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Research Article

Evaluation of Egg Production, Fertility, Hatchability, Embryonic Mortality and Chick Quality of Different Chickens

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Abstract

The present study was evaluated the egg production performance, fertility, hatchability, embryonic mortality and chick quality from Cosmopolitan (C), Improved Horro (H), ♂Improved Horro*Cosmopolitan ♀ (HC), ♂ Cosmopolitan*Improved Horro ♀ (CH), Indigenous (L), and Koekoek (KK) genotypes. A Completely randomized design was used in the study. A total of 1800 eggs and 300 eggs of each genotype were used for the hatchability and fertility trials. A total of 360 chicks and 60 chicks of each genotype were used for chick quality study. A total of 720 genotypes (5female: 1 male) and 120 from each genotype were used for egg production. Age at first egg and age at peak varied across genotypes. KK had the highest egg production followed by CH, H, CH and C but L had the lowest egg production. KK had the highest weight and feed intake followed by HC, HC, and C, whereas had the lowest followed by H. Feed conversion ratio varied among genotypes. H had the highest egg fertility followed by CH. Conversely, C, HC, L and KK chicken genotypes were comparable and had the least egg fertility. H and CH showed the highest hatchability from set egg, whereas L showed the lowest hatchability from set egg followed by the intermediate KK, HC and C. CH indicated the highest hatchability from fertile egg set, while L confirmed that the lowest hatchability from fertile egg set followed by the intermediate KK, HC and C. The overall embryonic mortality of L was the highest, but CH had significantly lowest overall embryonic mortality followed by KK, HC and C. Chicks hatched from KK had the highest chick weight and chick length, but chicks hatched from L had the least chick weight and chick length. Eggs of L had the highest percentage egg weight yield followed by KK, whereas the CH, C, HC and H had intermediate yield percent during incubation. Conclusively: The genotype differences of hens substantially influenced egg production performance, fertility, embryonic mortality, hatchability and chick quality.

Keywords

Egg Production, Fertility, Embryonic Mortality, Hatchability, Chick Quality

1. Introduction

Depending upon economic conditions and climatologic constraints, egg production normally takes place in either fully confined or semi-confined housing [11]. Uniformity of body weight in pullets and laying hens is a vital husbandry concern [5]. Sexual maturity in the growth period of pullets is affected by genotypes and crosses [39, 19]. Egg is highly heritable trait

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that can vary among genotypes [12]. Egg production is one of the most important parameter poultry productions [17]. Egg-laying performance determines production and reproduction performance of hens [39, 7]. The age at first egg (AFE), bodyweight at first egg (IBW), Egg numbers (EN) and production (HDEPP and HHEP) are among the most important traits which are regulated by genetic and endocrine factors [13].

Fertility and hatchability are a major parameter of reproductive performances that influence the production and profitability of chicken industries [47]. Egg fertility refers to the overall actual reproductive capacity of males and females as reflected by their ability to produce progeny when mated together [32]. Furthermore, Hatchability percentage maybe expressed as either hatch of fertile eggs or hatch of total egg [7]. Fertility of eggs is the first factor which influences the number of chicks hatched from a breeder flock [34]. Hatchability is a complex quantitative trait that depends on genetic make-up, incubational conditions, and nutritional factors [18]. Hatchability is the factor that could possibly reduce the supply of day-old chick [1]. Both egg fertility and hatchability are affected by genetic makeup and environment [2]. cock and hen affect the fertility and hatchability [25]. References showed that the size and weight of egg influence the hatchability and fertility performances which ultimately influence the future performance of the bird [47]. Light breeds had higher fertility and better hatchability as compared to heavy breeds [3]. Fertility and hatchability meaningfully affected by genotypes [27, 17]. Different authors explained that several sperm quality traits such as sperm metabolism, semen concentration, sperm motility, and the percentage of abnormal or dead sperm cells can affect fertility of roosters in chickens [15, 27].

Reports ascertained that embryonic mortality can be categorized as early, mid, late and pipeline mortality rates [17, 7] Reference informed that chicken embryonic mortality have significantly affected by breed, size and Shape of eggs [27]. Moreover, live embryos (fertile eggs) ranging from 6.2 to 11.6% fails to hatch during the incubations period due to embryonic [30]. Early, pipe and late embryonic mortality were affected across poultry genotypes [17]. Embryonic mortality was varied between Koekoek and Horro genotypes, respectively (12.50% vs. 21.50%) [15]. High embryonic mortality can decline profitability of poultry producers by reducing the number of chicks hatched [8].

Scholars indicated that chick quality parameters such as egg weight, chick weight, and chick yield percentage and chick length are important for production and reproduction performances [17]. Chick quality is determined on the basis of physical parameters and might include the activity, feathering, condition of eyes, conformation of legs, and condition of the navel area, yolk retraction, and status of the membranes [46]. A high-quality chick should display optimum development throughout incubation and have a high survival rate, good development after hatching, and yield qualities in conformity with the standards [17, 7]. Likewise, chicks are classified according to the physical properties [45] and quantitative and qualitative methods are employed to determine chick quality [4, 29]. chick weight was affected by egg weight [11]. Chick weight as a measure of chick quality is less valuable because of its correlation with egg weight [7]. Chick yield in percentage is more reliable for chick quality determination [7]. The standard weight of egg recommended for incubation varies among genotypes [10, 31]. The variation in chick length among breeds could be due to the difference in egg size [14].

The selection of Horro chicken has brought about an increase in growth of 95% and egg number of 123% on body weight at 16 weeks and egg number at 45 weeks of age [48]. The improved Horro breeds have shown higher egg production (171/year) than the unimproved Horro ecotypes (66.5) under on-station condition [48]. Evidences have shown that Cosmopolitan chickens have currently been observed to be the most diversified chicken breeds and have been found from interbreeds of domestic chickens from different countries of the world [40] Cosmopolitan chickens have been explained also to serve as the symbol of global chicken diversity [40]. The advantages of using Cosmopolitan chickens have been explained as artistic breed initially made by Koen Vanmechlen but currently remained important under the changing climate scenario with less risk of extinction of many breeds of chickens. Similarly, Cosmopolitans have unifying advantage in terms of scientific, political, philosophical and ethical issues under the current changing environmental conditions globally. Moreover, the variability of climate has shown emphasis on options of livestock technologies for stress and heat tolerance in tropics. The cosmopolitan hen can produce 200 eggs per year [40]). Literature showed that Koekoek genotype (KK) is one of the exotic chicken genotypes which are the composite of White Leghorn, Black Australorp and Bared Plymouth Rock [11, 47]. The Koekoek chicken genotype has a dual purpose, free ranging chicken with laying capabilities (Egg production/hen/year = 170-200) as well as a large body size (Average body weight up to 24 weeks of ages = 2-3 kg) for meat production [36, 11]). The Koekoek genotype is characterized by higher meat and egg production, good scavenging behavior, resistant to diseases and adaptive to tropical environmental conditions [17]. In Ethiopia, the indigenous chickens have higher proportion than that of exotics and hybrids Nevertheless, the weight of the indigenous chicken is low when compared to exotic chicken [23, 7]. The egg production potential of the indigenous chicken is 66.50 eggs per year per hen [45]. The indigenous chicken is characterized by low meat and egg production performance, live in low input-output productions, resistant to diseases and highly adaptive to tropical environmental conditions [20].

Furthermore, the indigenous chicken (L) was used as a reference following the selection and breeding description studies reported in [20, 23]. As the cosmopolitan breed is newly imported to Ethiopia, it is evident that this genotype also demanded initial research information and documentation of egg production performance, fertility, hatchability, and embryonic mortality and chick quality parameters before dissemination. Additionally, Cosmopolitan (C), and Improved Horro (H) were directly and reciprocally crossed, Cosmopolitan♂*Improved Horro♀(CH), Improved Horro ♂*Cosmopolitan♀(HC), with reasonably hypothesized variations (The hypothesis of this research was that there could be significant variation among the parameters of the hen genotypes) of egg production performance, fertility, hatchability, embryonic mortality and chick quality of the genotypes, and these genotypes were compared in references to indigenous (L) and Koekoek (KK) genotypes. Therefore, the objective of this initiated research was to compare the egg production, fertility, hatchability, embryonic mortality and chick quality performances of different chicken genotypes.

2. Materials and Methods

2.1. Description of the Study Areas

The experiment was conducted in collaboration of Werer Agricultural Research Centre (WARC) and Debrezeit Agricultural Research center (DZARC), Ethiopia. The Werer Agricultural Research Center is found 280km away from Ethiopia's capital, Addis Ababa, and is also located at an altitude of 820 meters above sea level and 55' N latitude, and 40o 40' E longitude. The annual rainfall and average minimum and maximum temperatures for Werer Agricultural Research Center rangesrange 400 mm to 600 mm, and 19.3℃ and 45℃, respectively.

2.2. Experimental Animals, Management and Sampling Procedures

2.2.1. Experimental Chicken Genotypes

The experimental animals were namely, I= Improved Horro (H), II= Cosmopolitan (C), III= Koekoek (KK), IV= Indigenous (L), V= Cosmopolitan♂*Improved Horro♀(CH), and VI= Improved Horro♂*Cosmopolitan♀(HC).

2.2.2. Management of Experimental Birds

The watering and feeding troughs were cleaned, disinfected, and sprayed against external parasites before the start of the experiment. The floor of each pen was bedded with disinfected grass hay having a depth of 15 cm (absorb moisture) and was replaced when deemed appropriate. Each chicken was provided 0.25 m^2 of floor space (each experimental chicken genotype was guaranteed appropriate floor space in a randomly allotted pen). The house had 24 pens of each 7.50 m^2. Chickens were fed the same commercial rations (starter; 20.50% crude protein and 3000 kcal/kg of ME, grower; 18.80% crude protein and 2950 kcal/kg of ME, and finisher; 16.00% crude protein and 2800 kcal/kg of ME) following their age phases (Alema feeds co., Ltd., Debrezeit, Ethiopia) and indicated in (Table 1) andthe amount of feed provision per hen genotype was a 125 g.

Table 1. *Nutrient Composition of the Diet Fed to KK, HC, CH, C, H, and L chickens.*

Nutrient	Starter	Grower	Layer
Metabolizable energy (Kcal/kg)	3000.00	2950.00	2800.00
Crude protein (% DM)	20.50	18.80	16.00
Crude fiber (% DM	5.50	5.80	7.00
Calcium (% DM)	0.90	0.90	3.55
Fat (% DM)	6.50	5.00	5.00
Moisture (%)	10.00	10.00	10.00

The feed composition of starter, grower, and layer provided by Alema Koudjis, Feed Co., Ltd., Debrezeit, Ethiopia

Chickens were vaccinated against Newcastle, Gumburo (Infectious Bursal Disease-IBD) and Fowl Typhoid diseases using appropriate vaccine according to the recommendation of Ethiopia national veterinary institute (NVI, Bishoftu, Ethiopia) (Table 2). Experimental Chickens were reared as mixed sex and subjected to similar management under on station conditions. Health Stata were monitored during the entire trial. Feed manufactured by Alema koudjis; Feed Co., Ltd., Debrezeit, Ethiopia was used during the entire trial period and supplements were given through drinking water.

Table 2. *Vaccination schedules for all experimental genotypes.*

Day	Week	Name and type of vaccination	Route of administration
Day 1	1	Marek's	Sub-cutaneous
Day 3	1	NCDV (HB1)	Ocular (Eye droplet)
Day 9	2	Gumboro (IBDV)	Drinking water
Day 21	3	Gumboro (IBDV)	Drinking water
Day 27	3	NCDV (Lasota strain vaccine)	Drinking water

Day	Week	Name and type of vaccination	Route of administration
Day 45	6	Fowl typhoid	Sub-cutaneous
Day 63	8	NCDV (Lasota strain vaccine)	Drinking water
Day 90	12	Fowl typhoid	Sub-cutaneous
Day 70-105	10-14	Fowl pox	Wing web
Day 112-120	16	NCDV (inactivated)	Ocular (eye droplet)

NCDV = Newcastle diseases vaccine, IBDV= Infectious Bursal Disease vaccine

2.2.3. Sampling Procedures

(i). Egg Production Performance

A total of 720 pullets and cockerels (5 females to 1 male) from H, C, KK, L, CH and HC chickens (25 pullet and 5 cockerels from each breed at each pen) were used for this study. A total of 24 pens for the six genotypes with four replications were used during the egg production performance data collection. Egg production performance was measured at pen level in terms of age at first egg (AFE), egg number (EN), mass (EM). The AFE was calculated as the number of days from hatch to the day the first egg was laid provided the second egg in the pen was laid in the next three days. Egg production was recorded on daily basis from the first day of egg production up to 52 weeks of age. These data was used to determine EN per hen for the entire period. The body weight of hens was measured at first egg and at the end of the experiment. Feed intake was recorded daily on pen basis. Feed conversion ratio (FCR) was calculated as a gram of eggs produced per gram of feed consumed [19]. A separate deep-litter pens covered with litter material were used to house pullets and cockerels according to the recommended space requirement. Egg mass was calculated as a factor of egg weight and hen-day egg production [19]. The formulae for egg mass (EM), hen day egg production (HDEP) and hen housed egg production (HHEP) are presented as follow; EM = (egg production x egg weight)/100; HDEP (%) = (number of eggs collected per day)/Number of hens present that day) x 100; HHEP (%) = (number of eggs collected per day)/Number of hens initially present) x 100.

(ii). Fertility, Hatchability, Embryonic Mortality and Chick Quality

Selections of hatching eggs were done on their uniform size, good shape and clean shell. The average weight of hatching eggs was calculated in grams by using digital balance. All sampled eggs were cleaned with the disinfectant before taking to hatchery. All sampled eggs were fumigated with potassium permanganate and formalin at hatchery. The eggs were stored for 7 days and maintained at 18˚C and kept up with a 75% relative humidity. The eggs were set in the same incubator (Eggs were incubated at once) as disinfected and prepared for hatching. Candling was done on 7th day of incubation for the identification and removal of infertile and dead embryos. On 21st day the number of hatched chicks including the normal, abnormal chicks, dead chicks in shell and after hatch were counted separately. Digital balance was used to measure the average weight of day-old chicks.

Fertility and hatchability of eggs were determined after the introduction of cocks to the hen pens. A total of 1800 (300 eggs x 6 genotypes; 100 eggs/hatch tray/genotype) eggs were used to evaluate fertility and hatchability. A total of 360 chicks (60 chicks /genotype) were used to measure and determine the chick quality. Eggs were incubated with their sharp ends pointing downwards using fully automatic multi-stage setter machine (Model OL-15120; Brand Name: ONELYE; Model Number: ONELYE; Capacity: 10000; Hatcher Model OL-15120) and at 37.5˚C - 37.8˚C, 50-60% relative humidity the machine turns eggs at every one-hour interval until 18 days. Egg candling was done at 18th day of the incubation period (at transfer) using individual candling lamp. Eggs with live embryo were transferred to hatching unit while the infertile eggs were removed and investigated for early embryonic mortality. Percentage fertility was calculated by dividing the total number of fertile eggs by total number of eggs set multiplied by 100. Percentage hatchability was calculated as total eggs set against the number of chicks hatched and number of fertile eggs after candling against number of chicks hatched. All eggs in each replication were weighed in group at setting and during transfer to the hatchery unity to determine egg weight loss. Embryo that died during the incubation period were counted and used to determine percentage embryo mortality in relation to total number of eggs set. A morphometric measurement was made to assess some of the chick quality parameters. The quality of day-old chicks was assessed using chick weight (Chq), chick length (ChL), and chick yield percentage (Yield). Chick length (ChL) was measured using flexible measuring tape from tip of the beak to the middle toe. Chick weight at hatching was determined by weighing the chick after 12 hours of hatching and the chick yield was calculated as the percentage of chick's weight to initial egg weight.

Data on Fertility, Hatchability, embryonic mortality and chick quality were in generally computed as:

$$\%\text{Fertiity (MEF)} = \left(\frac{\text{Number of Fertile Egg}}{\text{Total Number of Eggs set}}\right) * 100$$

$$\%\text{Hatchability of Total eggs set (HSE)} = \left(\frac{\text{Nunmber of Eggs hatched out}}{\text{Total Number of Eggs Set}}\right)$$

$$\%\text{Hatchability of Fertile eggs set (HFE)} = \left(\frac{\text{Nunmber of Eggs hatched out}}{\text{Total Number of Fertile Eggs Set}}\right) * 100$$

$$\%\text{Embryonic Mortality (MR)} = \left(\frac{\text{Number of Dead Embryo}}{\text{Total Number of Egg set}}\right) * 100$$

$$\%\text{Chick Yield (Yield)} = \left(\frac{\text{Chick Weight}}{\text{Egg weight before hatch}}\right) * 100$$

2.3. Statistical Analysis

The data was recorded as per the prepared sheet and was entered into excel regularly. The data collected was summarized and analyzed by the GLM model using SAS software. When the GLM showed a significant difference at $P \leq 0.05$ the Duncan's multiple range tests were used for mean separation.

The model used for the analysis was:

$$Yik = \mu + Gi + eik$$

Where,
Yik = the response variables
μ = the overall Mean
Gi = the effect of genotype, eik = Random error

3. Results and Discussion

3.1. Egg Production Performance of KK, HC, CH, C, H, and L Chicken Genotypes

The results of egg production of different chickens are presented below in Table 3. The age at first egg (AFE) was significantly the highest for L, higher for C and CH, and high for KK, whereas H and CH had the lowest AFE. The age at peak egg production (APP) was significantly the highest for L, higher for KK followed by HC and C, while H and CH had the lowest APP. The difference in AFE and APP are ascribed to variation in genetic constitutions [43] The AFE and APP could also be affected by feed quality, daylight hours, and husbandry practices [38, 17]). The difference in genetic makeup notably impacted the AFE and APP [39] KK had significantly higherhen day egg production (HDEP) andhen housed egg production (HHEP) than CH, HC and C, H, but L had the lowest HDEP and HHEP. The HDEP and HHEP were found to be higher in Atabey than Atak-S [5] In line with study, the HDEP and HHEP rates were substantially affected by genotypes [12, 43]. The egg mass (EM) was significantly the highest for KK, higher for CH, HC and C, while EM was the lowest in L followed by H. The difference in EM was attributed to the effect of genotype [12]. The variation in EM among laying genotypes might be due to difference in egg number and egg weight [11, 7] The egg number (EN) was significantly the highest for KK followed by CH and H, while EM was the lowest in L followed by C and HC (Table 3). the highest egg production was obtained by FIRI followed by RIFI, RIR and the Fayoumi chickens [41]. Besides, that SR (119.2) and KO (97.8) had the highest EN compared to KU (107.8) and IH (97.8) up to 40 weeks [7]. However, GF (71) had notably lowest EN followed by TL (75) but PK (121) had the highest EN followed by HR (101) up to 29 weeks [17]. Egg laying genotypes with higher EN had better genetic potential compared to lower EN [11]. In agreement with the current study, the difference of laying genotypes in EN is attributed due to genetic makeup [36, 42] Furthermore, the difference of chickens in EN could be due to genetic constitution and type of husbandry practices [38].

Table 3. *Egg production performance of KK, HC, CH, C, H, and L chicken genotypes.*

Category Parameters	KK	CH	C	Genotype (G) HC Mean ±SE	H	L	P-value G
AFE	20.78±0.15c	19.57±0.19d	21.84±0.09b	21.99±0.11b	19.82±0.13d	27.95±0.33a	0.001
APP	29.89±0.36b	25.94±0.44d	27.87±0.85dc	28.17±0.35c	26.49±0.54d	37.48±0.51a	0.001
HDEP	56.95±0.57a	55.02±0.60ba	54.53±0.66b	54.71±0.69ba	49.82±0.56c	14.03±0.71d	0.0003

Category Parameters	KK	CH	C	Genotype (G) HC Mean ± SE	H	L	P-value G
HHEP	50.32 ±0.36a	46.24 ±0.38b	43.59 ±0.32c	43.92 ±0.41c	45.11 ±0.53bc	12.89 ±0.31d	0.0005
EM	30.02 ±0.68a	26.18 ±0.54b	25.07 ±0.74b	25.29 ±0.67b	22.70 ±0.77c	5.69 ±0.41d	0.001
EN	183.65 ±0.53a	168.79 ±0.52b	159.11 ±0.51d	160.31 ±0.74d	164.64 ±0.45c	47.06 ±0.27e	0.0002

abcd Mean under the same category bear different superscript letters are significantly different,** = P≤0.001, SE = Standard error, MEF AFE = Age at first egg in weeks, APP = Age at peak production in weeks, HDEP= Hen day egg production (%), HHEP = Hen housed egg production (%), EM = Egg mass, EN = Egg number in 52 weeks, MR = Mortality rate (%), Cosmopolitan (C), Improved Horro (H), Cosmopolitan♂*♀Improved Horro (CH), Improved Horro♂*♀Cosmopolitan (HC), indigenous (L) and Koekoek (KK) genotypes

Body Weight, Feed Intake and Feed Conversion Ratio Performance of KK, HC, Ch, C, H, and L Egg Laying Genotypes.

The body weight at firs egg (IBW) and the body weight at the entire experiment (FBW) were significantly the highest for KK, higher for CH and HC, high for C and H and the lowest for L egg laying chicken genotypes. e IBW was the highest for KU (2013) followed by SR (1764), KO (1483) and IH (1120) [7]. Conversely, IBW and FBW were the lowest for GF (1238 vs. 1641) followed by TL (1279 vs.1671), HR (1301 vs.1983) and PK (1693 vs.2490), respectively [17]. The variation in BW (IBW and FBW) of hens in the current study demonstrated the existence of genetic difference among genotypes [41, 12]. KK and L genotypes had the highest and lowest BWC and ADG compared to other genotypes studied (HC, CH, C, and H), respectively. A significantly lightest BWC and ADG were recorded in GF and TL, while PK had the heaviest BWC and ADG followed by HR [17]. Heavier weight hens have higher meat yield compared to lighter weight hens [28, 43]. Conversely, Lighter weight hens had less AFI than that of heavier weight hens [24, 7]. KK chicken had the highest feed intake (AFI) followed by HC and CH, whereas L chicken had the lowest AFI followed by H and C. L had the lowest conversion ratio (FCR) followed by KK, while CH, C, HC and H had the highest FCR (Table 4). The proportion of feed to weight of laying genotypes is attributed to the notable variation in FCR [6, 43]. The difference in BW, BWC, ADG, AFI and FCR are attributed to variation in genetic potential possibly due to past genetic improvement contributions, environmental and feed quality conditions [11, 44].

Table 4. *Body weight, feed intake and feed conversion ratio performance of KK, HC, CH, C, H, and L egg laying genotypes.*

Category Parameters	KK	HC	C	Genotype (G) CH Mean ± SE	H	L	P-value G
IBW	1671.26 ±10.64a	1409.41 ±6.14b	1335.12 ±4.39c	1388.94 ±5.72b	1330.76 ±6.26c	1042.84 ±8.79d	0.001
FBW	2503.67 ±14.04a	2080.77 ±10.21b	1986.51 ±12.01c	2029.13 ±9.90b	1965.46 ±10.88c	1412.92 ±12.31d	0.001
BWC	832.41 ±9.41a	671.36 ±7.18b	651.39 ±5.84c	640.19 ±6.02bc	634.71 ±4.91dc	370.25 ±6.24d	0.001
ADG	2.28 ±0.12a	1.84 ±10b	1.79 ±0.05b	1.75 ±0.08b	1.74 ±0.06b	1.04 ±0.09c	0.004
AFI	122.09 ±0.93a	118.18 ±0.57b	114.31 ±36c	116.53 ±0.64bc	110.44 ±40d	91.68 ±0.75e	0.001
FCR	2.32 ±0.06b	2.48 ±0.07a	2.49 ±0.11a	2.52 ±0.09a	2.42 ±0.08a	2.26 ±0.04c	0.002

abcde Mean under the same category bear different superscript letters are significantly different,*** = P≤0.001, ** = P≤0.01, SE = Standard error, IBW = Initial body weight at first egg (g)(see table 3), FBW = Final body weight (g) at 52 weeks of age, BWC = Body weight change (g), ADG = Daily weight gain (g), AFI = Average daily feed intake (g), FCR= Feed conversion ratio (g AFI/g egg), Cosmopolitan (C), Improved Horro (H), Cosmopolitan♂*♀Improved Horro (CH), Improved Horro♂*♀Cosmopolitan (HC), indigenous (L) and Koekoek (KK) genotypes

3.2. Egg Fertility and Hatchability Parameters of KK, HC, CH, C, H, and L Chicken Genotypes

The results of chick quality parameters of different chickens are shown in Table 5. The mean egg fertility (MEF) was significantly (P≤0.01) the highest for H (96.25±0.36), higher for CH (93.75±0.32), and the lowest for C (92.50±0.31), HC (91.67±0.46), L (90.42±0.47) and KK (90.42±0.38) across breeds. IH (86.9), SR (86.7) and KK (89.4) had shown the highest fertility percentage followed by KU (82.0) chicken breed [7]. TL (98.9), HR (95.6) and PK (92.2) had higher fertility percentage than GF (56.7) genotypes [17]. Br (77.3) had the lowest fertility percentage followed by Gr (89.2) and Bb (90.2), while Na (95.6), Bl (94.0) and F (92.0) genotypes showed the highest Fertility, which witnessed that the differences of those breeds for reproductive capacity [16]. The mean hatchability from set egg (HSE) was significantly (P≤0.01) the highest for H (93.64±0.42) and CH (92.47±0.59), Higher for C (89.26±0.37), HC (88.93±0.81) and KK (87.38±0.43), whereas the lowest for L (84.21±0.93) breeds. Eggs from SR (52.0) exhibited lower hatchability than that of eggs from KU (71.5), KO (72.0), and IH (73.0) [7]. Nevertheless, hatchability from set eggs had slightly affected across genotypes [43]. The mean hatchability from fertile set egg (HFE) was significantly (P≤0.01) the highest for CH (98.22±0.17, higher for H (96.90±0.31), HC (96.82±0.39), KK (96.77±0.29) and C (96.36±0.34), whereas the lowest for L (93.52±0.33c) breeds. TL (88.9), PK (86.7) and HR (81.0) had higher hatchability fertile egg percentage than GF (56.9) genotypes [17]. Moreover, hatchability from fertile eggs had affected across genotypes [43]. Fertility and hatchability percentages of eggs substantially affected by age, egg storage time, setter, and hatcher type and genotype [18].

3.3. Embryonic Mortality (Early, Mid, Late, Pipeline) Characteristic of KK, HC, CH, C, H, and L Genotypes

Embryonic mortality (early, mid, late, pipeline) characteristic of genotypes is presented in Table 5. Early embryonic mortality percentage (Early) was significantly (P≤0.001) higher for L (5.06±0.28) than HC (1.42±0.26), KK (1.34±0.24), H (1.20±0.17), C (1.19±0.33), and CH (0.67±0.08). Embryonic loss occurring in the first week of the incubation is termed early embryonic. Scholars noted that the difference in early embryonic mortality in the first six days of incubation due to generics [48, 16]. Early embryonic mortality is attributed to chromosomal effects. Study found that the heritability of early embryonic mortality is higher than those occurring in the later stages [2]. Mid embryonic mortality percentage (Mid) was significantly (P≤0.01) highest for L (2.72±0.47), higher C (1.05±0.21), high for KK (0.82±0.11) and H (0.79±0.36), whereas low for HC (0.47±0.10), and CH (0.35±0.12). Reports revealed that the differences in mid embryonic mortality could be associated with non-additive influence that additively [26]. Mid embryonic mortality could be influenced by adaptability of the genotypes. In agreement with our study, mid embryonic mortality is affected by genotypes [7].

Late embryonic mortality percentage (Late) was significantly (P≤0.01) highest for L (1.91±0.93), higher HC (0.93±0.12), high for C (0.78±0.18), H (0.61±0.42), whereas low for HC (0.47±0.10), and KK (0.57±0.13). The variations in late embryonic mortality are notably affected across genotypes [17]. Pipeline embryonic mortality percentage (Pipe) was significantly (P≤0.01) highest for L (1.42±0.33), higher C (0.61±0.04), high for KK (0.49±0.09), H (0.61±0.42), whereas low H (0.43±0.31), HC (0.36±0.03) and CH (0.32±0.04). Pipeline embryonic mortality was affected across genotypes [17]. In line with the study, scholars explained that the differences in pipeline embryonic mortality might be attributed to dam and sire [2, 43]. Previous results showed that the differences in pipeline mortality could be due to inadequate supply of oxygen [35]. Nonetheless, pipeline embryonic mortality was slightly affected by genotypes [16]. Embryonic mortality after piping in eggs from breeders may be due to producing smaller chickens, which may not be able to break the shell during hatching.

Overall embryonic mortality percentage (EMR) was significantly (P≤0.001) highest for L (11.11±0.22), high for C (3.63±0.12), KK (3.22±0.08), HC (3.18±0.10), H (3.03±0.27), whereas low for CH (1.78±0.05). Genetic factors contribute to embryonic mortality [7, 17]. Embryonic mortality that occurs during the incubation period might be due to incubation conditions, egg quality and an imbalanced diet Less developed embryos are less differentiated and contain fewer cells, and advanced embryos are in a more active stage of development [37].

Table 5. Egg fertility, Hatchability and Embryonic Mortality (early, mid, late, pipeline) Characteristic.

Category Parameters	KK	CH	C	Genotype HC Mean ±SE	H	L	P-value G
MEF	90.42±0.38b	93.75±0.32ab	92.50±0.31b	91.67±0.46b	96.25±0.36a	90.42±0.47b	0.001
HSE	87.38±0.43b	92.47±0.59a	89.26±0.37b	88.93±0.81b	93.64±0.42a	84.21±0.93c	0.001
HFE	96.77±0.29b	98.22±0.17a	96.36±0.34b	96.82±0.39b	96.90±0.31b	93.52±0.33c	0.003

Category Parameters	KK	CH	C	Genotype HC Mean ± SE	H	L	P-value G
Early	1.34 ±0.24b	0.67 ±0.08b	1.19 ±0.33b	1.42 ±0.26b	1.20 ±0.17b	5.06 ±0.28a	0.01
Mid	0.82 ±0.11c	0.35 ±0.12d	1.05 ±0.21b	0.47 ±0.10d	0.79 ±0.36c	2.72 ±0.47a	0.01
Late	0.57 ±0.13c	0.44 ±0.07d	0.78 ±0.18b	0.93 ±0.12b	0.61 ±0.42c	1.91 ±0.93a	0.005
Pipe	0.49 ±0.09bc	0.32 ±0.04c	0.61 ±0.04b	0.36 ±0.03c	0.43 ±0.31c	1.42 ±0.33a	0.01
EMR	3.22 ±0.08b	1.78 ±0.05c	3.63 ±0.12b	3.18 ±0.10b	3.03 ±0.27b	11.11 ±0.22a	0.001

abcd Mean under the same category bear different superscript letters are significantly different,** = P≤0.01, SE = Standard error, mean egg fertility, HSE = Hatchability from total eggs set, HFE = Hatchability from fertile eggs, Early = Early embryonic mortality (%), Mid = mid embryonic mortality (%), Late = Late embryonic mortality (%), Pipe = Pipeline embryonic mortality (%), EMR = overall embryonic mortality (%), Cosmopolitan (C), Improved Horro (H), Cosmopolitan♂*♀Improved Horro (CH), Improved Horro♂*♀Cosmopolitan (HC), indigenous (L) and Koekoek (KK) genotypes

3.4. Chick Quality Parameters of KK, HC, CH, C, H, and L Chicken Genotypes

The results of chick quality parameters of different chickens are shown in Table 6. Mean egg weight before hatch (EW-b) was highest for KK (49.53±0.48), higher for CH (46.49±0.20), high for HC (45.12±0.22), intermediate for HC (44.90±0.38) and H (44.48±0.17), and the lowest for L (37.05±0.28). Egg weight was notably varied by the size of laying hens and eggs, which appeared to be consistent with this study [9, 33]. Weight of day-old chick (Chq) was highest for KK (32.79±0.42), intermediate for CH (28.98±0.31), C (28.63±0.36), HC (28.51±0.40) and H (28.86±0.24), and the lowest for L (25.77±29). Weight of day-old chick was highest for PK (32.80), intermediate for HR (29.20) and TL (28.90), and lowest for GF (21.90) [17]. Moreover, Weight of day-old chick was highest for KU (39.50) and SR (39.40), intermediate for KO (34.90), and lowest for IH (30.60) [7]. Conversely, Exotic breed had lower chick weight than that of Arbor Acres, Cobb, and Ross [3]. In line with study, the differences in chick weights are attributed to the variation in the size of eggs [11]. Scholars also showed that the nutrient contents of the albumen and yolk might affect the chick quality [21]. In contrast, average egg size is recommended for incubation to hatch better quality chicks [22].

Mean chick yield percentage (Yield) was highest for L (32.79±0.42), high for KK (66.20±1.22), H (64.88±0.63), C (63.76±0.99), HC (63.18±0.89) and CH (62.33±0.80). Chick yield percentage significantly affected by genotypes [16]. However, Chick yield percentages during incubation were similar among the breeds [7]. Likewise, chick yield values (Yield) were slightly varied among chickens [22]. Mean chick length (ChL) was highest for KK (15.09±0.17), high for HC (14.40±0.29), CH (14.37±0.25), C (14.35±0.23), H (14.11±20), whereas lowest for L (13.08±0.06). Chick length was highest for PK (14.6), higher for HR (14.0), high for TL (13.0) but the lowest for GF (12.2) [17]. Chick length was highest for SR (16.1) and KU (15.9) followed by KO (15.3), whereas the lowest for IH (14.9) [7]. Studies explained that the differences of chick length could significantly affected by the size of genotypes [21]. The variation in chick length (ChL) among genotypes in the present study could be due to the difference in egg size.

Table 6. Chick quality characteristics of KK, HC, CH, C, H, and L genotypes.

Category Parameters	KK	CH	C	Genotype HC Mean ± SE	H	L	P-value G
EW-b	49.53 ±0.48a	46.49 ±0.20b	44.90 ±0.38c	45.12 ±0.22c	44.48 ±0.17c	37.05 ±0.28d	0.001
Chq	32.79 ±0.42a	28.98 ±0.31b	28.63 ±0.36b	28.51 ±0.40b	28.86 ±0.24b	25.77 ±29c	0.01
Yield	66.20 ±1.22b	62.33 ±0.80c	63.76 ±0.99c	63.18 ±0.89c	64.88 ±0.63c	69.55 ±1.14a	0.01
ChL	15.09 ±0.17a	14.37 ±0.25b	14.35 ±0.23b	14.40 ±0.29b	14.11 ±20c	13.08 ±0.06d	0.007

abcd Mean under the same category bear different superscript letters are significantly different, ** = P≤0.01, SE = Standard error, EW-b =egg weight before hatch, Chq = Chick weight, Yield = Chick weight/egg weight before hatch ×100, ChL= Chick length, Cosmopolitan (C), Improved Horro (H), Cosmopolitan♂*♀Improved Horro (CH), Improved Horro♂*♀Cosmopolitan (HC), indigenous (L) and Koekoek (KK) genotypes

4. Conclusion and Recommendation

Age at first egg and age at peak varied across genotypes. KK had the highest egg production followed by CH, H, CH and C but L had the lowest egg production. KK had the highest weight and feed intake followed by HC, HC, and C, whereas had the lowest followed by H. Feed conversion ratio varied among genotypes. The H had the highest fertility followed by CH. Conversely, C, HC, L and KK genotypes had the least fertility. The H and CH had the highest hatchability compared to other genotypes. Early, mid, late and pipeline embryonic mortality rate was meaningfully affected by genotypes. The overall embryonic mortality of L was the highest, whereas CH had significantly lowest overall embryonic mortality followed by the intermediary KK, HC and C. Chicks hatched from KK had the highest chick weight and chick length, but chicks hatched from L had the least chick weight and chick length. Eggs of L had the highest percentage chick yield followed by KK, whereas the CH, C, HC and H had intermediate chick yield. In conclusion: The genotype differences of chickens substantially influence on egg production performances, fertility, embryonic mortality, hatchability and chick quality.

Abbreviations

C	Cosmopolitian Chicken
H	Improved Horro Chicken
HCI	Improved Horr*Cosmopolitan Crossbred Chicken
CH	Cosmopolitan*Improved Horro Crossbred Chicken
L	Indigenous Chicken
KK	Koekoek Chicken
WARC	Werer Agricultural Research Centre
DZARC	Debre Zeit Agricultural Research Center

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Author Contributions

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Conflicts of Interest

The authors declare no conflicts of interest.

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Research Fields

Shambel Taye Fulla: Animal breeding, Genetics, Animal physiology, Crossbreeding, animal production

Atsbaha Hailemariam Gebreslassie: Animal breeding, GenetiMcs, Animal physiology, Crossbreeding, animal production