic erosion by dilution or eradication of the local genetic portfolio (Rege and Gibson, 2003). Prescribed mating strategies for Africa for high animal performance have been actualized either through utilization of exotic animal genetic resources or by intense crossbreeding. Domestic animal genetic resources numbering the huge population of livestock and poultry in Africa has declined as a result of subjection to inappropriate crossbreeding and animal replacement. The extent of erosion of domestic animal resources has been a major concern that the long term sustainability of crossbreeding of highly productive introduced genotypes and domestic animal genetic resources in now contentious (Otten and Van den Weghe, 2011). Mating systems for enhanced animal productivity has unnecessarily focus on indiscriminate crossing and replacement of domestic animal genetic resources. It would be unwise to focus on Africa closing the widening gap on animal productivity by indiscriminate crossbreeding because this has negative implication through the loss losing unique genetic attributes, especially those responsible for adaptations to the past, current, and even future climatic and variability challenges, such as parasitic infectious diseases, heat and drought tolerance etc. There is need to acknowledge the low-maintenance of most domestic animal genetic resources that are ideally convenient to the rural economies of animal farming systems in Africa and, as far as can be confirmed have remained relatively stable during the past millenniums. On the other hand, the non-commercial and commercial contribution of domestic animal genetic resources in Africa's resource poor rural economies has not been the major focus in estimating agriculture and economic development which has resulted in the undervalued economic indexes with regards to their contribution. The review looks at the influence of crossbreeding exotic animal genetic resources with the domestic animal genetic resources as the major driver of drastic animal genetic diversity loss in Africa.

2. Crossbreeding and the dynamics of the animal agriculture in Africa

Domestic animal genetic resources are numerous and diverse and typically well adapted to the harsh prevailing environment conditions in Africa and suits the smallholder nutritional and management scenarios

(Marshall et al., 2019). Spectrum of domestic animal genetic resources possess genes well suited to the management style and needs of the resource poor farmer who requires a relatively low-maintenance and relatively high-output animal, due to their constrained environment. Due to passage of time domestic animal genetics endowments of Africa were exposed to the harsh extreme of the climate which influenced their resistance to diseases and parasites, nutritional availability and water availability. Its presumably correct to ascertain that the exposure to the adverse climate through the years favored the animals genetically suited to the Africa's adverse environmental conditions. The perception of inferiority of domestic animal genetic due to the short term benefits of the so called high-input, highly productive exotic animal genetic resources might be misplaced. The fact that domestic animal genetic resources are able to survive with minimum level of management and resources (water, feed etc.) is critical. The danger of dilution of domestic animal genetic resources with exotic animal genetic resources is based on assumption that resources are limitless where nutrition can be supplemented and animal diseases remedies are inexpensive. There is need to improve animal productivity through breeding, conservation and utilisation of domestic animal genetic resources. Alternative approaches on mating systems need to be sort which is not based on crossbreeding and replacement of domestic animal genetic resources. There are a lot of factors which makes exotic animal genetic resources not compatible to the resources availed by smallholder animal agriculture, these include climatic, nutritional stress, water scarcity and low management level. Recommendations for crossbreeding have been poorly adopted in the communal areas due to unavailability of exotic bulls. However, extension messages did not emphasize that such crossbreeding programmes were usually associated with the risk of loss of genetic diversity and reduced hybrid vigour in later generations of the crossbred cattle. The introduction of exotic animal genetic resources in the resource poor smallholder farming systems in Africa will disrupt animal agriculture in the long term as their productivity will be hindered by several constraints that include high prevalence of diseases and parasites, limited feed availability and water scarcity in which the domestic animal genetic resources have prevailed. The advent of genome science and genetic markers the majority of the domestic animal genetic resources could now be characterized and attributes associated with their resilience in adverse condition ascertained at molecular level can be promoted. Therefore, the breeding strategies can now be modeled from genetic of both adaptation and production traits. Dynamism of resources in poor animal agriculture is at different stages of transformation do not need to focus on crossbreeding as a mode of supporting animal productivity because of its long term negative implication on authentic gene pool. Any intervention strategy to enhance on domestic animal genetic resources should not compromise adaptiveness of animal populations. The strategies should take a form which acknowledge both diversity and dynamism hence customized not to totally disrupt redesign the resource poor animal agriculture in Africa. It is important to note that smallholder agriculture has a limited capacity animal breeding strategies hence quick address of animal genetics in domestic animal genetic resources through crossbreeding will be disastrous. More time should be availed to design models which target sustainable utilization of domestic animal genetic resources without not compromising their adaptive attribute which may be handy in the prevailing harsh environmental condition which are anticipated to worsen due to climate change and variability. Strategies which have worked in developed countries have proven to be not applicable in smallholder agriculture for rural economies. Emergency of novel diseases compounded by limited capacity of the smallholder animal agriculture biosecurity issues can be a major drawback in introduction of exotic animal genetic resources in rural economies.

3. Impact of crossbreeding on genetic loss of domestic animal resources

Current practice in most smallholder farming sectors in Africa is to cross highly adapted but lowly productive domestic animal genetic resources with poorly adapted but highly productive exotic animal genetic resources. Ayalew et al. (2003) and Rutledge et al. (2010) who presented overwhelming evidence of unsuccessful crossbreeding schemes on the negative impact of use of exotic animal genetic resources, however in spite of all that such plan of action is still regular practice. In a similar observation, Hanotte et al. (2010) retaliated that crossing of domestic animal genetic resources with highly productive animal genetic resources may be beneficial in short term, however its long term disastrous consequences are that apart from induced displacement and genetic erosion there is disappearance of domestic animal genetic resources diversity. This entails imposition of exotic animal genetic resources will after some time dilute and deplete the authentic domestic animal genetic pool of Africa's livestock and poultry species. Crossbreeding is the imminent cause and practice immersed in loss of domestic animal genetic pool as this has been necessitated by unthoughtful demand for the so called superior

animal genetic resources in rural economies in Africa. Due to population expansion which has created a huge demand for animal products in Africa, there has been an attempt to argument animal productivity with the introduction of highly productive exotic breeds expediting indiscriminate crossing with domestic animal genetic resources, predominantly in the smallholder animal agriculture sector. However, in Africa and elsewhere, the favorable outcome of upgrading, replacement and/or creating new breeds of animal population, has been highly inconsistent and conditional on the prevailing local conditions (Madalena et al., 2002). This points to the fact that breeding strategies which might have yielded positive result elsewhere might not apply the same in a resource poor novel environment in Africa. The existence of genotype environment interaction in animal production which may discourage breeding strategies that make emphasis on increased production traits disregarding animal environmental sensitivity issues are disastrous. In a rather similar observation in pigs translocated subgroups genetically homogenized faster than expected than local pig genetic resources, as a result changing prior management scenario and on the other hand prevail upon the disappearance of local adaptations (Berthouly-Salazar et al., 2015). Rauw et al. (1998) noted that promoting high production efficiency in animal breeding has its own share of negative implications such as risk for behavioral, immunological and physiological processes in animals. This has been worsened by ceaseless changes in climate and variability in the environment as opposed to the assumed static world. When introducing new genetic material (exotic breeds) through crossbreeding, there is need to discreetly appraise the animals in the exporting countries of their immense superiority to local production environmental conditions, because the major challenge of new breeds in novel environment, especially in Africa which experiences perpetual adverse environmental conditions, is lack of adaptation. The inability to adapt of new breeds or crosses has greatly compromised their productivity and increased animal mortality. The adverse climate, high incidence of diseases and parasites, poor quality and inadequate nutrition has not been favorable for sustaining production of highly productive exotic breeds of livestock and poultry in smallholder farming sector. The whole scenario has been worsened by low correlative socio-economic support that has raised doubt about the sustainability of crossbreeding in smallholder livestock farming sector in Africa.

4. Crossbreeding and animal adaptability

Domestic animal genetic resources are the inescapable integral of smallholder animal agriculture in Africa. Domestic animal genetic resources display a unique distinction of their ability to survive on poor feed resources and proved to be adaptable to adverse prevailing environmental conditions of bearing up against heat and exhibit tolerance to local diseases and parasites. Presently, there is grave apprehension worldwide that genetic diversity or variation within domestic animal genetic resources is vanishing through animal upgrading, replacement and crossbreeding. The dwindling of domestic animal genetic diversity populations as much as it will cause a major disruption of the continued function of resource poor rural economies in Africa, it is a precursor of reducing the capacity to counteract the adverse changes in environmental conditions, disease and parasite incidence, dwindling feed resources, water scarcity and food demand patterns. Due to mismatch in nutrition and management in smallholder animal agriculture to crossbreeding scheme progeny the so called improved animal generation buildup is very minimum. The difficulty of matching feeding and management of small population of improved progeny and the already existing genetic resources will pose some challenges. The inappropriate utilization of domestic animal genetic resources will cause major unrepairable damage to the resource poor rural economies. The domestic animal genetic resources despite being labelled lowly productive have been popular to the rural folk and acted as a “living cheque,” for decades, in addition to food security provision, nutrition and rural economy security for the resource poor farmers. The non-commercial contribution of the domestic animal genetic resources has been underrated, however in pastoral animal agriculture domestic animal genetic resources have played a major role in the mainstay economies in Africa. This points to the significance of the domestic animal genetic resources for future utilization in agriculture and economic development in the foreseen adverse effects of climate and variability on animal agriculture. Domestic animal genetic resources’ competence to adapt to the direct and indirect results of harsh environmental condition such as upturn heat, water scarcity and stress, imminent diseases, weather adversity and dwindling feed resources etc. is one of the most significant attribute which bestow them as appropriate candidates of animal genetic portfolio for future use in animal agriculture systems in Africa. Animal genetic resources that favorably respond to modifications of the sources of water resources - with undersupply and diminishing availability are the ones applicable to poor resourced smallholder animal agriculture. There is a remote possibility that we could cross-breed exotic and domestic animal genetic resources to induce

adaptive traits under Africa's harsh environmental conditions. But that would have other, unanticipated genetic consequences that are not likely to be beneficial. Perpetual crossbreeding would result into total replacement of domestic animal genetic resources for novel animal genetic populations. If this happens, Africa will pay immensely in long term due to the loss of adaptive genes and attributes due to replacement of domestic animal genetic resources. There has not been attempt to measure the magnitude of genetic disruption in favour of highly productive genotypes which has been caused by crossbreeding in smallholder animal agriculture on the continent. It may be reasonable to assume that the loss, dilution and replacement of specific genes in domestic animal genetic resources could contribute to weakened adaptive traits. This might include unknown gene losses that may have occurred as a consequence of prolonged crossbreeding, that may have played a direct role in the evolution of weak adaptive phenomenon in first and second animal generations. Losses of genes are often detrimental for an organism, being associated with malformations or diseases. However, despite being somewhat counterintuitive, losing genes can also be beneficial for an organism, for example when gene loss contributes to adaptations to specific environmental conditions or new lifestyles. This requires identifying the genetic origin of adaptive phenotypes, i.e., the involved genomic changes, which may reveal insights into the underlying molecular and cellular mechanisms. Breeding strategies that target to improve domestic animal genetic resources in smallholder animal agriculture should take into account the multiplicity of roles attached to animal resource and the differential attributes of an amplified contradiction between huge population of domestic animal genetic resource in rural Africa in support of their livelihood and acting as a safety valve against food insecurity, and those exotic animal genetic resources raised in intensive commercial animal production entities.

5. Crossbreeding, climate change and domestic animal genetic loss

Animal genetic resources worldwide will be negatively impacted by climate change and variability, and it has been approximated that 50% of all world's species could disappear because of the effects of climate change and variability (Römisch, 2019). In Africa, elevated temperatures, water scarcity, feed resource dwindling, persistent droughts, emergency of novel diseases' and parasites are some of the indirect effects of climate change which will put pressure on smallholder agriculture and its animal genetic constituency. Africa's lack of resources has translated to incapacitation in dealing with climate change and variability hence this will make the continent being the most vulnerable, especially its smallholder animal agriculture. The multiple direct and indirect consequences of climate change and variability compounded by Africa's low animal agriculture adaptive capacity calls for promotion of existing profile of domestic animal genetic resources. Climate change as a constraint has added on an already overburdened smallholder animal agriculture which is saddled with a plethora of challenges. Indiscrimate crossbreeding of exotic animal genetic resources with domestic animal genetic resources in an environment where climate effect is grave may outstrip the ability of the new progenies to adapt genetically, especially that of smallholder animal producers who have failed to adjust their management regime in response to climate change. Domestic animal genetic resources due to time have proved to have the capacity to be raised during dry periods of poor and dwindling feed resources, water scarce periods, and they have developed feeding behaviors which makes them survive such environmental and nutritional constraints, making them harmonious to adverse environmental conditions. This means that the domestic animal genetic resources have acquired both behavioral and physiological attributes to endure in adverse environmental conditions, that suggests this mechanism has become an inbuilt genetic phenomenon acquired by natural selection over evolution. Therefore, Africa smallholder animal agriculture need to adjust through exploring sustainable strategies to minimize vulnerability to climate change and variability which affects domestic animal genetic resources. However, any adoption of strategy which weakens the adaptive capacity of domestic animal genetic resources diversity is tantamount to disastrous future outcome causing unrepairable disruption of smallholder animal agriculture. Fortifying adaptive traits with relative improvement in productivity in domestic animal genetic resources will be crucial in dealing with climate change. It should be acknowledged that sustainable use of domestic animal genetic diversity is a vital for climate change adaptation model. Given the increasing global potential environmental consequences of climate change on animal production, there is need for breeding strategies in smallholder animal agriculture sector in Africa, revisiting the implementation of long-term unsustainable crossbreeding programs as it has proved to be a vehicle of loss of vital resilience genes in domestic animal resources. Promotion and development of domestic animal genetic resources should be part of Africa's climate change mitigation strategies, which target domestic animal genetic resources sustainable utilization which might drive a shift towards their conservation. It is now common knowledge that

climate change will greatly affect the smallholder animal agriculture due to lack of mitigation strategies'. Climate change will affect animal water resources, influence scarcity of feed resources and a plethora of emergence of new diseases due to changes in environmental conditions. To make matters worse the physiological disruption effects of higher temperatures on individual animals will be intense, this means they will be high risk on created new generation of animals with more exotic blood which will be badly affected by these climatic changes. It is presumed that in smallholder animal production sector breeding goals have to match the various adverse conditions of high temperatures, low quality nutrition, and elevated diseases challenges. Climate change's impact has shown it potential influence on future smallholder animal agriculture and this can only be safeguarded by promotion of the existing domestic animal genetic resources through securing its genetic diversity. It will be unwise for Africa to lose the precious genetic diversity through focusing on unsustainable smallholder crossbreeding projects. The noble focus in the eminent climate change and variability is to opt for genetic improvement strategies which minimize the loss of adaptive traits, however pushing for relative improvement in productivity. It is important for Africa to maintain the adaptive traits of the domestic animal genetic resources to match the changes in environment. It is assumed that the loss of domestic animal genetic diversity adaptive traits will be difficult to regain this genetic portfolio because it takes millenniums to induce adaptive traits. Genetic mechanisms influence fitness and adaptation. Barker (2009) defined adaptedness as the state of being adapted, the ability of animal groups to produce and reproduce in a given set of environment.

6. Implications

Crossbreeding as a breeding strategy of mating domestic animal genetic resources with the improved exotic animal genetic resources may not be a sustainable option for smallholder animal agriculture in Africa. The inability of the resultant progeny from crossing which of most of the time are more that 50% exotic blood to cope with the adverse changes in environmental conditions has compromised their survival and performance in smallholder animal agriculture. The promotion and development of domestic animal genetic resources populations is one strategy that rural livestock and poultry smallholder farmers must employ to maintain high diversity in on-farm niches and to buffer against climatic and economic adversities. Crossbreeding is the imminent cause and practice immersed in loss of domestic animal genetic pool in Africa. Taking into account commercial and non-commercial contribution of domestic animal genetic resources diversity their productivity merits outweigh the demerits because productivity model equation for domestic animal genetic resource takes into account of the multiple products and services provision to the rural economies. The intense use of productive animal genetic resources in resource poor based rural animal agriculture provided a route to the unmethodical use of exotic animal genetic resources and this has improved to be disastrous in distortion of authentic domestic animal genetic pool. Crossbreeding with exotic breeds can be recommended when resources and market demands allow the potential of such stock to be exploit, which has failed to materialise. The long-term unsustainability of the organizational system behind the crossbreeding schemes in resource poor rural animal agricultural systems in Africa has to be scrutinized to the same extent as the expected potential productivity improvement of domestic animal genetic resources. The challenge of replacement of animals genetic resources through crossbreeding is that you are changing the genetics of animals without equally changing their survival environment, not all components of smallholder the environment (feed resources limited, disease incidences, water scarcity, infrastructure) cannot be easily manipulated to match the performance of the crossbreds. This mean the failure of crossbreeding strategy has emanated from the fact that the manipulation of the smallholder animal agriculture to suit the conditions for minimum performance of the crossbreds has been difficult to achieve. It has been argued that it might be sustainable to maintain the crossbred animals at 50% exotic and 50% domestic for sustainable performance considering the prevailing constrained resources in smallholder animal agriculture in rural Africa.

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