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Research Article
Evaluation of Fertility, Hatchability and Egg Quality of Rural Chicken in Gorogutu District, Eastern Hararghe, Ethiopia

[1]Ahmedin Abdurehman and [2]Mangistu Urge

[1]Department of Animal and Range Sciences, Bule Hora University, P.O. Box 144, Bule Hora, Ethiopia
[2]School of Animal and Range Sciences, Haramaya University, P.O. Box 138, Dire Dawa, Ethiopia

Abstract
This study was conducted to evaluate the fertility, hatchability and egg quality of rural chicken in three agro-ecologies. Eggs of indigenous cross and exotic breed were collected from each selected rural kebeles for determination of fertility, hatchability and egg quality parameters. A total of 270 eggs were incubated for fertility and hatchability, 180 eggs were used for egg quality evaluation. Fertility and hatchability study revealed no significant ($p>0.5$) difference between agro-ecologies. There was no significant ($p>0.5$) difference between agro-ecologies but egg weight obtained from highland (47.13±3.5) was heavier than that of midland (45.43±3.9) and low land (44.68±3.0). Shell weight 3.7±0.2, 5.5±0.6 and 5.7±0.6 g for local, cross and exotic breed, respectively. There was significant ($p<0.5$) difference between breeds for average egg weight, albumen height and weight, yolk weight, height and diameter and shell weight. There was no statistically significant difference ($p>0.05$) among indigenous, cross and exotic breeds for yolk color, yolk index, shell thickness and Haugh unit. In all the parameters, exotic breeds had higher mean values than that of the cross and indigenous breed's eggs collected except yolk color and yolk index.

Key words: Egg quality, fertility, hatchability, rural chicken

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Corresponding Author: Ahmedin Abdurehman, Department of Animal and Range Sciences, Bule Hora University, P.O. Box 144, Bule Hora, Ethiopia
Tel: 00251910100133/00251972742672

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Livestock production covers 40% of agricultural output in Ethiopia, playing an important role in the national economy as it contributes 18% of the total GDP (Sorensen, 2010). A Central Statistics Agency (CSA., 2005) report revealed that 97.8% of the total poultry population comprises indigenous birds, while 2.2% are exotic breeds. The poultry sector in Ethiopia can be characterized into three major production systems based on some selected parameters such as breed, flock size, housing, feed, health, technology and bio-security. These are large commercial, small scale commercial and village or backyard poultry production system. These production systems have their own specific chicken breeds, inputs and production properties. Each can sustainably coexist and contribute to solve the socio-economic problems of different target societies (Tadelle *et al*., 2003b).

In most part of Ethiopia, village chicken represents a significant component of the rural household livelihood as a source of cash income for immediate household expenses and nutrition. Production of both egg and chicken meat has certainly assisted in reducing the gap in the supplies of animal protein for human consumption (Leta and Bekana, 2010).

Fertility and hatchability are major parameters of reproductive performance which are most sensitive to environmental and genetic influences (Stromberg, 1975). 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).

The overall quality of an egg can be discussed under two broad categories namely, external and internal quality (Monira *et al*., 2003). The external quality of the egg is determined by features such as the size and shape of the egg as well as the structure, thickness and strength of the shell (Bain, 2005). The internal quality is measured on the basis of the quality of the albumen as indicated by the Haugh Units (HU), the relative size of the various internal components and the integrity of the shell membrane. Several studies have looked at these egg quality assessment in chickens (Tona *et al*., 2002; De Ketelaere *et al*., 2004; Bain, 2005) as well as changes in the micro environment provided by the egg during storage and early incubation and how these affect hatchability (Narushin and Romanov, 2002; Tona *et al*., 2002; Reijrink *et al*., 2008).

The backyard (traditional) poultry production system is characterized by low input, low output and periodic destruction of large proportion of the flock due to disease outbreaks (Tadelle *et al*., 2003a). With the aim of improving poultry productivity, different breeds of exotic chickens (Rhode Island Red, Australorp, New Hampshire and White Leghorns) were imported to Ethiopia since the 1950's. Since then higher learning institutions, research organizations, the Ministry of Agriculture and Non-Governmental Organizations (NGO's) have disseminated many exotic breeds of chicken to rural farmers and urban-based small-scale poultry producers (Demeke, 2008).

The quality of egg laid could be one indication of productivity and the overall care given for improved chicken at village level. As a result, systematic study is required to assess fertility, hatchability and evaluate egg quality traits of improved, cross and indigenous chicken under village production system. Thus, the present study was conducted with the following objectives:

- To assess some quality parameters of eggs produced under scavenging production system
- To asses fertility and hatchability of eggs produced under scavenging production system in the district

MATERIALS AND METHODS

Description of the study area: The study was conducted at Gorogutu district from November, 2013 to May, 2014. The district is found in East Hararghea administrative zone of Oromia National Regional State (ONRS). The study district shared boarders with Meta wereda in East, Deder wereda in South, Somali National Regional state in k8 north and west and west Hararghe in the west. Karamile, the administrative and commercial centre of the district, is located 408 km East of Addis Ababa and 117 km West from Harar. The study wereda has a total land area of 536.88 km^2. The altitude of the study district ranges 1250-2575 m a.s.l. The average annual rain fall is estimated to be 850 mm (ranges 700-1000 mm) and the average temperature is 29°C (ranges 26-32°C). The study district lies between 9°20 N 41°10 E latitude and 9.333°N 41.167°E longitude. Agro-ecologically, Gorogutu district was classified as 23% Dega (highland), 28% Weina Dega (midland) and 49% Kola (lowland) (GDAO., 2012).

Site selection: Gorogutu district consists of 28 Rural Kebeles (RKs) which are situated in three agro-ecologies, namely, highland (8 kebeles), Midland (9 kebeles) and lowland (11 kebeles). Two rural kebeles from each agro-ecology were purposively selected based on poultry population, accessibility of the kebele's, area coverage and representativeness for the study areas. Accordingly, Warji jalala and biftu diramu, Chafe Anani and Madhisa Waltaha and Ere Mada hin Chine and Saphalo were selected to represent the highland, midland and lowland agro-ecologies.

Data collection

For hatchability and fertility: Eggs laid during one week were collected from up to 10 households from each rural kebeles and transported to Haramaya University for fertility, hatchability and egg quality analysis. The eggs were labeled with the code given to the rural kebele at the time of collection from the respective households. Eggs from indigenous, pure (exotic) and cross bred birds were identified at collection. A total of 270 eggs (45 eggs from each rural kebeles and 15 eggs for each breed) were incubated using incubator at Haramaya University hatchery. The incubation temperature, humidity and turning device were adjusted according to the recommendations of the manufacturer. Candling was done on the 7th, 14th and 18th day of incubation.

Finally, fertility was calculated for the15 eggs collected from each breed and each rural kebele's as:

$$\text{Fertility (\%)} = \frac{\text{Total fertile eggs}}{\text{Total eggs set}} \times 100$$

Hatchability results were calculated for 15 eggs collected from each breed and each rural kebele's as:

$$\text{Hatchability on fertile egg basis (\%)} = \frac{\text{No. of chicks hatched}}{\text{Total fertile eggs}} \times 100$$

$$\text{Hatchability on total egg basis (\%)} = \frac{\text{No. of chicks hatched}}{\text{Total eggs set}} \times 100$$

For eggs quality parameters: Egg quality was assessed in terms of egg weight, albumen weight, yolk weight, shell thickness, shell weight, yolk color, albumen height, yolk height, yolk diameter, yolk index and Haugh Unit Score (HUS). All weight data was taken by sensitive balance. The shell thickness was the average of the thicknesses of blunt, middle and sharp points of the egg and was measured using a micrometer gauge. Roche color fan consisting of a series of fifteen colored plastic strips was used as a reference to determine yolk colour, with 1 rated as very pale yellow and 15 as deep intense reddish orange. Yolk height and albumen height were measured by tripod micrometer. The albumen of the broken eggs was carefully separated from the yolk. Albumen and yolk weights were measured by using sensitive balance. Yolk diameter was measured by ruler after breaking the egg on flat tray and separated from albumen. The average Haugh unit value for each rural kebeles was calculated by using the formula given by Stadelman and Cotterill (1986).

$$\text{Haugh Unit (HU)} = 100 \text{ Log}\left[\text{H}-\sqrt{\text{G}}\,\frac{(30\text{W}^{0.37}-100)}{100}+1.9\right]$$

where, HU = Haugh unit, G = Gravitational constant, 32.2, H = Albumin height (mm) and W = Weight of egg.

Yolk index was also computed using the following formula:

$$\text{Yolk index} = \frac{\text{Yolk height}}{\text{Yolk diameter}} \times 100$$

Statistical analysis: Data from both internal and external egg quality parameters, fertility and hatchability were analyzed by SAS and logistic regression depending on the nature of the data and by using the General Linear Model Procedure and Mean difference was assessed by LSD.

RESULTS AND DISCUSSION

Fertility and hatchability: Mean values for fertility and hatchability are presented in Table 1. The logistic regression results of fertility for all eggs of breeds of chicken collected from the three agro-ecologies of the study area showed no significant difference ($pr>\chi^2 = 0.8523$ and 0.4965 at $\alpha = 0.05$) with Wald chiSq value of 0.3197 and 1.4002 between agro ecologies as well as between breeds, respectively.

According to the results obtained, the current study showed significant difference ($pr>\chi<0.0363$ and ($pr>\chi<0.0484$) between breeds with respect to hatchability on fertile egg and hatchability on total egg set, respectively. Indigenous breed had significantly higher percentage of hatchability on fertile eggs (91.46%) and hatchability on total egg set (67.78%) than cross (89.41 and 64.45%) and exotic breeds (76.98 and 51.11%), respectively (Table 1). This might be due to egg weight and shell thickness. This finding was in line with the report of Kingori (2011) who reported that the most influential egg parameters that influence hatchability are: weight, shell thickness and porosity and the consistency of the contents. There was no statistically significant difference

Table 1: Fertility and hatchability of indigenous, cross and exotic breed's egg in the three agro-ecologies of Gorogutu district

	Agro-ecology				Breed					
Parameters	Highland	Midland	Lowland	p-value	Exotic	Cross	Indigenous	p-value	Agro-ecology Breed	CV
Fertility (%)	71.11	71.11	71.12	1.00	66.67	72.22	74.45	0.445	0.461	14.65
Hatchability on fertile eggs basis (%)	81.91	81.99	93.93	0.091	76.98^{b}	89.41^{ab}	91.45^{a}	0.0560	0.111	11.107
Hatchability on total egg basis (%)	57.78	58.88	66.68	0.297	51.11^{b}	64.45^{a}	67.78^{a}	0.0418	0.312	16.46

^{a,b}Means within a row under the same heading with different superscript differ significantly ($p<0.05$), CV: Coefficient of variation

Table 2: Overall means of external and internal egg quality parameters in Gorogutu district

Parameters	Mean±SE
Egg weight (g)	45.75±1.98
Albumin height (mm)	5.15±0.304
Albumin weight (g)	25.05±1.54
Yolk height (mm)	14.11±0.18
Yolk weight (g)	15.05±0.38
Yolk diameter (mm)	3.98±0.05
Yolk color (1-15)	11.48±0.14
Yolk index	356.64±3.86
Shell weight (g)	4.95±0.30
Shell thickness (mm)	0.29±0.006
Haugh unit	75.69±1.57

SE: Standard error of mean

between agro-ecologies in terms of hatchability on fertile as well as total egg set bases. This study was in line with the report of Peters *et al*. (2004) who noted that strain and breed difference affects fertility of eggs in their study, they showed that smooth/normal feathered local chicken laid more fertile eggs and higher hatchability than the exotic strain in Nigeria. Islam and Nishibori (2009) also found that scavenging indigenous chickens had better fertility and hatchability than exotic chickens in hot humid.

Internal and external egg quality: As shown in Table 3, there is no significant difference for mean egg weight among agro-ecologies but egg weight obtained from highland (47.13±3.5 g) was heavier than that of midland (45.43±3.9 g) and lowland (44.68±3.0 g). Kul and Seker (2004) suggested that HU and egg weight are the parameter greatly influenced by egg storage period and temperature. Since lowland and midland temperature is higher than highland, egg weight to in the farmer two agro-ecologies might be higher leading to reduced egg weight. The result was similar with that reported by Halima (2007), for eggs collected from seven chicken ecotypes of North-West Amhara. The average egg weight obtained from this study in the district was 45.75±1.98 g this result agree with that of Teketel (1986) who reported an average egg weight of 46 g for Ethiopian local breed chicken but lower than that reported by Halima (2007) for RIR chicken breed eggs (53.4 g) and higher than the value of 35-39 g reported by Ahmed (1994) for Bangladesh indigenous scavenging chicken eggs.

There was no statistically significant ($p>0.05$) difference between eggs collected from different agro ecologies with respect to average albumin height, albumin weight, yolk weight, yolk diameter, Haugh unit, shell weight and eggshell thickness. The average shell weight, shell thickness and Haugh unit obtained in the study area was 4.95±0.3 g, 0.29±0.006 mm and 75.69±1.57, respectively (Table 2).

There is significant difference among the breeds with respect to egg weight (Table 3). The data showed that egg weight recorded for exotic breed was significantly different from that of cross and indigenous. The average egg weight recorded for exotic (56.5±1.5 g) is significantly higher ($p<0.001$) than that of cross (42.3±1.1 g) and indigenous (37.7±0.7 g). The exotic breed egg weight is higher than the report of Halima (2007) for RIR chicken breed eggs (53.4 g). The exotic breeds in the study district are white leghorn and issabrown. However, there was no statistically significant difference ($p>0.05$) among indigenous, cross and exotic breeds for yolk colour, yolk index, shell weight and Haugh unit.

Based on the values recorded, exotic had the highest ($p<0.05$) average albumin height (6.4±0.6 mm) followed by cross (4.6±0.2 mm) and indigenous (4.5±0.2 mm). The average albumin weights for indigenous was not statistically different from cross breed, while exotic was statistically higher ($p<0.05$) than indigenous and cross breed on average albumin weight. The eggshell weight of indigenous was significantly lower than cross and exotic breed ($p<0.05$). The mean Haugh units were 80.2±3.8, 72.9±1.1 and 74.0±1.8 for exotic, cross and indigenous, respectively and are not significantly different. The average eggshell thickness measured for indigenous, cross and exotic breeds were 0.29±0.1, 0.27±0.01 and 0.29±0.01 mm, respectively. Egg shell thickness was lower than the value of 0.71 and 0.69 mm reported by Halima (2007) for eggs collected from intensively managed local chicken ecotypes of North-West Amhara and RIR chicken breeds, respectively. Similarly, Teketel (1986) reported an average egg shell thickness of 0.35 mm for

Table 3: Effect of agro-ecology and breed on internal and external egg quality (Mean±SE)

	Agro-ecology				Breed					
Parameters	Highland	Midland	Lowland	p-value	Indigenous	Cross	Exotic	p-value	Agro-ecology breed	CV
EW (g)	47.13±3.5	45.43±3.9	44.68±3.0	0.287	37.70±0.7[c]	43.13±1.1[b]	56.50±1.5[a]	0.0001	0.894	5.61
AH (mm)	5.40±0.6	5.00±0.2	4.90±0.6	0.673	4.50±0.2[b]	4.60±0.2[b]	6.40±0.6[a]	0.0142	0.4142	19.38
AW (g)	26.00±3.1	24.90±3.0	24.20±2.1	0.524	19.40±0.5[b]	22.80±0.7[b]	32.90±1.9[a]	0.0001	0.20	10.91
YH (mm)	13.70±0.3[b]	14.20±0.3[a]	14.40±0.2[a]	0.010	13.40±0.3[b]	14.40±0.2[a]	14.50±0.3[a]	0.0004		2.43
YW (g)	15.30±0.3	14.60±0.5	15.20±1.04	0.50	13.50±0.5[b]	15.70±0.6[a]	15.90±0.3[a]	0.0038	0.6751	6.6
YD (mm)	4.04±0.1	3.90±0.1	3.90±0.1	0.293	3.70±0.04[b]	4.04±0.1[a]	4.20±0.1[a]	0.007	0.1461	3.12
YC (1-15)	11.20±0.3	11.40±0.2	11.90±0.1	0.136	11.80±0.2	11.40±0.3	11.20±0.2	0.1682	0.7299	4.86
YI	341.30±4.6	364.30±5.6	364.20±5.4	0.130	361.50±9.1	357.90±3.8	350.50±6.5	0.3104	0.308	3.35
SHW (g)	4.70±0.3	4.80±0.4	5.30±0.7	0.575	3.70±0.2[b]	5.50±0.6[a]	5.70±0.2[a]	0.0132	0.675	20.7
SHT (mm)	0.28±0.01	0.30±0.01	0.29±0.01	0.540	0.29±0.01	0.27±0.01	0.29±0.01	0.413	0.99	10.55
HU	76.90±3.3	74.40±3.4	75.70±1.3	0.800	74.00±1.8	72.90±1.1	80.20±3.8	0.1598	0.421	8.48

[a-c]Means within a row under the same heading with different superscript differ significantly between the two agro ecologies and breeds ($p<0.05$), EW: Egg weight, SHT: Shell thickness, SHW: Shell weight, YC: Yolk color, YD: Yolk diameter, YW: Yolk weight, YH: Yolk height, AH: Albumen height, AW: Albumin weight, YI: Yolk index, HU: Hough unit and SE: Standard error

Ethiopian local breed chicken eggs. Asuquo *et al.* (1992) also reported an average egg shell thickness of 0.30 and 0.35 mm for Nigerian local breeds and Isa-Brown breed chicken eggs, respectively.

The logistic regression results for yolk color showed no significant difference ($pr>\chi^2>0.4375$ and $pr>\chi^2>0.3873$ at $\alpha = 0.05$) between agro ecology and breeds, respectively with Wald chiSq value of 1.6532 among agro ecology and 1.8972 among the breeds. The yolk color means from SAS output are presented in Table 3.

Exotic breed eggs collected from midland (15.15 mm) and cross breed eggs collected from lowland (15.04) had significantly ($p<0.05$) higher yolk height than all the other eggs collected from all the three breeds in all agro ecologies of the study area, while local breed eggs collected from highland had significantly lower yolk height than all eggs of indigenous, cross and exotic breeds of midland and lowland.

In general there was no significant difference between highland, midland and lowland eggs collected from the farmers in all egg quality parameters except yolk height, but there was significant difference between breeds in egg weight, albumin height, albumin weight, Yolk height, yolk weight, yolk diameter and shell weight. In all the parameters, exotic breeds had higher mean values than that of the cross and indigenous breed’s eggs collected except yolk color, yolk index and shell thickness.

CONCLUSION

There was no significant difference between agro-ecologies as well as between breeds, respectively on fertility of the eggs collected from the study district. But, there was significant difference between breeds with respect to hatchability on fertile egg and hatchability on total egg set. There was no statistically significant difference between agro-ecologies in terms of hatchability on fertile as well as total egg set.

In general there was no significant difference between eggs collected from highland, midland and lowland in all egg quality parameters except yolk height, but there was significant difference between breeds in egg weight, albumin height, albumin weight, Yolk height, yolk weight, yolk diameter and shell weight. In all the parameters, exotic breeds had higher mean values than that of the cross and indigenous breed’s eggs collected.

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