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Review Article

Relative Phenotypic Performance of Crossbred Chicken as Step in Synthetic Breed Development in Ethiopia: A Review Article

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Abstract

The present review article aims to provide and summarize synthesized information regarding some of economically important traits on reproductive and productive performance of crossbred chicken to develop both adaptive and sustainable breed to the intended beneficiaries. Most of crossing were used full diallel mating design in both direct and reciprocal ways. Growth traits, egg production traits, reproductive traits and other economically important traits of crossbred chicken were assessed in comparison to their counterpart's purebred both native and exotic parents. In the majority of crossbreeding studies, the hybrids surpassed the original native parental breeds in various traits studied, including body weight, feed conversion ratio, age at first egg, egg production, egg weight, and egg mass. The majority of hybrids achieved sexual maturity at an earlier age, laid more eggs, and produced a greater egg mass when compared to local chickens. Eggs from the hybrids were also heavier than those from the local chickens in certain crossbreeding experiments. In overall, crossbred chickens that combine the blood of exotic and local breeds tend to perform relatively better than indigenous chickens, which are typically characterized in low production due genetics. The frequent production of F_1 crossbred demands in subsequent importation of exotic parent due to produced offspring chicken are terminal genetically. Also, the degree of heterosis retained in the crossbred decreased as generation increased due recombinant ad segregations effects. To overcome such problem producing adaptive and sustainable chicken breed through synthetic breeding is crucial for developing countries like Ethiopia.

Keywords

Crossbred, Growth Traits, Egg Production Traits, Synthetic Breeding

1. Introduction

The production of poultry plays a significant role in the economies of developing nations and contributes significantly to poverty reduction through income generation and ensuring food security at the household level [29]. Chicken population in Ethiopia is estimated to be around 57 million. Out of this population, approximately 9.11 % are crossbred chicken [10]. Chicken production in Ethiopia plays a crucial role in supplying eggs and meat to both rural and urban areas, and it serves as a significant source of income, particularly for women. Over time, the importance of poultry in Ethiopia has been increasing. Proper feed supplementation and healthcare are important for optimizing the genetic potentials of indig-

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enous chickens and conserving these valuable genetic resources [16]. Recognizing this significance, various organizations have made efforts to introduce high-performance exotic poultry breeds to smallholder farming systems in Ethiopia. These initiatives aim to address the low production potential of indigenous chicken ecotypes [11]. In the early 1950s, the chicken improvement initiative to enhance egg and meat production from indigenous chickens was started in Ethiopia [33].

Initially, the genetic improvement initiatives for indigenous chickens in Ethiopia have predominantly relied on the introduction of various high-yielding exotic chicken breeds [11]. Regrettably, these programs have proven to be unsuccessful as the exotic chicken breeds have struggled to adapt to the local production systems for which they were not originally developed. The practice of selective breeding has not been widely implemented in developing nations, primarily due to the absence of the necessary infrastructure required for performance recording and genetic evaluation schemes [36]. Alternative breeding approach which aids in increments of production and productivity of indigenous chicken needed to be explored which relatively pay cheap infrastructure and drops out in short period of times.

Crossbreeding is a commonly employed technique in the commercial chicken industry to take advantage of heterosis when the desired traits are a combination of existing lines or breeds. It is also used to enhance the efficiency of operations by utilizing specialized sire and dam lines [32]. This method is utilized in the production of crossbred chickens [12]. Additionally, crossbreeding capitalizes on non-additive genetic variation resulting from heterosis or hybrid vigor. Heterosis has been extensively utilized in poultry breeding programs to produce offspring that demonstrate superior performance compared to the average of their parental breeds [38].

The process entails the crossing of two distinct chicken breeds, which leads to offspring that frequently display enhanced quantitative characteristics in comparison to either one or both of the parent breeds. However, the long-term viability of utilizing exotic crosses for increased productivity was hindered by the limited adoption of these birds in the rural farmers, primarily due to various socio-economic and environmental obstacles [35]. Consequently, there is a clear requirement for birds that possess a certain degree of local inheritance, enabling them to endure the challenging conditions associated with family poultry production. Furthermore, the inclusion of native inheritance also enhances the acceptability of these birds within rural areas.

Numerous studies have demonstrated that crossbred chickens outperform purebred chickens in terms of growth, egg production, and egg quality traits [18, 34, 17, 13, 37]. The level of hybrid vigor, which is the measure of the superiority of the crossbred offspring, is expected to be directly proportional to the level of heterozygosity in the crosses. Conversely, it is inversely correlated with the genetic similarity between the parental populations [22]. Furthermore, lack of alternative of dual-purpose chicken breeds, which are capable of producing both meat and eggs, exacerbates the already existing constraints and poses a significant challenge to the production and availability of chicken meat and eggs in Ethiopia. The present informative review article aims to compile phenotypic performance of crossbred chicken in Ethiopia as step in synthetic breed development for different production system.

2. Relative Growth Traits Performance of Crossbred Chicken

Growth is a crucial factor in chicken breeding as it directly affects productive efficiency and reduces production costs [18]. The body weight of chickens plays a significant role in determining their production capacity, whether they are raised for eggs, meat, or both. It is important to note that the body weight of chickens can vary among different strains, ecotypes, or breeds, both at the age of first egg and at hatching. Crossing is a method that can improve growth performance in poultry, which have a main purpose that produce superior crosses for growth traits which are influenced by various genetic and non-genetic factors. Growth can be regarded as a direct fitness trait that increases meat productive efficiency and thereby decreases production costs.

Several investigators confirmed the superiority of crossbreed over the pure breeds in body weight at different ages [30, 19, 39, 34, 17, 13]. The average of body weight for crossbred was significantly higher than Sinai when it was cross with Hubbard. However, Hubbard was significantly superior and higher than that of Sinai or crossbred for body weight at different ages [6].

The Ethiopian improved Horro chicken crosses with kuroiler demonstrated the highest average body weight at hatch compared to their parent kuroiler chicken breeds [34]. Similarly, [8] observed an increase in hatch weight when local Kei chickens were crossed with Rhode Island Red and Fayoumi breeds. Likewise, when indigenous chickens were crossed with RIR and Fayoumi breeds the body weight at hatch were rise. This suggests that F_1 crosses showed greater body weight gain and significant improvements compared to the purebred parents due to the effects of crossing [14].

In a crossbreeding experiment involving exotic Sasso-RIR and indigenous chickens of Ethiopia, the crossbreds displayed higher body weight than the indigenous breed at different ages [40]. The reciprocal crosses of Fayoumi and Sasso also exhibited higher body weight and body weight gain compared to the purebred. Additionally, the Koekoek × Fayoumi crosses outweighed both parents at 8 weeks, while White leghorn × Fayoumi crosses were heavier than both parent breeds at 12, 16, and 20 weeks of age [20, 21, 13]. The reciprocal crosses of the local Egyptian breed (Sinai) with Lohmann Brown layer [12] was reported to be heavier and gained more weight than purebred parent. Different crosses (Naked Neck x White leghorn, Frizzle Feathered x White leghorn, and Normal

Feathered x White leghorn) in Nigeria [4] were exhibited higher body weight than their exotic parent at different age levels. Similarly, in Ethiopia, the reciprocal crosses between Fayoumi and White leghorn gained more weight than both parents at different ages, while Fayoumi x White leghorn crossbreds outperformed two of their parents in body weight. [13]. The Rhode Island Red (RIR)-crosses exhibit a higher body weight in comparison to the Fayoumi-crosses, while the Kei local Ethiopian ecotype may owe their weight to the genetic superiority of the RIR breed in terms of body weight, which is a trait that is highly heritable and known for its non-additive genetic response to crossbreeding.

Table 1. *Growth traits performance of crossbred chicken under crossing.*

Crossbred	Crossing type	Bwt at 8 wk (gm)	Bwt at 16 wk (gm)	Study site	Author/s
Rhode Island Red ×Fayoumi	Direct mating	261.00	-	Hawassa university, Ethiopia	[14]
Fayoumi × Rhode Island Red	Reciprocal mating	246.00	-	Hawassa university, Ethiopia	[14]
Dominant Red barred × Improved Horro	Direct mating	625.22	1292.56	Debereziet Research Center	[23]
Improved Horro × Dominant Red barred	Reciprocal mating	577.86	1158.56	Debereziet Research Center	[23]
Fayoumi × Koekoek	Direct mating	345.07	985.04	Haramaya university	[13]
Koekoek × Fayoumi	Reciprocal mating	291.97	927.81	Haramaya university	[13]
Koekoek × improved Horro	Direct mating	707.54	-	Debereziet research center	[31]
Improved Horro × Koekoek	Reciprocal mating	818.42	-	Debereziet Research Center	[31]
Kuroiler × improved Horro	Direct mating	1073.07	-	Debereziet Research Center	[31]
Improved Horro × Kuroiler	Reciprocal mating	1106.82	-	Debereziet Research Center	[31]
Cosmopolitan × improved Horro	Direct mating	544.83	1428.63	Afar, Ethiopia	[42]
Improved Horro × Cosmopolitan	Reciprocal mating	560.14	1500.34	Afar, Ethiopia	[42]
Sasso × Fayoumi	Direct mating	383.75	1052.24	Haramaya university	[13]
Fayoumi × Sasso	Reciprocal mating	471.75	1177.49	Haramaya university	[13]

Always male parent written first in crossing

3. Relative Egg Production Trait Performance in Crossbred Chicken

During the production cycle of a layer, egg production is a multifaceted metric trait that showcases numerous variations [20]. Crossbreeding has widely been used as method to combine the high egg production of exotic breeds with the adaptability of indigenous breeds. In addition to the individual contributions of each breed towards meeting these requirements, there are significant non-additive heterotic effects in egg yield and fertility traits that combine to enhance the overall productivity of the first generation (F_1) of the crosses. Numerous studies showed that age at first egg (AFE) was shorter in crossbred chicken than their purebred counterparts [38, 25, 22, 34, 13]. This might indicate that crossbreeding improves sexual maturity. Reciprocal crosses of fayomui with koekoek showed higher body weight at first egg than Fayoumi, not Koekoek. Reciprocal crosses of Horro and Kuroiler showed the highest performances in egg number, hen housed egg production and hen day egg production [34]. The reciprocal crosses involved Fayoumi and White leghorn performed better than both parents, and White leghorn × Fayoumi in egg number, hen housed egg production, and egg mass. The crosses of Fayoumi males and White leghorn females would benefit from heterosis in egg production [28]. The higher performance in different egg production traits of Koekoek male × Fayoumi female and Fayoumi male ×White leghorn females over Fayoumi male x Koekoek females and White Leghorn male x Fayoumi females [13] might suggest the existence of sex-linked effects. Improved Horro × Kuroiler crossbred hen showed superior ($P<0.05$) performance in hen housed egg production (HHEP), Henday egg production (HDEP), egg number than their counter parents. Egg weight was higher for Kuroiler×improved Horro, and improved Horro×Kuroiler with comparable values with kuroiler purebred chicken but the much greater than improved Horro chickens [31]. Better performance in hen-housed egg production and hen-day egg production percentages had reported

by various scholars [41, 7, 24, 31] than their counter parts parent.

There was no significant difference in egg number, egg weight, and egg mass between the two F_1 crosses [14]. However, hen-housed egg production showed a significant difference in the crossing involving (Fayoumi and RIR) as dam lines and (Naked Neck and Local White) as sire lines. In another study conducted under farmers' management conditions, the crossing involving local red feathered chicken ecotype, and Fayoumi and RIR breeds outperformed the paternal breed (Local Red) in all traits considered such as hen-day egg production, hen housed egg production, egg weight, and egg mass [27]. Both Fayoumi and RIR crosses produced more eggs and had higher egg mass compared to Local Red chicken ecotypes. Additionally, the Fayoumi-crosses were found to produce more eggs than RIR crosses, suggesting that the Fayoumi breed would be a better choice for improving the performance of indigenous chicken populations.

The average egg weight of crosses between white Leghorn and Nigerian indigenous chickens was 41 g, a weight comparable to that of Fayoumi-crosses (40 g) of local red chicken ecotypes in Ethiopia [5, 27]. The study highlighted that the significance of heterosis resulting from both dominance and epistasis in egg production traits, as evidenced by the decrease in heterosis for hen housed and hen day egg production from two way cross to four ways cross. However, there was a minimal contribution of heterosis for other traits like body weight and egg weight, as indicated by the slight decrease in heterosis from two way cross to four way cross chickens. Additionally, it was evident that on average, two-way crosses outperformed three way crosses, which in turn outperformed four way crosses in terms of some egg production traits.

Table 2. *Egg production traits performance of crossbred chicken under crossing.*

Crossbred	Crossing type	Egg wt (gm)	Part period egg production	Study site	Authour/s
Rhode Island Red ×local kei ecotype	Direct mating	44.2	85.2	Hawassa university, Ethiopia	[27]
Fayoumi ×local kei ecotype	Direct mating	40.00	98.5	Hawassa university, Ethiopia	[27]
Dominant Red barred ×Improved Horro	Direct mating	55.74	85.76	Debereziet, research center	[24]
Improved Horro ×Dominant Red barred	Reciprocal mating	56.58	43.9	Debereziet, research center	[24]
Fayoumi ×Koekoek	Direct mating	44.19	43.71	Haramaya university	[13]
Koekoek ×Fayoumi	Reciprocal mating	44.49	52.80	Haramaya university	[13]
Koekoek ×improved Horro	Direct mating	49.44	67.28	Debereziet, research center	[34]
Improved Horro ×Koekoek	Reciprocal mating	52.68	53.66	Debereziet, research center	[34]
Kuroiler ×improved Horro	Direct mating	52.05	75.00	Debereziet, research center	[34]
Improved Horro ×Kuroiler	Reciprocal mating	49.33	75.46	Debereziet, research center	[34]
Cosmopolitan ×improved Horro	Direct mating	-	168.79	Afar, Ethiopia	[42]
Improved Horro ×Cosmopolitan	Reciprocal mating	-	160.31	Afar, Ethiopia	[42]

Always male parent written first in crossing

4. Relative Reproduction Traits Performance in Crossbred Chicken

Reproduction is one of the most important aspects of poultry breeding [3] and it is characterized by parameters, such as, age at sexual maturity, fertility, hatchability, clutch size and clutch length [1]. Among reproduction traits, sexual maturity is paramount in terms of progress in poultry breeding [9]. Age at sexual maturity refers to age at which the reproductive system achieves its complete development and it has long been considered as an important factor that determines fecundity trait and affects subsequent performance [15]. In females, age at sexual maturity can be easily determined externally as age at which hens lay their first egg. Compared to their respective female parents (exotic chickens), age at first egg was reduced nearly by one week in the Fayoumi x

Naked Neck crosses and by more than a month in the RIR x Local White crosses [14]

Numerous scholars showed improvement of age at sexual maturity (age at first egg) through crossbreeding of local chickens ecotypes with different exotic chicken breeds [8]. Age at first egg was reduced on average by 6 days in F_1 crosses as compared with exotic commercial chicken breeds of Lohmann white and New Hampshire [26]. The average age at first egg of both F_1 crosses fayoumi and RIR with necked neck and *Netch (white)* local ecotypes observed for decrement than local Ethiopian ecotypes involved in crossing. The differences in attaining sexual maturity might be due to the genetic differences of strains involved in the crossbreeding scheme in addition management condition like nutrition, light condition layer house.

Table 3. *Reproductive traits performance of crossbred chicken under crossing.*

Crossbred	Crossing type	AFE (days)	BwtAFE (gm)	Study site	Author/s
Rhode Island Red × local kei ecotype	Direct mating	154.13	-	Guraghe Zone, the southern of Ethiopia	[27]
Fayoumi × local kei ecotype	Direct mating	161.14	-	Guraghe Zone, the southern of Ethiopia	[27]
Dominant Red barred × Improved Horro	Direct mating	137.33	1220.00	Debereziet, research center	[24]
Improved Horro × Dominant Red barred	Reciprocal mating	130.67	1310.00	Debereziet, research center	[24]
Fayoumi × Koekoek	Direct mating	151.67	1206.15	Haramaya university	[13]
Koekoek × Fayoumi	Reciprocal mating	160.00	1314.10	Haramaya university	[13]
Koekoek × improved Horro	Direct mating	136.67	1826.33	Debereziet, research center	[34]
Improved Horro ×Koekoek	Reciprocal mating	150.33	1814.78	Debereziet, research center	[34]
Kuroiler × improved Horro	Direct mating	139.33	2372.33	Debereziet, research center	[34]
Improved Horro × Kuroiler	Reciprocal mating	135.33	2448.00	Debereziet, research center	[34]
Cosmopolitan × improved Horro	Direct mating	134.19	-	Afar region, Ethiopia	[42]
Improved Horro × Cosmopolitan	Reciprocal mating	153.93	-	Afar region, Ethiopia	[42]

Always male parent written first in crossing. AFE-Age at first egg, BwtAFE-bodyweight at first egg, - no data

5. Conclusion and Recommendations

Crossbreeding between high producing exotic breeds and indigenous chicken ecotypes has been practiced in Ethiopia and in a different place of tropical countries to generate crossbreds suitable, adaptive and sustainable for family poultry production systems. In most of these studies, crossbreds outperformed their indigenous parents in production traits and exotic parents in adaptability traits. Furthermore, enhancing the productivity of native chicken also necessitates a substantial investment of time, resources, and advanced infrastructure in order to implement an effective selection program. The continuous need for exotic genetic material, along with the high costs associated with acquiring and maintaining exotic breeding stocks, hinders the implementation of regular crossbreeding. Alternatively, creating a synthetic breed through a few crosses between different breeds offers a more efficient approach, requiring the maintenance of only one population with all desired traits instead of multiple exotic flocks. Therefore, this review article suggests that a performing one or a few crosses between two or more breeds to create a synthetic breed is an alternative approach in terms of the regular crossing option. It may be beneficial for improving the growth rate, and egg production of the indigenous breed in Ethiopia while maintaining their good adaptability traits.

Abbreviations

bwt	Bodyweight
gm	Giram
F1	First Generation Filial
HHEP	Hen Housed Egg Production
HDEP	Henday Egg Production

RIR	Rohde Iceland Red

Author Contributions

Shambel Taye: Conceptualization, Writing - original draft
Chala Edea: Writing - review & editing
Atsbaha Hailemariam: Writing - review & editing
Misba Alewi: Writing - review & editing

Data Availability Statement

This article does not involve any creation or analysis of new data. Therefore, data sharing is not applicable.

Conflicts of Interest

The authors declare no conflicts of interest.

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