DOI: https://doi.org/10.20372/afnr.v2i2.970
ISSN: 2520-7687 (Print) and 3005-7515 (Online)
Journal of Agriculture, Food and Natural Resources
J. Agric. Food Nat. Resour. May-Aug 2024,2(2):49-54
Journal Home page: https://journals.wgu.edu.et

Review Article

Genetic Diversity, Gene Conservation and Indigenous-Chicken Gene Erosion in Ethiopia: A Review

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Abstract

Indigenous chickens exhibit the highest rate of population type variation among chicken species, particularly in many African countries. These local or indigenous chickens are renowned for their excellent adaptive traits and are characterized by significant variations in morphological features and production parameters. Ethiopia is home to at least eleven distinct indigenous chicken ecotypes: Tilili, Horro, Chefe, Jarso, Tepi, Gelila, Debre-Elias, Melo-Hamusit, Farta, Guangua, and Mecha, named after either their feather color or their region of origin. This diversity offers a substantial advantage for developing sustainable breed improvement strategies through selection and crossbreeding. However, the genetic integrity of these indigenous chickens is under threat due to various factors. The introduction of exotic germplasm, changes in production systems, shifting market preferences, natural disasters, inconsistent public and private sector policies, and a lack of adequate funding for conservation efforts have all contributed to the genetic dilution of these valuable animal genetic resources. As a result, indigenous chickens, which are well-suited to extensive husbandry systems and are vital for resource-poor poultry farmers with limited income, should be carefully studied and preserved as a foundation for both their improved utilization and conservation. The genetic erosion of indigenous chickens is a significant concern, primarily driven by the indiscriminate distribution of exotic chickens, uncontrolled breeding of local chickens, and inefficient local breed improvement strategies. These factors pose a substantial threat to the genetic diversity and conservation of indigenous chicken genes that resulted in indigenous gene erosion.

Article Information

Article History:

Received : 24-01- 2024

Revised : 23-08-2024

Accepted : 25-08-2024

Keywords:

Breed improvement
Gene erosion
Genetic conservation
Indigenous chicken

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INTRODUCTION

Poultry production offers significant economic, social, and cultural benefits, playing a crucial role in family nutrition, especially in developing countries (Hinsemu *et al*., 2018). The term 'poultry' originates from the French/Norman word 'poule,' derived from the Latin 'pullus,' meaning small animals. Poultry refers to all domestic birds raised for meat and egg production, including chickens, turkeys, ducks, geese, quails, ostriches, and guinea fowl (Prabakaran *et al*., 2020). Chickens (*Gallus gallus domesticus* or *Gallus domesticus*) represent the most prevalent domesticated animal species globally. In 2017, the worldwide population of chickens surpassed 22 billion (FAO, 2020).

Chickens are the most economically important poultry species worldwide, integral to rural households as a source of high-quality animal protein and emergency cash income (Birhanu *et al*., 2023). They also play a significant role in the socio-cultural life of rural communities and in empowering women economically. Poultry species, domesticated from the red jungle fowl, originated in Southeast Asia and are now widespread globally (Eda, 2021). Molecular evidence from whole-genome sequencing suggests that chickens were domesticated from the red jungle fowl around 8,000 years ago in China and India and later spread geographically through trade to the Mediterranean region (Peters *et al*., 2022). Large-scale commercial chicken farming began in the 19th century, although Spanish explorers reportedly introduced domesticated fowl to the New World in the 16th century. Despite limited information on the introduction of domesticated chickens to Africa, evidence, such as a drawing of a domestic cock found in Egypt, suggests an early presence on the continent (Wilson *et al*., 2021).

Ethiopia's indigenous chickens are closely related to the red jungle fowl (Getu, 2014). The term 'Indigenous' broadly describes birds kept in extensive systems, scavenging in free-range environments, with no identified breed description, serving multiple purposes, and remaining

unimproved. These indigenous chickens are vital reservoirs of genetic material for studies on genetics, gene improvement, preservation, and conservation. Indigenous breeds are often named after the color of their feathers or their region of origin. Ethiopia, for example, is home to at least eleven indigenous chicken ecotypes: Tilili, Horro, Chefe, Jarso, Tepi, Gelila, Debre-Elias, Melo-Hamusit, Farta, Guangua, and Mecha (Getu and Tadesse, 2014).

Most urban and peri-urban communities in Ethiopia prefer indigenous breeds due to their adaptability to local environmental conditions. Indigenous chickens in the tropics have inherent scavenging and nesting habits, are more resistant to diseases, are less vulnerable to predators, and can endure harsh nutritional and environmental conditions (Kpomasse *et al.*, 2023). These chickens possess special adaptive features that allow them to survive and reproduce in challenging climatic, nutritional, and management conditions, typically associated with low-input, low-output production systems.

However, the productive performance of indigenous chickens is often low, characterized by low egg production potential, high mortality rates, and longer reproductive cycles, leading to slow growth rates, late sexual maturity, and prolonged broodiness (Aleme, 2022). Genetic diversity is essential for the sustainable use and improvement of indigenous chickens, both now and in the future. Local chickens in African countries, including Ethiopia, exhibit a wide range of morphological traits and production characteristics.

In Ethiopia, efforts have been made to gather valuable information on the conservation of animal genetic resources through genetic characterization studies, although most of these studies have focused on cattle and small ruminants, rather than chickens. Among poultry species, indigenous chickens have the highest rate of population diversity. Chebo *et al*. (2022) indicate that Ethiopian indigenous chickens exhibit greater genetic diversity and possess significant potential for long-term breed improvement through selective breeding strategies.

However, exotic chicken breeds frequently encounter difficulties in adapting to tropical production environments. These challenges include increased susceptibility to diseases and parasites, inadequate feed resources, suboptimal housing conditions, and the constraints of traditional farming practices (Mesele, 2023). The widespread adoption of exotic breeds, commercialization of the production system, and uncontrolled breeding practices could threaten the genetic integrity of native chickens. Hence, native chickens should be viewed as gene reservoirs, particularly for genes that are valuable for adaptation to tropical environments. Understanding the relationship between genetic diversity and adaptability is crucial for guiding breed development initiatives supported by genetic markers. Consequently, evaluating the genetic diversity, gene conservation, and prospects of Ethiopia's native chicken ecotypes is essential for sustainable poultry production. Therefore, this review seeks to evaluate existing literature on genetic diversity, gene conservation, and the erosion of indigenous chicken genes in Ethiopia.

LITERATURE REVIEW

Ethiopian Indigenous Chicken Ecotypes

Ethiopia is endowed with rich chicken genetic resources (CSA, 2020). The country's total poultry population was estimated at 57 million, with approximately 78.85% being indigenous breeds, 12.02% hybrids, and 9.11% exotic breeds (CSA, 2021). According to Nigussie *et al*. (2010), indigenous breeds vary in color, comb type, body conformation, and weight, contributing significantly to poultry meat and egg production and consumption in the country. These indigenous breeds account for up to 90% of the total poultry products in Ethiopia.

In various literature, the terms "ecotype" and "breed" are often used interchangeably. "Ecotype" in evolutionary ecology refers to a population that is genetically adapted to specific environmental conditions (Vallejo-Trujillo *et al*., 2022). Alternatively, the term "ecotype" is described as "a non-static adaptive variation over many traits across the natural landscape with no discernible boundaries" (Lowry, 2012). Different scholars, including Tadelle *et al*. (2003) and Halima *et al*. (2007), also use the terms 'indigenous,' 'native,' 'local,' or 'traditional' interchangeably.

Ethiopia's vast population of poultry, along with its varied agronomic and agroecological practices, presents a valuable opportunity for enhancing the agricultural sector and improving livelihoods. According to Solomon (2008), the country has native, exotic, crossbred, and hybrid chicken breeds. Indigenous chickens in Ethiopia are characterized by their distinct coloration, comb type, body conformation, innate scavenging instincts, nesting behavior, and capacity for environmental adaptation (World Bank, 2014; Feseha *et al*., 2010; Aman *et al*., 2017). Consequently, Ethiopia is reported to have at least eleven indigenous ecotypes of chickens, including Mecha, Horro, Tilili, Debre-Elias, Melo-Hamusit, Farta, and Jarso (EBI, 2016).

Tolasa (2021) reported the presence of approximately ten indigenous chicken ecotypes in Ethiopia. These include Chefe and Gebsima, which exhibit barley plumage; Horro, Jarso, and Keyi, which display red plumage; Naked Neck and Netch, which have white plumage; Tepi and Tikur, which are characterized by black plumage; and Tilili (ILRI. 2016 and Solomon, 2008). Additionally, Assefa and Melesse (2018) identify several other ecotypes, such as buff/yellow, white-barley, golden-red, black-tailed white, and silver indigenous ecotypes. The image of the Red Junglefowl depicted in Figure 1

Figure. 1- The red jungle fowl Source: Cacklehatchery.com

Uncontrolled breeding and genetic erosion of Indigenous chicken

Neeteson-van Nieuwenhoven *et al*. (2013) emphasize that productivity and efficiency traits should be integral to animal breeding objectives. According to Wondimeneh (2015), while it is possible to genetically enhance desirable traits, the environment in which these traits are expressed must be accurately identified, regulated, and optimized. However, in less-than-ideal environments, such as those prevalent in developing nations, the performance of a breed can be significantly compromised. Despite these challenges, Thornton (2010) suggests that developing countries have considerable opportunities to improve production even under environmental constraints. Nevertheless, Hoffmann (2009) and the Food and Agriculture Organization (FAO,

2007) estimate that 33% of regional chicken breeds are at risk of extinction.

To assist countries in better characterizing, utilizing, and conserving chicken genetic resources, the FAO, in collaboration with USAID, established the Domestic Animal Diversity Information System (DAD-IS) in 1952, also known as the Communication and Information System (Halima, 2007). However, animal genetic resources (AnGR) have suffered genetic dilution due to the introduction of exotic germplasm, changes in production systems, market preferences, natural disasters, inconsistent public and private sector policies, and insufficient funding for conservation efforts (Dana, 2011). Although these programs are crucial, there has not been an adequate focus on evaluating these resources or on establishing optimal and realistic breeding objectives. As a result, a significant portion of Africa's animal genetic resources is at risk of extinction. Without prompt action to identify and protect these resources, they may disappear before they can be fully understood and documented. Furthermore, there is evidence of a significant decline in genetic diversity, with poultry genetic resources being among the most endangered (Crawford, 1990; Halima, 2007).

Selective breeding within breeds is an alternative strategy to enhance production levels. However, unbalanced extension systems, production-derived breed references, indiscriminate crossbreeding, and production system modifications have been primary contributors to the genetic degradation of indigenous chickens. Inbreeding poses a particular risk to indigenous chickens, potentially leading to the loss of important selective traits. Since inbreeding often results in reduced vigor and fertility, detailed production documentation is essential for advancing chicken production in the future (Muasya *et al*., 2013).

Future Prospects of Indigenous Chicken in Ethiopia

Ethiopia's economy is predominantly agrarian, with agriculture contributing an estimated 42.3% of the country's GDP (World Bank, 2014). Within this sector, livestock including poultry accounts for approximately 26.4% of the GDP (ILRI, 2016). The country's vast poultry population, coupled with its diverse agronomic and agroecological practices, presents a significant opportunity for sectoral growth, which could, in turn, improve the livelihoods of impoverished livestock keepers. Indigenous chickens in Ethiopia represent the largest share of all poultry breeds in terms of economic contribution (Ruxton, 2013).

Due to the suboptimal performance of indigenous chickens, the government initiated the introduction of exotic breeds from temperate zones. However, efforts to enhance the productivity of indigenous chickens through crossbreeding with exotic strains have proven largely ineffective over several decades. According to Nigussie *et al*. (2010), these shortcomings may stem from the dissemination of inappropriate technologies without a thorough understanding of the production environments in which indigenous chickens are raised, as well as a lack of insight into breeding goals and farmers' preferred traits. Despite Ethiopia's large population of indigenous chickens, the Food and Agriculture Organization of the United Nations (FAO) (2019) reported that the contribution of poultry to farm households and the national economy does not reflect their potential.

Efforts to improve local poultry breeds began in the 1950s, with the introduction and distribution of exotic chickens such as Rhode Island Red, New Hampshire, White and Brown Leghorns, Cornish, and Australorp Light Sussex (Tamir *et al*., 2015). More recently, additional exotic breeds like Bovans Brown, Potchefstroom Koekoek, and Sasso have been introduced, which now constitute the majority of Ethiopia's exotic chicken population (Aman *et al*., 2017). However, the productivity and production of these exotic breeds have been hindered by various challenges, including diseases, predators, inadequate healthcare, insufficient feed supplies, and poor marketing knowledge (Natnael, 2015).

Adebabay (2018) has argued that instead of relying solely on the importation of exotic breeds, long-term poultry breeding programs should focus on improving Indigenous chickens through selective breeding. This approach could better meet the demands of low-input and tropical systems. In line with this, the Ethiopian Institute of Agricultural Research (EIAR) introduced alternative strategies, such as the selective breeding of indigenous Horro chickens and the development of the DZ-white synthetic chicken, to enhance performance while preserving local genetic resources. The Horro chicken selective breeding program has shown promising results, as reported by Woldegiorgiss (2015) and Dana *et al*. (2011). Notably, the program achieved a 74% increase in average body weight at 16 weeks and a 21% increase in egg production at 24 weeks post-laying onset between the fourth and sixth generations.

Selective breeding of superior hens and cocks holds the potential to enhance the productivity of local chicken ecotypes without compromising genetic diversity, a risk often associated with indiscriminate crossbreeding practices in developing countries. Indigenous chickens, which are well-adapted to large-scale husbandry systems and suited for resource-poor poultry farmers, should be carefully studied to optimize their utilization and conservation. Table 1 below presents statistical data from the Central Statistical Agency (CSA) for 2010 to 2022, illustrating a rapid decline in the native chicken population alongside a marked increase in the prevalence of hybrid and exotic chickens

Table 1 Growth trend of Exotic and hybrid chicken in Ethiopian Chicken Population

Years of Introduction	Breed of Chicken		
	Indigenous	Hybrid	Exotic
2010	97.30	0.38	2.32
2012	97.00	0.58	2.42
2013	96.83	0.80	2.37
2014	96.90	0.54	2.50
2017	94.30	3.21	2.49
2019	81.71	10.86	7.43
2021	78.85	12.02	9.11
2022	78.04	17.58	4.38

Source: CSA (2011-2023).

SUMMARY

This review article provides a comprehensive analysis of the genetic diversity, conservation challenges, and the erosion of indigenous chicken genes in Ethiopia. Indigenous chickens in Ethiopia are genetically diverse and play a crucial role in the livelihoods of smallholder farmers. This diversity is evidenced by the existence of at least eleven distinct indigenous chicken ecotypes, each adapted to specific environmental conditions and named after their feather color or region of origin. These chickens are well-suited to extensive husbandry systems and are vital for resource-poor poultry farmers who rely on them for income and nutrition. However, the genetic integrity of these indigenous chickens is under threat due to a variety of factors, including the introduction of exotic breeds, changes in production systems, shifting market preferences, natural disasters, and inconsistent public and private sector policies.

The review critically examines the strengths and weaknesses of the existing literature on genetic diversity and gene conservation of indigenous chickens in Ethiopia. It highlights the substantial genetic diversity within Ethiopian indigenous chickens, which presents significant opportunities for breed improvement through selective breeding strategies. However, the review also points out the challenges posed by the widespread adoption of exotic breeds, which often struggle to adapt to the harsh tropical environments of Ethiopia. These challenges include increased susceptibility to diseases, inadequate feed resources, and poor housing conditions, which have led to the genetic dilution and erosion of indigenous chicken genes.

The review also identifies several gaps and contradictions in the existing literature. For instance, while there is a consensus on the importance of conserving indigenous chicken genetic resources, there is a lack of agreement on the most effective strategies for achieving this. Some studies advocate for the selective breeding of indigenous chickens, while others emphasize the need for crossbreeding with exotic breeds to enhance productivity. Moreover, the review notes that the inconsistent implementation of conservation policies and the lack of funding for conservation efforts are significant barriers to the effective preservation of indigenous chicken genes.

CONCLUSION

Genetic diversity is essential for the sustainable utilization and advancement of indigenous chickens, both in the present and future generations. Ethiopia, with its vast chicken population and rich genetic resources possesses significant potential for poultry production. The genetic diversity of indigenous chickens in Ethiopia is a valuable asset that must be preserved to ensure the sustainability of the country's poultry sector. Despite the challenges posed by low productivity, high mortality rates, and the introduction of exotic breeds, indigenous chickens remain vital for the livelihoods of smallholder farmers. The review highlights the importance of strategic interventions, such as selective breeding and the development of breeding programs that prioritize the unique adaptive traits of indigenous chickens. However, the review underscores the need for a more comprehensive approach to conservation that includes robust policies, increased funding, and a greater focus on the genetic characterization of indigenous chickens. By taking these steps, Ethiopia can safeguard its indigenous chicken populations and secure the long-term sustainability of its poultry sector. In conclusion, the review takes a clear stance in support of conserving the genetic diversity of indigenous chickens in Ethiopia. It argues that while the introduction of exotic breeds may offer short-term productivity gains, it poses a significant risk to the long-term sustainability of indigenous chicken populations. The review advocates for the implementation of selective breeding programs that prioritize the unique adaptive traits of indigenous chickens, coupled with robust conservation policies and increased funding for research and conservation efforts. By preserving the genetic diversity of indigenous chickens, Ethiopia can ensure the sustainability of its poultry sector and the livelihoods of the smallholder farmers who depend on it.

Conflict of Interest

The authors declare that there is no conflict of interest.

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