

Review Article

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

Shambel Taye^{*} , Chala Edea , Atsbaha Hailemariam , Misba Alewi 

Debreziet Agricultural Research Center, Bishoftu, Ethiopia

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 F₁ 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-

^{*}Corresponding author: olyaadshambel@gmail.com (Shambel Taye)

Received: 1 April 2024; **Accepted:** 23 April 2024; **Published:** 24 May 2024



Copyright: © The Author(s), 2024. Published by Science Publishing Group. This is an **Open Access** article, distributed under the terms of the Creative Commons Attribution 4.0 License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

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 \times Fayoumi crosses outweighed both parents at 8 weeks, while White leghorn \times 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 \times White leghorn, Frizzle Feathered \times 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 xFayoumi	Direct mating	261.00	-	Hawassa university, Ethiopia	[14]
Fayoumi xRhode Island Red	Reciprocal mating	246.00	-	Hawassa university, Ethiopia	[14]
Dominant Red barred xImproved Horro	Direct mating	625.22	1292.56	Debereziet Research Center	[23]
Improved Horro xDominant Red barred	Reciprocal mating	577.86	1158.56	Debereziet Research Center	[23]
Fayoumi xKoekoek	Direct mating	345.07	985.04	Haramaya university	[13]
Koekoek xFayoumi	Reciprocal mating	291.97	927.81	Haramaya university	[13]
Koekoek ximproved Horro	Direct mating	707.54	-	Debereziet research center	[31]
Improved Horro xKoekoek	Reciprocal mating	818.42	-	Debereziet Research Center	[31]
Kuroiler ximproved Horro	Direct mating	1073.07	-	Debereziet Research Center	[31]
Improved Horro xKuroiler	Reciprocal mating	1106.82	-	Debereziet Research Center	[31]
Cosmopolitan ximproved Horro	Direct mating	544.83	1428.63	Afar, Ethiopia	[42]
Improved Horro xCosmopolitan	Reciprocal mating	560.14	1500.34	Afar, Ethiopia	[42]
Sasso xFayoumi	Direct mating	383.75	1052.24	Haramaya university	[13]
Fayoumi xSasso	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 xFayoumi 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 x Fayoumi female and Fayoumi male xWhite 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 x 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 Kuroilerximproved Horro, and improved HorroxKuroiler 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 F₁ 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	Debrezeit, research center	[24]
Improved Horro × Dominant Red barred	Reciprocal mating	56.58	43.9	Debrezeit, 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	Debrezeit, research center	[34]
Improved Horro × Koekoek	Reciprocal mating	52.68	53.66	Debrezeit, research center	[34]
Kuroiler × improved Horro	Direct mating	52.05	75.00	Debrezeit, research center	[34]
Improved Horro × Kuroiler	Reciprocal mating	49.33	75.46	Debrezeit, 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 F₁ crosses as compared with exotic commercial chicken breeds of Lohmann white and New Hampshire [26]. The average age

at first egg of both F₁ 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	Deberziet, research center	[24]
Improved Horro × Dominant Red barred	Reciprocal mating	130.67	1310.00	Deberziet, 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	Deberziet, research center	[34]
Improved Horro × Koekoek	Reciprocal mating	150.33	1814.78	Deberziet, research center	[34]
Kuroiler × improved Horro	Direct mating	139.33	2372.33	Deberziet, research center	[34]
Improved Horro × Kuroiler	Reciprocal mating	135.33	2448.00	Deberziet, 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.

References

- [1] Addisu H, Hailu M, Zewdu W Addisu 2013 Review: Indigenous chickens productions system and breeding practice in NorthWollo, Amhara region, Ethiopia. *Scholarly Journal of Agricultural Science*, 3: 433-444.
- [2] Abrar Biazen, Urge Mengistu, Ameha Negassi, Aseffa Getenet, Abegaz Solomon and Dessie Tadelle. 2021. Comparative growth performance, carcass characteristics and meat quality of local Horro and exotic cockerels of tropical origin fed growers diet. *Open Journal of Animal Sciences*, 1: 62–83.
- [3] Abou-Elewa EM, Enab AA, Abdou FH. 2017. Sexual Maturity of Male Chickens According To Early Response of Semen Collection. *IOSR Journal of Agriculture and Veterinary Science*, 10(7): 58-63.
- [4] Adedeji, O. S., Farinu, G. O, Ameen, S. A. and Olayeni, T. B. 2006. The effects of dietary bitter kola (*Garcinia kola*) Inclusion on body weight, hematology and survival rate of pullet's chicks. *Journal Animal Veterinary Advances*, 5: 184–187.
- [5] Ajayi FO. Nigerian indigenous chicken: A valuable genetic resource for meat and egg production. *Asian Journal of Poultry Science*. 2010; 4(4): 164-172.
- [6] Aly, O. M. and Y. Nazla. Abou El-Ella (2005). Effect of crossing on the performance of local strains. Estimates of pure line difference, direct heterosis, maternal additive and direct additive effects for growth traits, viability and some carcass traits. *Egypt. Poult. Sci. Vol (26) (I)*: (53-67).
- [7] Amao, S. R., 2017. Egg production and growth performance of Naked Neck and Rhode Island Red chickens crosses under Southern Guinea savanna condition of Nigeria. *International Journal of Agriculture and Earth Science*, 3(2), 1–10.
- [8] Bekele F, Ådnøy T, Gjøn HM, Kathle J & Girma A. 2010. Production performance of Dual- Purpose crosses of two indigenous with two exotic chicken breeds in sub-tropical environment. *International Journal of Poultry Science*, 9: 702-710.
- [9] Chiemela PN, Jun HL, Egbu CF, Seung-Hwan L. 2018. Review on the Genetic Potential of Nigerian Local Chickens. *Journal of Animal Breeding and Genomics*, 2(4): 199-211.
- [10] CSA (Central Statistical Agency). 2021. Agricultural Sample Survey 2020/21. Volume II. Report on Livestock and Livestock Characteristics. Federal Democratic Republic of Ethiopia, Central Statistical Agency. Statistical Bulletin No. 589, Addis Ababa, Ethiopia.
- [11] Demeke S, 2008. Poultry sector country review: Ethiopia, FAO Animal Production and Health Division.
- [12] El-Tahawy, W. S., Habashy, W. S., 2021. Genetic effects on growth and egg production traits in two-way crosses of Egyptian and commercial layer chickens. *South African Journal of Animal Science*, 51(3): 349–354.
- [13] Fikerneh N., Abegaz, S., Tadesse, Y., Jembere, T., Esatu, W., Dessie, T. 2023 Evaluation of growth performance and feed efficiency in reciprocal crosses of Fayoumi with three exotic chicken breeds. *Acta Agric. Scand. A -Anim. Science*.
- [14] Fassill Bekele, Ådnøy, T., Gjøn, H. M., Kathle, J. and Girma Abebe. 2010. Production performance of dual-purpose crosses of two indigenous with two exotic chicken breeds in sub-tropical environment. *International Journal of Poultry Science*, 9(7): 702–710.
- [15] Forment P, OusteC, Pelletier R, BrillardJP. 2009. Rôle de L'AMP activé protéine kinase dans l'activation des cellules de Sertoli mature (*Gallus domesticus*). *Huitième Journées de la recherche à la vicole, StMalo.*, pp25-26.
- [16] Khobondo, J. O., T. K. Muasya, S. Miyumo, T. O. Okeno, C. B. Wasike, R. Mwakubambanya, A. M. Kingori, and A. K. Kingori. 2015. "Genetic and Nutrition Development of Indigenous Chicken in Africa." *Livestock Research for Rural Development* 27(7).
- [17] Itafa, B. T., Mohamed, A. S., Abate, W. H., Derseh, M. A., Woldegiorgis, W. E., 2021. Effect of reciprocal crossing Koekoek and Sasso chickens on growth performance, feed efficiency, carcass yield, mortality rate and genetic components. *Journal of Applied Poultry Research*, 30: 100214.
- [18] Iraqi, M. M., Khalil M. H., El-Attrouny, M. 2013 Estimation of crossbreeding components for growth traits in crossing Golden Montazah with White Leghorn chickens, in: VI the International Conference: Balnimalcon, pp. 3–5.
- [19] Khalil, M. K., Al-Homidan, A. H. and Hermes, I. H., 2004. Crossbreeding components in age at first egg and egg production for crossing Saudi chickens with White Leghorn. *Livestock Research for Rural Development*, 16(1).
- [20] Khawaja, T., Khan, S. H., Mukhtar, N., Ullah, N. and Parveen, A., 2013. Production performance, egg quality and biochemical parameters of Fayoumi, Rhode Island Red and their reciprocal crossbred chickens. *Journal of Applied Animal Research*, 41(2), 208-217.

- [21] Kamel, E. R. 2016. Comparative study of growth and economic performance of Fayoumi, Rhode Island Red and their reciprocal crossbred chickens. *International Journal of Current Research*, 8(5): 30613-30619.
- [22] Kasaye A, Yosef T, Ewonetu K, and Negassi A. 2021. Evaluation of different traits from day-old to age at first eggs of Fayoumi and White Leghorn F1 chickens and their reciprocal crossbreeds. *Journal of Advanced Veterinary and Animal Research*, 8(1): 1-6.
- [23] Kedija H, Gebeyehu G, Wondmeneh E and Solomon Ab. 2018. Evaluation of crossbreeding effect on growth of local Horro ecotype crossed with exotic Dominant Red Barred D 922 chickens: A step towards synthetic breed development in Ethiopia. *American-Eurasian Journal of Scientific Research*, 13(4): 74–84.
- [24] Kedija Hussien, Wondmeneh Esatu, Gebeyehu Goshu and Solomon Abegaz. 2020. Crossbreeding effect on egg production traits of Horro ecotype crossed with exotic Dominant Red Barred D 922 chickens: A step towards synthetic breed development in Ethiopia. *British Journal of Poultry Sciences*, 9(1): 1–17.
- [25] Lalev, M., Mincheva, N., Oblakova, M., Hristakieva, P. and Ivanova, I., 2014. Estimation of heterosis, direct and maternal additive effects from crossbreeding experiment involving two White Plymouth Rock lines of chickens. *Biotechnology in Animal Husbandry*, 30(1), 103-114.
- [26] Melesse A., Maak S. and Von Lengerken G. 2011. Effects of genetic group \times ambient temperature interactions on performance and physiological responses of Naked-Neck chickens and their F1 crosses with Lohmann White and New Hampshire laying hens. *J. Animal and Feed Science*. 20, 588-601.
- [27] Melesse, A., Alewi, M. and Teklegiorgis, Y. 2013. Evaluating the reproductive and egg production traits of local chickens and their F1 crosses with Rhode Island Red and Fayoumi breeds under farmers' management conditions. *Iranian Journal of Applied Animal Science*, 3(2): 379–385.
- [28] Negash F, Abegaz S, Tadesse Y, Jembere T, Esatu W, Dessie T. 2023 Evaluation of reciprocal F1 crosses of Fayoumi with two exotic chicken breeds 2: additive and non-additive effects on egg quality traits. *Trop Anim Health Prod*. 2023 Sep 19; 55(5): 296.
- [29] Sambo E, Bettridge J, Dessie T, Amare A, Habte T, Wigley P and Chridtley R M. 2015. Participatory evaluation of chicken health and production constraints in Ethiopia. *Preventive Veterinary Medicine* 118: 117–27.
- [30] Sheble M K, Mervat A, Magda M B and Tag El-Din T H 1990 Evaluation of combining ability for some body size traits and feathering in diallel cross of chickens. *Egyptian Poultry Science* 10: 159-177.
- [31] Shambel T., Gebeyehu G, Misba A, and Solomon A. 2022. "Egg Production Performance of Improved Horro Chicken Crossed with Koekoek and Kuroiler Breeds." *Journal of Animal Scientific Research* 10(1): 99–108.
- [32] Padhi M K, Chatterjee R N, Rajkumar U, Niranjana M and Haunshi S. 2016. Evaluation of a three-way cross chicken developed for backyard poultry in respect to growth, production and carcass quality traits under intensive system of rearing. *Journal of Applied Animal Research* 44: 390–94.
- [33] Tadelle, D., Alemu, Y. and Peters, K. J. 2000. Indigenous chickens in Ethiopia: Genetic potential and attempts at improvement. *World's Poultry Science Journal*, 56: 45–54.
- [34] Taye, S., Goshu, G., & Abegaz, S. (2022). Effect of Crossbreeding on Growth Performance of Improved Horro Crosses with Koekoek and Kuroiler Chicken Breeds. *Poultry Science Journal*, 10(1), 35-44.
- [35] Teklewold H, Dadi L, Yami A and Dana N. 2006. Determinants of adoption of poultry technology a double hurdle approach. *Livestock Research Rural Development*. Vol 18.
- [36] Thornton, P. K. 2010. Livestock production: Recent trends, future prospects. *Philosophical Transactions of the Royal Society B*, 365: 2853–2867.
- [37] Wang Y, Sun Y, Ni A, Li Y, Yuan J, Ma H, et al. Research note: heterosis for egg production and oviposition pattern in reciprocal crossbreeds of indigenous and elite laying chickens. *Poultry Science*. 2022; 101: 102201.
- [38] Williams, S. M., Price, S. E. and Siegel, P. B., 2002. Heterosis of growth and reproductive traits in fowl. *Poultry Science*, 81, 1109–1112.
- [39] Yacin S., X -Zahang, G R. Mc Danil and D. I Kublers. 2000 effects of divergent selection for incidence of tibial Dyschondroplasia (TD) on purebred and crossbred performance 2-processing yield. *British poultry science* 41(5) 566-569.
- [40] Wolde, S., T. Mirkena, A. Melesse, T. Dessie, and S. Abegaz. 2021. "Hatchability and Growth Performances of Normal Feathered Local, Sasso-RIR and Their F1-Cross Chickens managed Under On-Station Conditions in Southern Ethiopia. *Tropical Animal Health and Production* 53(5): 1–8.
- [41] Wondmeneh E., Dawud I. and Adey M. 2011. Comparative evaluation of fertility and hatchability of Horro, Fayoumi, Lohmann Silver and Potchefstroom Koekoek breeds of chicken. *Asian Journal of Poultry Science*. 5, 124-129.
- [42] Atsbaha, Wondmeneh E, Solomon A, Mengistu U, Getnet A, Tadelle D 2023 Effects of crossbreeding on growth, production and selected egg quality traits of Improved Horro crosses with Cosmopolitan chickens 14(1). *Journal of Agriculture and Food Research*.