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Research article

Evaluation of fertility, hatchability, and growth performance of indigenous, sasso and their F1 cross chicken genotypes in Southern Ethiopia

Berhanu Bekele[1*], Aberra Melesse[2], Wondmeneh Esatu[3] and Tadelle Dessie[3]

[1]*Department of Animal science, College of Agricultural science, Wachemo University, Hossana, Ethiopia*
[2] *School of Animal and Range Science, College of Agriculture, Hawassa University, Hawassa, Ethiopia*
[3]*International livestock research institute (ILRI), Addis Ababa, Ethiopia*

Abstract

Three chicken genotypes were involved in the study with the objectives of evaluating fertility, hatchability, and growth performance of three chicken genotypes. For the experiment, 1550 (600 of indigenous, 450 of Sasso, 500 of crossed) eggs were labelled and incubated. The data were analyzed using SAS. Relatively higher proportion of fertility was observed for the eggs collected from Sasso (89.6%) followed by crossed eggs (72.8%). Correspondingly, hatchability was higher for Sasso. Body weight was increased from 27.9 to 321.7 g for indigenous, 36.8 to 431.2 g for Sasso, and 32.4 to 353.4 g for crossbred from week0 to week7. Agroecology by genotype had a significant ($p<0.05$) influence on the growth performance of the chickens during week11 and week15. The interaction between agroecology and sex was significantly influenced growth rate of the chickens in all weeks of their age, except the chickens at their 11^{th} weeks of age. Genotype by sex interaction had highly significant effect in the growth performance of the chickens at their 11^{th}, 15^{th}, and 20^{th} weeks age. The chickens' growth has been influenced by the interaction among agroecology, genotype, and sex. Higher proportion of indigenous (22%) and Sasso (24%) birds were died in highland in between W7-13, however higher proportion of crossbred birds were lost in lowland for same week interval. Considering the most parametes of chickens, midland agroecology is more promising for their production. This is because, better feed resources, climatic condition, and awareness of farmers how to manage their birds.

Keywords: Agroecology, Fertility, Growth performance, Hatchability, Mortality

Corresponding author: Berhanu Bekele, Department of Animal science, College of Agricultural science, Wachemo University, Hossana, Ethiopia Email: berhanub06@gmail.com.

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INTRODUCTION

Poultry production in Ethiopia plays a crucial role in generating employment opportunities, poverty reduction, improving family nutrition, and in women empowerment. It is a suitable business for resource-poor households due to the small land requirement and low initial investment costs needed (FOA, 2019).

Fertility is an important parameter in chicken and reflects the total actual reproductive capacity of females and males expressed by their ability when mated together to produce offspring. An egg is said to be infertile when it fails to show any evidence of developing embryo and it depends on various factors such as breed, season, pre-incubation holding period, lighting, level of nutrition, mating and time of mating (Miazi et al., 2012; Adedeji et al., 2015).

Hatchability is a trait of economic importance in the chicken industry because it has a strong effect on chick output. It is influenced by several factors such as egg weight, turning of eggs, storage, humidity, shell strength, egg size and genetic factors within the chickens kept. The ability of the embryo to successfully escape from the shell is called hatchability. Good hatchability of eggs is to some extent heritable but is determined by a complicated genetic constitution and the environment (Wolc et al., 2010; Adedeji et al., 2015).

To increase the genetic potential of chickens, planned breeding program is a demand of time. However, broodiness is one of the major characteristics of indigenous chicken which causes less egg production. Artificial incubation of eggs can minimize the problem of broodiness. As a result of reduced broodiness, egg production would be expected to be increased as well (Hossain, 2014).

Egg characteristics greatly influence the process of incubation and are responsible for its success (Narushin and Romanov, 2002). The eggshell has an important role during embryonic development, isolating the embryo from the external environment while allowing the proper gas exchange through the shell. Barnett et al. (2004) reported that eggs with hair-cracks showed increased bacterial exposure and weight loss, with significantly lower hatchability (56.4% vs. 80.9%) compared with intact shells. Bennet (1992) compared thin and thick shells based on specific gravity measurements and reported a reduction in hatchability of 3 to 9%, which attributed to increased cracks, moisture loss and bacterial contamination of eggs with thin shells.

Fertility and hatchability are major parameters of reproductive performance which are most sensitive to variation in environment and genetic makeup. Fertility refers to the percentage of incubated eggs that are fertile while hatchability is the percentage of fertile eggs that hatch. Fertility and hatchability are major parameters of reproductive Performance which are most sensitive to environmental and genetic influences (Sapp et al., 2004; Abdurehman and Urge, 2016). Therefore, the study was conducted with the objectives of evaluating fertility and hatchability of different chicken genotypes and growth performance of chicken at different conditions.

MATERIALS AND METHODS

Experiment Site

The study was conducted in poultry farm of Hawassa University, College of Agriculture, Hawassa Zuria District, Wondogenet, and Malga Districts, Sidama Regional State of Ethiopia. Hawassa is situated in the shores of Lake Hawassa in the Great Rift Valley on longitude 38° 28' 34.86 E and latitude 7° 03' 43.38 N.

Sources of eggs and incubation

In this experiment, 600 eggs of indigenous chickens were collected from the selected farmers around Hawassa, 450 eggs from Sasso were collected from Hawassa Poultry farm, and 500 eggs from arranged mating of Sasso female and Indigenous males to produce crossbred chicks in Poultry farm of college of Agriculture, Hawassa University.

The eggs prepared for incubation from the three genotypes were ready after checking them to avoid unsuitable eggs (cracked, dusty, shapeless, too small, too large). Before incubation, the incubator was sanitized and fumigated (run) for 72 hours without setting the eggs. This was done to ensure that the incubator is maintaining the proper temperature and relative humidity before the eggs were set. Total of 1550 eggs were labelled for their genotypes and placed in PETERSIME (model ST. 7-B) incubator at a temperature of 38°C.

The eggs were candled at the 18th day of incubation to check for fertile eggs. Consequently, eggs that showed signs of developing embryos by means of a visible network of blood vessels spreading from the center of the egg's outwards were fertile and shifted to hatchery.

Management of experimental chicks

The brooding house and chicken rearing equipment were cleaned and disinfected prior to one week of the beginning of experiment. On hatching, chicks were weighed, and brooded for 7 weeks in Poultry farm, college of Agriculture, Hawassa University. Chicks were kept in a deep litter housing system with concrete floors covered with wood shavings and pens divided by mesh wire for each genotype. The chicks were vaccinated regularly with Marek's (DOC), HBI (Thermostable) at 7th day, Gumboro (IBD) at 17th day, Lasota (Thermostable) at 42nd day of their age based on the recommendation of manufacturer. All the three genotypes were fed the same standard commercial dual purpose chicken feed as per the recommendation of feeding chemical composition by Alema Feed Plc, Debrezeit, Ethiopia (Table 1).

Table 1 Chemical composition of commercial dual purpose chick feeds used

Nutrient composition	Age	
	W0-W3	W4-W7
Crude protein (%)	20.9	18.5
Crude fiber (%)	4.50	5.80
Crude fat (%)	3.00	5.00
Calcium (%)	1.15	0.90
Phosphorus (%)	0.55	0.49
Energy (kcal/kg)	3035	2950

W0 = Body weight of day-old chiks; W3 = third week; W4= fourth week; W7 = seventh week

Data Collection

Body weight was recorded from growing chicks starting from hatching to the age of week 7 (W0-W7) while they were managed on station. After W7 age, the chicks were distributed to pre-selected households representing three agro-ecologies (lowland, midland, and highland) where the growth performance data were evaluated under on-farm condition. A total of 450 chicks (50 chick of each of the three genotype) was distributed to the selected farmers in lowland (Hawassa Zuria), midland (Wondogenet) and highland (Malga) districts. The data on mortality and growth rate of the chicks across the three agro-ecologies were recorded until their 20th weeks old at different age interval (9th, 11th, 15th, and 20th weeks) for body weight performance and W7-13 and W13-W20 for mortality rate under the farmers management system.

Fertility was calculated based on total eggs set whereas hatchability and mortality on hatching day were calculated based on total fertile eggs set. Fertility, hatchability, and mortality were calculated using following formulae:

$$Fertility\ (\%) = \frac{total\ number\ of\ fertile\ eggs\ after\ candling}{total\ number\ of\ eggs\ set} * 100$$

$$Hatchability\ (\%) = \frac{total\ number\ of\ chicks\ hatched}{total\ number\ of\ eggs\ set} * 100$$

$$Hatchability\ of\ fertile\ eggs\ (\%) = \frac{total\ number\ of\ chicks\ hatched}{total\ number\ of\ fertile\ eggs} * 100$$

$$Mortality\ (\%) = \frac{total\ number\ of\ dead\ chicks}{total\ number\ of\ fertile\ eggs} * 100$$

Data management

Data were checked for consistency and outliers. Then the data were analyzed using SAS and the following model was used.

$$Y_{ijklmno} = \mu + A_i + G_j + S_k + A*G_l + A*S_m + G*S_n + A*G*S_o + e_{ijklmno}$$

where: Y_{ijkl}= individual observation; μ= fixed overall mean; A_j = effect of agro-ecology (j = lowland, midland, highland); G_J = effect of genotype (j = indigenous, Sasso, F1 crossbred); S_i = effect of sex (i = male, female); A*G = Effect due to interaction between agroecology and genotype; A*S = Effect due to interaction between agroecology and sex; G*S = Effect due to interaction between genotype and sex; A*G*S = Effect due to interaction between agroecology, genotype and sex; e_{ijk} = random residual error

Data management

All applicable international, national, and institutional guidelines for the care and use of animals were followed. Study was reviewed and approved by the School of Animal and Range Sciences, College of Agriculture, Hawassa University.

RESULTS

Incubation

Results of the questionnaires administered equally (96 per area council) to assesMore than half of the total eggs incubated was fertile. The proportion of fertility was higher for the eggs obtained from Sasso (89.6%) followed by eggs of indigenous (68.7%). The average fertility, hatchability, and mortality for all the three genotypes were 72.2%, 77.9% and 22.1% respectively (Table 2).

Table 2 Incubation, fertility, and hatchability of eggs from different genotypes

Variables	Genotype			Total	Mean
	Indigenous	**Sasso**	**F1-Cross**	**1550**	**517**
Eggs incubated	600	450	500	1036	345
Eggs fertile	412	403	291	849	283
Eggs hatched	266	327	256		72.2
Fertility of eggs (%)	68.7	89.6	58.2		54.7
Hatchability of total eggs incubated (%)	44.3	72.7	51.2		77.9
Hatchability of fertile eggs (%)	64.6	81.1	88.0		22.1
Mortality (%)	35.4	18.9	12.0		

% = percentage

Body weight performance

On-station growth performance of the three genotypes is presents in Table 3. Body weight of the day-old chicks was 27.9, 36.8, and 32.4 g for indigenous, Sasso, and indigenous by Sasso crossbred respectively.

The body weight of chicks of the three genotypes were significantly different ($p<0.05$) for all week limits except W7 where there is no significant difference ($p>0.05$) for the body weight performance of indigenous and crossbred chicks. The body weight was increased from 27.9 to 322 g (indigenous), 36.8 to 431 g (Sasso), and 32.4 to 353 g (indigenous*Sasso) from W0 to W7 of their age.

In the whole period of the time while the chicks were in the farm (on-station) from day one up to W7, only 3 (indigenous), 3 (Sasso) and 2 of the F1 crossbred died. Proportionally 1.13% from indigenous, 0.92% of Sasso, and 0.78% of crossbred chicks were lost. On-station mortality rate of chicks was very low; due to the better management towards them

Table 3 On-station growth performance and mortality (%) of different genotype chickens

Age	genotype			Avg	P-value		
	Indigenous (Ind)	Sasso	F1-Cross (Cr)		Ind. vs Sasso	Ind. vs Cr.	Sasso vs Cr.
Body weight							
W0	27.9[a]	36.8[c]	32.4[b]	32.4	0.0001	0.0001	0.0001
W2	82.0[a]	134[c]	118[b]	111	0.0001	0.0001	0.0001
W4	144[a]	202[c]	174[b]	173	0.0001	0.0001	0.0001
W7	322[a]	431[b]	353[a]	369	0.0001	0.178	0.0001
Mortality (W0-W7)	3 (1.13)	3 (0.92)	2 (0.78)	8 (0.94)			

W0 = body weight of day-old chicks; W2 = body weight at second wee; W4 = body weight at fourth week; W7 = body weight of chicks at seventh week

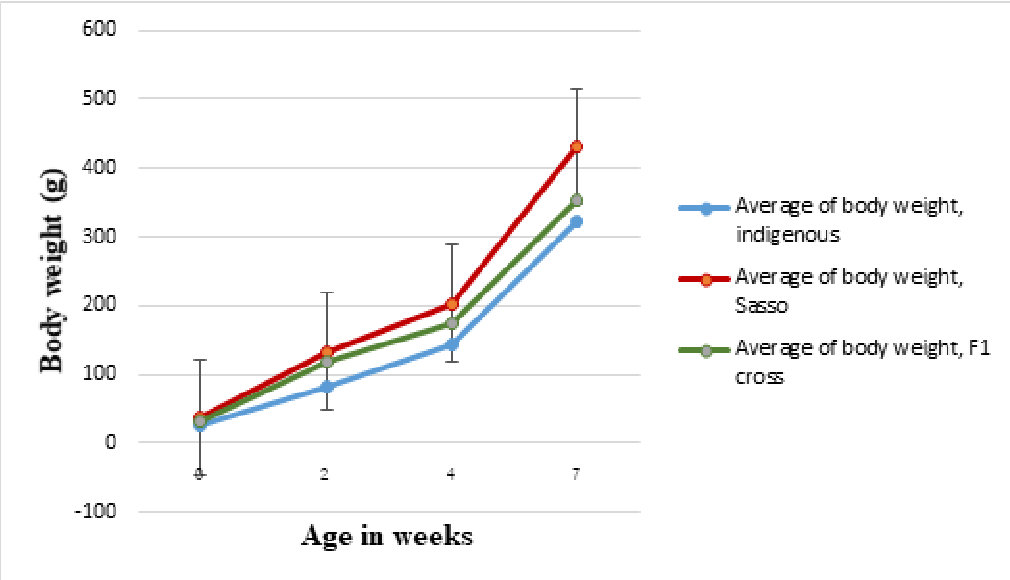

Figure 1 On-station growth rate of the three studied chicken genotypes.

Least squares mean of body weight performance of the chickens under farmers management system for the fixed effects and their interactions is presented in Table 4.

Agroecology effect

Agroecology had significant effect ($p<0.05$) on growth performance of the chickens for all week intervals where the body weight of the chickens exhibited heavier in midland (493 g in W11, 785 g in W15 and 1132 g in W20) except for W9, heavier in lowland.

Genotype effect

Genotype had highly significant ($p<0.0001$) difference during all the given week of the age. Sasso breed was superior compared to the other genotypes followed by F1 – cross chicken genotype.

Sex effect

Sex showed highly significant effect ($p<0.0001$) in all experiment weeks. Male chickens were higher than the female chicken.

Interaction effect

Agroecology by genotype had a significant ($p<0.05$) influence on the growth performance of the chickens during w11 and w15; however, the interaction between agroecology and genotype was not significantly influenced the body of the chickens in 9th and 20th week ages. The interaction between agroecology and sex was significantly influenced growth rate of the chickens in all weeks of their age, but not the chickens at their 11th weeks of age. Genotype by sex interaction had highly significant effect in the growth performance of the chickens at their 11th, 15th, and 20th weeks age. The interaction among the three fixed effects had no significant influence on the growth performance of the chickens during w9, w11 and w15 of their age; however, the chickens' growth has been influenced by the interaction among agroecology, genotype, and sex (AE*G*S).

Table 4 Least Squares Means of body weight (g) for agroecology, genotype and sex and their interaction effects on growth performance of the chickens.

Fixed effects	Week 9	Week 11	Week 15	Week 20
Agro-ecology				
Lowland	428^b	481^b	727^b	1020^a
Midland	418^a	493^c	785^c	1132^b
Highland	389^a	446^a	687^a	1067^a
Genotypes				
Indigenous	271^a	324^a	640^a	867^a
Sasso	519^c	581^c	876^c	1313^c
F1-crosses	445^b	516^b	683^b	1039^b
Sex				
Male	450^b	527^b	863^b	1260^b
Female	374^a	420^a	604^a	886^a
Sources of variations				
Agro-ecology (AE)	0.003	<.0001	<.0001	0.0103
Genotype (G)	<0.001	<.0001	<.0001	<.0001
Sex (S)	<0.001	<.0001	<.0001	<.0001
AE*G	0.319	0.0048	0.0147	0.0789
AE*S	0.032	0.4904	<.0001	0.0017
G*S	0.128	0.0020	<.0001	<.0001
AE*G*S	0.722	0.3324	0.1245	0.0056

$^{a-c}$ Means on the same column with different superscripts within the specified age group are significantly different

On-farm growth performance of the chickens at different week intervals in the three agro-ecologies are reported in Table 5. Genotypes and sex had highly significantly ($p<0.0001$) influenced the growth performance of the chickens within each agroecology. In all cases Sasso breed showed significantly ($p<0.0001$) higher body weight in all weeks of their age at each agroecology. Male chickens were highly significantly heavier than the females in all agro-ecologies.

Table 5 Mean values of growth performance (g) for the given genotypes and sexes within agroecology.

Agroecology			Week9	Week11	Week15	Week20
Lowland	Genotype					
		Indigenous	288^{a}	319^{a}	688^{a}	856^{a}
		Sasso	531^{c}	600^{c}	825^{b}	1187^{c}
		F1-Cross	464^{b}	525^{b}	667^{a}	1016^{b}
	Sex					
		Male	476^{b}	536^{b}	862^{b}	1163^{b}
		Female	379^{a}	426^{a}	591^{a}	875^{a}
Midland	Genotype					
		Indigenous	273^{a}	336^{a}	716^{a}	927^{a}
		Sasso	533^{c}	594^{c}	883^{b}	1391^{c}
		F1-Cross	449^{b}	549^{b}	754^{a}	1100^{b}
	Sex					
		Male	460^{b}	550^{b}	942^{b}	1368^{b}
		Female	376^{a}	436^{a}	626^{a}	897^{a}
Highland	Genotype					
		Indigenous	249^{a}	304^{a}	621^{a}	902^{a}
		Sasso	480^{c}	538^{c}	758^{c}	1222^{c}
		F1-Crosses	438^{b}	497^{b}	684^{b}	1077^{b}
	Sex					
		Male	413	495	784	1249
		Female	365	397	591	885
Sources of variations						
Genotype			<.0001	<.0001	<.0001	<.0001
Sex			<.0001	<.0001	<.0001	<.0001

[a, b, c] Means on the same column with different superscripts within the specified age group are significantly different

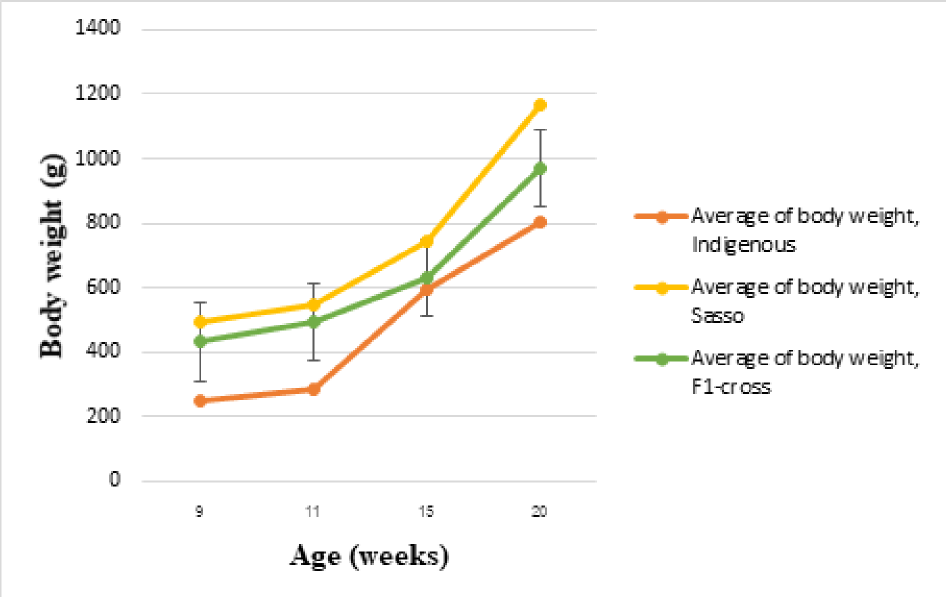

Figure 2 On-farm growth rate trend of three chicken genotypes.

On-farm mortality rate of chickens at the three agro-ecologies is presented in Table 6. Higher proportion of the indigenous (22%) and Sasso (24%) birds were died in highland in between W7-13; whereas high proportion of crossbred birds were lost in lowland for same week interval.

Table 6 Mortality rate (%) of three chicken genotypes across the three agro-ecologies

Genotype	Agroecology	W7-W13			W13-W20		
		n	Died	Mortality	n	Died	Mortality
Indigenous	Lowland	50	2	4.0	48	2	4.17
	Midland	50	4	8.0	46	1	2.17
	Highland	50	11	22.0	39	1	2.56
Sasso	Lowland	50	5	10.0	45	-	-
	Midland	50	1	2.0	49	2	4.08
	Highland	50	12	24.0	38	4	10.5
F1 crossbred	Lowland	50	6	12.0	44	5	11.4
	Midland	50	4	8.0	46	7	15.2
	Highland	50	1	2.0	49	7	14.3

n = number of chickens, W = week, Indg = indigenous

DISCUSSION

Unlike with the current study (Table 2), Abdurehman and Urge, (2016) reported that the fertility and hatchability observed for local chickens was more than exotic and crossbred chicken genotypes. This variation might be due to the egg source. For the current study eggs of indigenous chickens were collected from farmers that may decrease the fertility and hatchability through the handling process, and transport stress, unlike the eggs of Sasso and crossed eggs in farms under careful handling of eggs, appropriate male to female ration, and zero transport challenge.

As reported under the study of Ajayi and Agaviezor, (2016), the hatchability of the pure normal feathered chicken is 86.36%, whereas lower values of 62.09 and 66.90% was recorded for pure frizzle and naked neck strains of Nigeria, respectively. The hatchability percentage of Ajayi and Agaviezor, (2016) revealed higher for pure normal feathered Nigerian chickens and which is comparable for pure frizzle and naked neck while comparing report of current study (Table 2).

Desha et al. (2015) reported corresponding proportion of fertility, however higher percentage of hatchability for indigenous chickens of Bangladesh.

The hatchability of fertile eggs for indigenous, Sasso, and crossbred was within the range (67.9%-89%) previously reported by (Alawi and Melesse 2013; Bamidele et al., 2019) for indigenous, exotic and their crosses in Ethiopia. Moreover, the hatchability of fertile eggs for all the three studied genotypes agreed with the reports under the study of Alabi et al. (2012) and Esatu et al. (2011), who reported values ranging from 52.4-87.0% for indigenous and exotic and almost nearest even for crossbred (88% in Table 2).

Body weight of indigenous chicks in current study which accounted 27.9 g, agrees with work conducted by Hassen et al. (2006) who reported that some indigenous chicken lines in Ethiopia such as Tilili, Gellilia, Debre Elias, and Mecha weighed 27.2 g, 27.8 g, 27.1 g, 27.9 g at their first day of hatching in Northwest of Ethiopia.

The live body weights of all the three studied chicken genotypes reported in this study were higher than those reported for intensively reared Kuchi chicken ecotype in Kenya by Lihare et al. (2020) who reported that 24 g in W0, 64.6 g in W2, 145.8 g in W4 and 280.7 g in W6 except for indigenous chickens which have been weighed 144.3g at W4 in current study (Table 3). However, Mulugeta et al. (2020) reported that higher day-old body weight of DZ-white (35.0 g) and improved Horro (29.3 g) chicks compared to the live body weight of day-old chicks of indigenous chickens in this study. This is an indicator of existing variation for different ecotypes across their various habitats hence possible improvement through selection and climatic conditions.

The body weight of Sasso is lower than the body weight of Sasso in Nigeria at DOC and W6 that accounts 39.0 g in W0 and 494.6 g in W6 (Bamidele et al., 2019). This was due to the variation in climatic condition across the countries.

Live body weight is the direct reflection of growth, and it influences the production and reproduction traits of chickens (Mulugeta et al., 2020). The growth performance of chicken is mostly affected by the environment, which reflects the differences in climatic condition. In this study, chickens in midland had averagely higher body weight than those in lowland and highland. Like the current study, the study conducted by (Alem, 2014) reported that, the average body weight of mature chickens was significantly higher in midland than in lowland agroecology in Ethiopia.

On-farm mortality of chickens was relatively higher in highland agroecology than the remaining agro-ecologies following the influence of environment. This is in line with the study of (Melesse et al., 2013; Alem, 2014) who reported that chickens in midland survive better than chickens in other agro-ecological zones of Ethiopia. The higher mortality rate in highland is not agreed with the report of Azoulay et al. (2011) and Mulugeta et al. (2020) who reported that high mortality rate under hot environmental conditions.

CONCLUSIONS

The results of this study have demonstrated that fertility was better for the eggs collected from Sasso, and all the three studied chicken genotypes in midland showed significantly ($p<0.05$) higher performance than highland and lowland agro-ecologies. On-station chicks' mortality was almost null for the three genotypes with in seven weeks of their age. Better body weight performance was recorded in midland agroecology followed by lowland, for better management and ecological advantage.

AUTHOR CONTRIBUTIONS

Berhanu Bekele: conceptualization; designing methodology; data collection; formal analysis; writing original draft.
Aberra Melesse: conceptualization; modifying the manuscript.
Wondmeneh Esatu: conceptualization; modifying the manuscript.
Tadelle Dessie: conceptualization; modifying the manuscript and provision of fund. All authors have read and approved the final manuscript.

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