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Review article

Prospects for indigenous chickens genetic improvement and conservation in Zimbabwe

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ABSTRACT

The multitude functions of indigenous chickens, which include the provision of high quality protein meat and eggs, cash through sales and socio-cultural roles, cannot be underestimated. Indigenous chickens is one of the genetic resources which Zimbabwe has failed to give adequate attention for the betterment of the majority of the rural poor population. Despite the indigenous chickens dual-purpose, selected and raised for meat or egg production, there does remain a considerable and largely unexploited genetic potential for increased production. The review explores the prospects for indigenous chickens genetic improvement and conservation in Zimbabwe. This is on the background that indigenous chicken are a heterogeneous population with no standardized characteristics and performance. This is mainly due to environmental and genetic constraints with bright prospects for genetic manipulation or improvement. Considerable genetic differences exist between local indigenous chickens populations, and production rates of local populations should be evaluated before introducing genetic improvement programs. The reported among population genetic diversity reflect the degree to which populations differ and can assist in improvement and conservation efforts.

1. Introduction

Indigenous chickens have a significant contribution to the rural economy, however production per chicken might be regard extremely low. Despite the low production, indigenous chickens production is of great importance to rural poor households , but they face the challenge of improving productivity of their flock, which could benefit them financially and promote food security as well as achieve market potential. Growth is slow while egg production is irregular, interrupted by hen high and mating is random given ways to unwanted inbreeding. Chickens are kept under scavenging production systems with limited application of management interventions to improve flock productivity. They have high reproduction rate per unit time, they are efficient in transforming feed protein and energy into human food, they use very low capital, labour and space, which allows chicken production to be practiced even by landless individuals (Muchadeyi et al., 2004). Most chicken in Zimbabwe are indigenous (30 million), distributed across different agro-ecological zones ((Mhlanga et al., 1999; Kusina et al., 2001).) and mostly under a traditional family -based scavenging management system (Faranisi, 1995). Muchadeyi et al (2007) observed that indigenous chickens are not substructured across agro-ecological zones but indicates a high genetic diversity within the Zimbabwe indigenous chicken population which makes it possible to create indigenous chicken breeds. This was on the assumption that agro-ecological isolation of indigenous chicken populations might lead to substructuring as each eco-type experiences different forces of evolution particularly drift, mutation and natural selection. It is suffice to say that indigenous chickens are part of the total poultry genetic diversity that comprises of chickens, turkeys, quails, ducks, goose, guinea fowls and pheasants. This diversity is needed for future advances and improvements in response to changing environments and consumer demands. An understanding of the production systems should therefore be coupled with an assessment of the genetic diversity within and between assumed population boundaries. Between population diversity reflects the degree to which populations differ and can assist in improvement and conservation efforts. According to Petrus et al (2011), use of improved breeds in developing countries presents farmers with a major challenge as the breeds require intensive management for them to realize full production potential. Genetic factors do not appear to be a restriction in Africa. Local animal genetic resources are able to make the best use of their actual environment, and, with better management, performance can be improved (Jahnke et al 1988).

2. Indigenous chicken genetic improvement strategy

In Zimbabwe, the indigenous chickens have remained insignificant due to lack of genetic improvement in commercially important traits (Kitalyi 1998; Mohd-Azmi et al., 2000; Li et al., 2006). Furthermore, they have not been genetically characterized into specific breeds, (Muchenje and Sibanda, 1997; Mhlanga et al., 1999) and no breeding programs have been put in place to improve these breeds. Genetic and phenotypic characterization of locally available farm animal populations provides essential information to make rational decisions for the improvement and the development of effective breeding program. Traditional chicken production system is characterized by lack of systematic breeding practice in chicken breeding is completely uncontrolled and replacement stock produced through natural incubation using broody hens. Use of nucleus centres is one of the breeding tools that can be used by farmers to improve their flocks. High rates of inbreeding should be avoided as they can reduce productivity. Proposals have been made for nucleus populations of indigenous genotype to be maintained at Government arms (Mhlanga et al., 1999). The smallholder sector is unable to provide the high levels of management and feeding levels required by improved breeds. The literature on community-based or village breeding schemes is scanty. Soelkner et al. (1998) analyzed determinants for success and failure of village breeding program citing various examples. A village breeding program is characterized by smallholder farming communities, often at subsistence level, combined with a low probability of changes in the environment, i.e. major constraints of disease, feed and land shortage are prevailing. Systematic recording of performance or animal identity is usually not taking place. If any selection is taking place, than the selection is often not directional, its goals are not defined and probably differ within and between farming communities. While the commercial breeding houses are ware of the shortcomings of the current breeds in meeting the needs of the smallholder sector, there are no plans to develop a specific breed for this sector (Mhlanga et al., 1999). Kitalyi (1998) and Li et al. (2006) argued that development efforts in Africa and Asia are more focused on introduction of exotic high yielding breeds than understanding the production potential of indigenous chickens. The commercial sector is challenged to produce a chicken breed that has less demanding feed requirements, is more resistant to diseases, grow faster or lay many eggs and suits free-ranging conditions.

Breed improvement and subsequent proper utilization of indigenous chicken genotypes require comprehensive characterization, including breeding practice. Genetic variation enables both adaptive evolutionary changes and artificial selection. Local chicken populations are seen as an important genetic reservoir developed over thousands of years and successful in extreme and unusual environments with limited veterinary and management input (Hall and Bradley, 1995).

Development of any genetic improvement strategy requires description of production environment, identifying the availability of infrastructure, setting appropriate breeding objective, selecting traits to be improved based on their influence on returns and costs to the producer and consideration of stockholders (Zewdu, 2004). Breeding and selection has been largely left to nature and to date no differentiations into broiler or layer strains have occurred (Faranisi, 1995). Thus, designing a breeding program needs decision on a series of such interacting components (Dansh and Jean, 2011). It is undisputable that Indigenous chickens are an important reservoir of genomes that may be used in future to produce hybrid birds since most strains have superior genetic constitution that has not been fully exploited (Pedersen, 2002). Crossbreeding of local strains with some imported strains can increase productivity of flocks (Pedersen, 2002) but should be coordinated to avoid replacement of indigenous stock (Mhlanga et al., 1999). Although better management procedures can significantly improve the performance of local birds, some feel there is also a need for genetic selection (Nwosu, 1979). Pure-breeding and selection programs have been developed in Bangladesh (Ahmad and Hashnath, 1983), although not implemented in the field. Both of the above groups concluded that although improvement of local poultry breeds would be beneficial, it is essential to evaluate breeds and their crosses before undertaking a breeding strategy. Genetic improvement of indigenous chickens should be based on non restricted genetic base as suggested by Delany, (2003). A reduction in population heterogeneity creates selection walls that result in reduced response to future selections. Many lines or strains can be created which can be used for crossbreeding purposes taking advantage of heterosis. However, this counteract the effect of high intensity and duration of selection which could probably result in loss of genetic variation through loss of alleles. Genetically distinct populations might carry unique genetic features due to unique alleles and allelic combinations. Within population diversity describes the genetic flexibility of a population and how it responds to different selection pressures. (Katule, 1991) concluded that selection for dual-purpose characteristics within individual local populations is both time-consuming and costly. Cross-breeding with improved breeds is recommended, followed by selection in the composite population. Indigenous chickens are kept for multi-functions therefore it is reasonable to suggest that it is important to restate that in the same bird, the traits of increased egg production and increased broodiness are genetically incompatible, as are the traits of high egg production and high meat production. Selection for any trait within these pairs will reduce the other trait of that pair making selection objectives difficult to design. Phenotypically, the main genetic types of Gallus gallus show a colorful feather pattern that varies in shape and size due to a great genetic variability. The population or genetic resources or strains also possess genes relevance such as naked neck , dwarf, spotted and frizzle , which could be useful in genetic improvement programs. The birds vary considerably in size, color, shape of comb and other features. In the eastern parts of the country, the naked-neck variety, which is also a large bird, is commonly seen. Very small bantams are found throughout the country, and there are also some varieties with short and bowlegs. Generally, the naked-neck variety is favored for its size and good mothering. Phenotypic characterization carried out by Pedersen (2002) revealed that village chickens are very heterogeneous in appearance within and between areas, relatively dark in plumage color, but varied in appearance due to their different features like crested chests or naked necks.

3. Biotechnologies and indigenous chickens genetic improvement

Biotechnology applications in the areas of animal genetics and breeding, including conservation of animal genetic resources, animal health, physiology of growth, and animal nutrition are a reality today and are finding their ways into research and development programs of developing countries. This is on the background that biotechnology is offering unprecedented opportunities for increasing animal productivity. Biotechnology is regarded as a means to meet both objectives through addressing the production constraints of small-scale or resource-poor farmers who contribute more than 70% of the food produced in developing countries. The use of major genes to improve productivity in smallholder poultry breeding programs has been researched in various tropical countries. Morphological traits that allow better heat dissipation such as large combs, large wattles and long legs have been studied. Gene coding for these traits, which are not major genes but the result of multiple genes and their interactions, could also be considered for incorporation into the development of high performance local birds for the tropics. The chances of major genes existing for most traits of interest, and of finding them are considered to be high (Mackinnon 1992). Since the 1970s, the discovery of technology that enables identification and genotyping of large Numbers of genetic markers, and research that demonstrated how this technology could be used To identify genomic regions that control variation in quantitative traits and how the resulting QTL could be used to enhance selection, have raised high expectations for the application Of gene-(GAS) or marker-assisted selection (MAS) in both poultry and livestock. Among livestock species, chicken has the most extensive genomics toolbox available for detection of quantitative trait loci (QTL) and marker-assisted selection (MAS). Recent advances in genome technology have enabled sequencing of entire genomes, including of several livestock species; the genomes of the chicken and cattle have been sequenced. Following mapping and identification of polymorphisms within the gene, associations of genotype at the Candidate gene with phenotype can be estimated (Rothschild and Plastow, 1999). Sequencing has been used to identify large numbers of positions in the genome that include SNPs, i.e. DNA base positions that show variation. For example, in the chicken, over 2.8 million SNPs were identified by comparing the sequence of the Red Jungle Fowl with that of three domesticated breeds (International Chicken Polymorphism Map Consortium, 2004). Recent advances in molecular genetic techniques will make dense marker maps available and genotyping many individuals for these markers feasible. Marker genotypes for thousands of loci across the genome can measure genetic similarity more precisely (Meuwissen, 2007). Markers that are identical in state may be shared through common ancestors earlier than those in the known pedigree. Genomic selection methods are centered on what assumptions are considered valid, the most critical being the assumed distribution of gene effect (Meuwissen et al ., 2001). Several studies have found that an assumption of the infinitesimal model, equivalent to BLUP with a genomic relationship matrix (GRM), performed as well as others (Bayes A or Bayes B, Hayes et al. , 2009; VanRaden et al. , 2009). The same opportunities and challenges for the use of molecular information for genetic improvement of indigenous chickens exist in Zimbabwe. Use of molecular methods to choose breeding animals with genes or markers for genes that are of economic importance has been proved possible in animal breeding. This involves detecting direct markers or genes responsible for the expression of the trait of interest or using genome wide association studies to identify QTL conferring to any productive traits. A genetic marker for a trait is a DNA segment which is associated with, and hence segregates in a predictable pattern as, the trait. The process of selection for a particular trait using genetic markers is called marker assisted selection (MAS). Availability of large numbers of such markers has enhanced the likelihood of detection of major genes influencing quantitative traits. The method involves screening the genome for genes with a large effect on traits of economic importance through a procedure known as linkage analysis (Paterson et al 1988). According to Calus, et al., (2013) genomic selection relaxes the requirement of traditional selection tools to have phenotypic measurements on close relatives of all selection candidates. This opens up possibilities to select for traits that are difficult or expensive to measure. It has been reported that about 50% additional genetic gain can be obtained if the marker explains 20% of the additive genetic variance and the economic trait has a heritability of 0.2 (Lande and Thompson (1990). While, Smith and Simpson, (1986) postulated that use of molecular markers can accelerate the rate of genetic progress by increasing accuracy-of selection and by reducing the generation interval. However, the benefit of marker assisted selection is greatest for traits with low heritability and when the marker explains a larger proportion of the genetic variance than does the economic trait. Microsatellites are codominant, highly polymorphic markers that are commonly used for assessing genome-wide genetic diversity (Baumung et al., 2005; Soller et al., 2006). They are assumed to be neutral to selection and can therefore give an insight into both current and unknown future genetic value of populations. They have been used in many diversity studies and have been found to give reliable estimates of genetic diversity within populations as well as the level of differentiation between breeds (Weigend and Romanov, 2001). However, n the developing world, despite the potential benefits, investment has been low for QTL detection and QTL selection has rarely been applied.

4. Indigenous chickens conservation strategies

There has been a global concern about the potential long term consequences of loss of domestic animal diversity and the need for conservation of animal genetic resources which are prerequisites for food security and the future agricultural innovations (CBD, 1992). Conservation of local animal genetic resources possessing genetic variations specific to the particular environment is essential for sustainable development. Determining the value of indigenous chicken strains is essential to define conservation priorities, manage genetic diversity and possible funding of conservation programs. Within- and between-ecotypes genetic diversity need to be assessed to preserve the highest intra-specific variability. Information on genetic diversity and risk status is still lacking for indigenous chickens in Zimbabwe, despite their distinct evolutionary trajectories and adaptation to extreme environmental conditions. The primary policy goal for conservation of biodiversity should focus on the diversity between and within indigenous populations of farm animals. However, it seems that animal genetic conservation in general is not easily justifiable economically, however, Smith (1984) expressing economic justification of conservation and preservation of genetic resources calculated the product of value expressing the used proportions of genes of the genetic resources and relative profit in economic efficiency. The feasibility of breeding programs and in situ conservation programs depends on whether they are tailor made for the particular production systems. Conservation can be defined as the management of human use of animal genetic resources to yield the greatest sustainable benefit for the current and to maintain the potential for future generation (Wollny, 1995). Indigenous poultry and livestock genetic resources are numerically and economically very important and promising genetic resources, however their conservation and sustainable use have lagged behind in Zimbabwe. For many years the performance of indigenous poultry and livestock of Africa was regarded as inferior in spite of the fact that Africa is richly endowed with a large number of indigenous poultry and livestock (Scholtz, 2012), however the increased demand for poultry and livestock products locally will open up economic opportunities for indigenous poultry and livestock production. Strategy on indigenous chickens conservation should be instrumental in ensuring the survival of this animal genetic resources population, while at the same time partaking a comprehensive genetic characterization and improvement on necessary bird traits which focuses on empowering the poor rural majority. There is a consensus that global animal genetic resources diversity, especially the native population, is under pressure. In the context of Zimbabwe, the existence of threat to most animal genetic resources is accepted, even though debate remains about the severity of genetic erosion. The extent of genetic erosion in indigenous chickens is not yet at an alarming stage which warrant panicking. Unknowingly some of our indigenous livestock genetic resources may be classified as insecure or vulnerable but not however endangered as such. One of the genetic erosion in Zimbabwe might be due to environmental changing associated with climate change i.e. droughts have resulted in loss of valuable indigenous chicken genetic resources, breeding tracts and mixing of genetic characteristics of various genetic grouping. The loss of animal genetic resources should be viewed with concern as their play an important socio-economic role in terms of supporting current and future livelihoods as well as profits (Hiemstra et al., 2006). However, on chickens a cushioning mechanism through local effort on conservation might start now through appropriate conservation centers complemented with in situ conservation and genetic improvement can be also done on various traits. There is need to invest in indigenous chicken research and involve rural farmers in indigenous chickens conservation to support chicken conservation and genetic improvement programs to accrue maximum benefit. Previously, an attempt in other livestock species, especially cattle, long term livestock improvement and conservation programs where executed on station, invariably included management techniques which were not used in traditional livestock systems such as routine disease control and restricted breeding season, planted forages and fencing. As a result conclusions were not relevant to resource poor farming sector that harbors most of the indigenous livestock genetic resources populations. Smallholder farmers would want to see more use of their own local indigenous animal genetic resources with this understanding local farmers will continue to maintain the local chicken strains because they have something to offer. This recognition of value of indigenous animal genetic resources will assist to develop acceptable long term conservation strategies. However, it should be acknowledged that an attempt to involve smallholder farming sector as the beneficiary in indigenous chickens conservation strategy a few challenges might be encountered. The majority of traditional poultry farmers can not read and write, this may complicate the whole conservation efforts. The inability to interpret information coming from documented research may cause some confusion. Participation of the resource poor farmer in indigenous chicken genetic resource conservation is highly desirable but ways and means of achieving success is a surmountable task and needs proper planning and implementation. Hence, there is need to implement conservation and sustainable use of indigenous chickens genetic resources to derive maximum benefit. Conservation and sustainable use of indigenous chickens genetic resources is essential due to their potentiality for multipurpose use, disease tolerance and low maintenance requirements. The future of animal production will rely on a wide use of indigenous chickens genetic resources that can survive and produce under harsh semi arid conditions of Zimbabwe.

Conservation genetics focuses on the effects of contemporary genetic structuring on long-term survival of a species (Wan et al., 2004). The use of oligonucleotide fingerprinting and fecal DNA is opening new areas for conservation genetics. With the application of molecular techniques in genetic studies of endangered species, conservation genetics has become a distinct discipline. Although, there might be a plethora of limitations in developing countries, such as Zimbabwe, on the use of biotechnology tools for characterizing and conserving indigenous chickens genetic resources, and of the many specific issues involved in applying them for rural development, opportunities exist in the use of cryopreservation and reproductive technologies for conservation of animal genetic resources. Semen from all mammalian livestock species as well as poultry species can be successfully frozen for future use. Freezing procedures for semen cryopreservation are species-specific. Gene bank can be created where a physical repository of samples of a genetic resource which are being preserved (e.g. live animals, embryos, oocytes, semen, tissues, DNA) are kept. Data bank which comprise of a collection of information on characteristics (including production system, production levels, adaptive traits and physical characteristics), status, husbandry, users and uses, etc, of genetic resources, stored in a systematic manner (usually electronic) and with provisions for editing and retrieval for viewing and analyses can also be part of animal genetic resource conservation. According to the European Cattle Genetic Diversity Consortium (2006) two methods have been developed for the assessment of conservation priorities on the basis of molecular markers. According to the Weitzman approach, contributions to genetic diversity are derived from genetic distances between populations. Alternatively, diversity within and across populations is optimized by minimizing marker-estimated kinships. Both Weitzman approach and the core set diversity measure of Eding et al. (2002) can be used to quantify the contribution of each breed to the maximum amount of genetic diversity and to identify breeds important for the conservation of genetic diversity. The technical advance of molecular markers has led to the blossoming of genetic analysis of populations in the last decade; however, the indiscriminate application of genetic markers used for population genetics to conservation genetics can potentially lead to inappropriate interpretations. The limitation of using conservation genetics is the capital outlays required to use bio-based genetic analysis which are presently higher than those of traditional conservation methods. Thus, it can be difficult to justify starting new animal genetic resource conservation industries based on biotechnology, which leaves such innovations to existing facilities in developed world. This leads to the observation that only intermediate developing countries, those with existing infrastructure and some scientific capacity, can realistically consider applying biotechnology to animal genetic conservation. Other developing countries could still become involved in this sector in a limited fashion, through the use of their biological resources.

5. Implications

The potential for indigenous chickens improvement is a factor which need urgent attention meanwhile efforts should be continued to preserve indigenous chicken germplasm as a resource for the future dealing with the unpredictable climate change effects on both livestock and poultry production. It is difficult to imagine birds better adapted for survival under scavenger free-range conditions than the strains that have already evolved under those very same conditions, and are still surviving as proof of their ability to do so. Zimbabwean indigenous chickens are not under threat from uncontrolled mating practices and are at high risk of becoming genetically homogeneous because of the ecotypes in different agro-ecological regions. The high genetic diversity make the indigenous chickens populations suitable for future genetic improvement and utilization under a wide range of agro-ecologies in Zimbabwe. However, extensive work need to be carried out to elucidate the genetic variability and genetic relationship among different ecotypes which has direct relevance with the issues of sustainable use of indigenous chicken genetic resources. Work which will ascertain the current genetic diversity to understand whether the ecotypes in different ago-ecological regions are genetically differentiated. It is highly likely that there is low gene flow among indigenous chicken populations in Zimbabwe which can safeguard against loss of genetic diversity through genetic uniformity and a reduction in opportunities for future breed development. Therefore an attempt to develop improvement strategies should put mechanisms to prevent loss of genetic diversity, improve productivity and reduce uncontrolled genetic exchanges between populations. The promotion of indigenous chicken production can be a sustainable way of helping to meet the welfare needs of rural populations and raise their living standards if the lack of information on research to characterize, understand and develop the indigenous chicken production system in Zimbabwe is demystified. Marker identification and use should enhance future prospects for breeding for indigenous chicken productive and adaptive traits. Indigenous chicken genetic resource conservation and sustainable use can contribute to reduced vulnerability, increased food security and accelerated growth in rural economies in Zimbabwe. However, indigenous chicken genetic conservation should encompass changes in value and attitude of resource poor famers from the present consideration for number of birds as status symbol to more important objectives of higher productivity and socioeconomic benefits that are business oriented. The discussion conclude that in the planning and implementation of indigenous chicken conservation and improvement consideration to increase bird productivity, both conservation centers and smallholder farming sector conservation approach is proposed, placing the household as focal point of livestock conservation. Small scale farmers approach should become increasingly important and can have a tremendous influence on achieving the primary objective which should be the conservation of indigenous livestock genetic resources one of the most vital resources in rural economy. The maintenance of traditional livestock agriculture systems as part of indigenous chicken conservation and sustainable utilization strategy may be a starting point for future programs. It is assumed that in Zimbabwe, improvement and conservation of animal genetic biodiversity is inbuilt into the low input – low output production strategies of smallholder farming systems hence any improvement and conservation strategy which disregards this sector will not succeed . Conservation measures for indigenous despite not having reached a critical size might even be necessary before a detailed genetic and phenotypic evaluation and economic analysis can take place. It is assumed that the knowledge of distribution of potentially useful genetic polymorphisms within and between the world's animal genetic resources, objective decision s on conservation and utilization of genetic diversity would be relatively straightforward.

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