ORIGINAL ARTICLE

On-farm performance evaluation of tropically adapted chicken strains under semi-scavenging production system in western Amhara region, Ethiopia

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ABSTRACT

The study aimed to evaluate the growth and egg production performance of three tropically adapted chicken strains in three districts of the Amhara region. Kuroiler, Sasso, and Sasso-R were among the tested strains under on-farm conditions for 45 weeks. The study used a factorial design with 216 households, 72 from the midland (Achefer) and 144 from the highlands (Babija and Fagita-Lekoma). The effects of strain, location, and strain*location interaction were considered to evaluate the dependent variables. Both male and female chickens' body weight and daily weight gain, as well as egg production, egg weight, and body weight at first egg-lay, are affected by the strain*location interaction. At week 16, male and female Sasso chickens in Achefer had the highest body weight, but Kuroiler had a comparable higher body weight to Sasso at week 20. In the highlands, Sasso was as efficient as contemporary strains but found more efficient in the midland. Kuroiler at Achefer had better daily gain than the other strain*location interactions. Sasso (111.9 ± 3.9) and Kuroiler (112.2 ± 3.5) in Achefer, and Kuroiler (115.2 ± 4.7) in Banija, produced higher eggs up to 45 weeks. All strains in all locations reached the age at first egg-laying between week 25.33 to 26.75. Kuroiler and Sasso, on the other hand, had a higher body weight at the time of their first egg-laying in Achefer. Kurolier had significantly higher survivability (between 71.8 and 76.3%) than the other strains in all locations (up to 44 weeks). Kuroiler in the highlands, and Sasso and Sasso-R in the midlands, produced 187, 180, and 150% more eggs than the local chickens, respectively. Kuroiler and Sasso, thus, recommended to be produced in the study areas and similar environments. Further studies into the different traits of these strains, and their crosses with local chickens, should be conducted under various management systems.

Keywords: Dual purpose chicken, Location, Strain, Strain by location interaction

INTRODUCTION

To improve the productivity of the poultry sector in Ethiopia, various organizations have imported and disseminated many exotic chicken breeds to rural farmers and urban-based poultry producers (FAO, 2008). This attempt, however, has failed (Wondmeneh, 2016), because commercial chicken breeds were developed for intensive management systems and are often unsuited to local conditions, requiring a high level of investment in feed, veterinary support, and management. On the other hand, the low productivity of village production systems with indigenous chicken (as evidenced by high mortality, low egg numbers, late sexual maturity, and poor live performance) has resulted in high demand for fast-growing and prolific breeds for meat and egg production among chicken producers (ACGG Ethiopia baseline data, 2016). Such fast-growing and prolific breeds are best provided not only by commercial chicken germplasms but also by smallholder poultry-specific hybrid germplasms, which are improved dual-purpose chickens that incorporate genes for higher productivity and performance into the hardiness of locally adapted chicken. In Uganda, Kuroiler, an improved dual-purpose chicken breed, has been evaluated under on-farm conditions and found to be suitable for scavenging management systems (Galukande *et al*., 2016). Starting from 2007, on-farm testing of tropically adapted chicken strains (Kuroiler, Sasso, and Sasso-R) was carried out in four regions of Ethiopia as part of the African Chicken Genetic Gains (ACGG) project (www.africacgg.net), using a farmer-led research approach. The objective of this study, therefore, was to evaluate the growth and egg production performance of these three chicken strains under on-farm conditions in the western Amhara region of Ethiopia.

MATERIALS AND METHODS

Area Description

The study was conducted under on-farm conditions, as farmer-led research in the three districts (South Achefer, Banija, and Fagita Lekoma) of the Amhara region through the African Chicken Genetic Gains (ACGG) project. According to FAO (2006), an altitude that ranges between 1500-2300 m.a.s.l is classified as midlands and above this altitude level (> 2300 m.a.s.l) as highlands. Based on this agro-ecological classification, the study districts can be classified into midland (South Achefer) and highland (Banija and Fagita Lekoma) areas (Table 1).

Evaluated Strains

Three chicken strains were used for the on-farm testing. Kuroiler, a commercial dual-purpose hybrid chicken from India that derived through a crossing of White Leghorn roosters with Rhode Island Red hens by Kegg Farms Private Ltd. in the early 1990s (Ahuja *et al*., 2008), Sasso, a commercial breed originated from France, and Sasso-R is a cross of Sasso hens with Rhode Island Red male lines being distributed to different regions of Ethiopia by Ethio-Chicken (report of Ethio-Chicken poultry farm, 2016).

Experimental Arrangement

The study relied on the on-farm data collected between 2017 and 2018. A factorial design was used for the study, which included 216 households, 72 from mid-altitude (one district) and 144 from high-altitude (two districts). The strains were randomly assigned to the households, and each household received 25 chicks of the same strain at 6 weeks of age. Wing tags were used to identify all of the chickens in the study. All the households were visited every 2 - 4 weeks for 45 weeks to collect the required data on the chicken management and performance.

Management of Chicken

The chickens were brooded for six weeks at Debre Zeit Agricultural Research Center, Ethiopia. During this time, the chicks received the following vaccinations: Marks vaccine on day one, Newcastle vaccine (HB1 vaccine on day three and Lasota Vaccines on day twenty-six), and Gomboro vaccine on day fourteen and twenty-one. Prophylaxis and anti-coccidian drugs were also given on days 42 and 48, respectively. During brooding, the chickens are given a starter feed for 21 days, a rearing feed for 23 days (from day 22 to 45), and anti-stress vitamins.

After being distributed for on-farm testing, the chickens were managed in a semi-scavenging production system. The chickens fed a supplementary commercial feed that composed 60% energy sources (a mixture of maize and wheat bran) and 40% protein sources (noug-seed cake). They also fed locally available feeds such as agricultural by-products and kitchen wastes, and freshwater provided *ad-libitum*. Chickens also vaccinated the Newcastle disease vaccine every three months after being distributed.

Table 1. General information of the study districts

Features	South Achefer	Banija	Fagita Lekoma
Latitude	11.36° to12°09′N	10°52′to 11°03′N	11°04′- 11°05′ N
Longitude	36°95′-38°95′E	36°38′to 37°8′E	36°52′-36°54′ E
Altitude (m)	1500-2400	2400 - 2953	2300-3200
temperature (°C)	11.8-28.4	9.5 -22.5	11-25

Source: Respective District Agricultural Offices (2016)

Traits Recorded

Bodyweight: Male and female group body weights were taken at 12, 16, and 20 weeks of age using a weighing balance. Growth performance was determined by using the following formula:

$$\textit{Weight gain} = \frac{\textbf{Difference weight in between in hatching and a fixed age}}{\textbf{Number of days upto fixed age}}$$

Egg production performance: Age at sexual maturity was measured by age at the first egg in days, and egg production by the number of eggs up to 45 weeks of age from the point of lay. Eggs laid within two weeks are collected, weighed, and recorded on each household farm every week starting from 5% production (28, 30, 32, 34, 36, 38, 40, 42, 44 weeks of age).

Mortality: Data on chicken mortality were recorded from 6 to 45 weeks of age at four week intervals.

$$\textit{Servivability} = \frac{\textit{Total number of chicken servive}}{\textit{Total number of chicken at the start of the experemnt}} X100$$

Statistical Analysis

The analysis model for performance data includes the environment effect to compare body weight, egg production, and egg weight variation among strains and between districts. Two-way interactions (strain * location) analysis was used to know the performance of various parameters for the on-farm test. Because some environmental factors from different districts needed to be treated into the data, districts were used as a block, and each household farm distributed within the districts was used as an experimental unit. The Generalized Linear Model procedure (Proc GLM) of SAS (SAS, 2008) was used for statistical analysis. The effect of strain, location, and strain by location interaction was included in the model. The model for the on-farm test was

$$Y_{ijk} = \mu + T_i + \beta_j + T\beta_{ij} + \varepsilon_{ijk}$$

Where; Y_{ijk} is the observation of k in strain i and district j, μ is the overall mean of a parameter (body weight, egg production, egg weight, age and body weight at first lay and survivability) measured of the i^{th} group of strains and j^{th} districts, T_i is the effect of strain (Kuroiler, Sasso and Sasso-R), β_j is the effect of a district (South Achefer (mid-altitude), Banija (high altitude) and Fagita Lekoma (high altitude)), $T\beta_{ij}$ is the interaction effect of strain and district and ε_{ijk} is the random error.

RESULTS AND DISCUSSION

Body Weight of Chicken

The growth performances of female and male chickens are shown in Table 2 and 3, respectively. The strain by location interaction was significant (P<0.01) for body weight and daily gain for both female and male chickens. Significant effects of strain by location interactions showed the presence of genotype by environment interactions between household farms in different locations. Both female and male Sasso chicken in South Achefer had the highest bodyweight (1069.3±75.9 at week 12 and 1552.1±81.2 at week 16 for female Sasso and 1181.3±82.3 at week 12 and 1984.0±87.9 at week 16 for male Sasso) than the other strain by location interaction. However, at week 20, both female and male Kuroiler had statically equaled with Sasso chicken and had higher body weight at mid-altitude than other strain by location interaction. This difference could be related to environmental differences, genetic/strain differences, and their interactions. The result indicates that Sasso is an early grower chicken at mid-altitude and equally efficient as contemporary strains at high altitude but more efficient at mid-altitude than the other contemporary strains.

The live weight of Kuroiler at week 20 at midland was lower than the study of Kugonza *et al*. (2013), which is 3.6 kg under restricted range conditions in Rwanda. Similarly, male Kuroiler chicken reaches at least 1kg of weight at three months of age (ACGG fact sheet, 2016). In the current study, Kuroiler reached 1.3 kg of weight at four months of age, indicating that this breed could reach market weight at three months of age in a semi-intensive production system.

The bodyweight of Kuroiler and Sasso at week 20 in this study was higher than the bodyweight of Rhode Island Red (1350±33.76 g) and Bovans White (1220±36.55 gm) at 22 weeks of age. Similarly, the bodyweight of all strains tested at 12 weeks of age was higher than that of Fassil *et al*. (2010), who indicated the bodyweight for Fayoumi cross necked neck and Rhode Island red cross local white with the value of 1110.7 ± 12.4gm and 1095.9 ± 22.7 gm, respectively, at 12 weeks of age in Hawassa area, Ethiopia. Both female and male Sasso and Kuroiler chicken in South Achefer had the highest daily body weight gain between week 12 and week 16 than the other strains by location interaction (Table 2 and 3). However, between week 16 and 20, male Kuroiler in South Achefer and female Sasso-R in South Achefer had the highest daily body weight gain than the other strains by location interaction. The average daily body weight gain of Sasso and Kuroiler in the semi-scavenging system in the current study was higher than RIR and Bovan white, which exhibited 8.5 ± 0.17 and 7.7 ± 0.23gm, respectively, in Mekelle, Ethiopia (Kumar *et al*., 2014).This study revealed that the newly introduced tropically adapted strains (Kuroiler and Sasso) have higher body weight and daily body weight gain than previously introduced exotic breeds in a semi-scavenging chicken production system. Since maybe these breeds are developed for scavenging-based production systems rather than previously introduced exotic chickens that created for an intensive production system, which needs a more intensive management system than newly introduced tropically adapted chicken strains.

Table 2. Least square means (Mean ± SE) of female body weight (grams) and daily gain (grams) at 12, 16, and 20 weeks

Location	Strain	Body weight (12 week)	Daily gain (12-16 week)	Body weight (16 week)	Daily gain (16-20 week)	Body weight (20 week)
South Achefer	Kuroiler	632.8^{cd} ± 46.9	17.9^{a} ± 1.7	1133.6^{b} ± 81.2	22.6^{a} ± 1.6	1766.3^{a} ± 87.7
	Sasso	1069.3^{a} ± 75.9	17.2^{a} ± 1.7	1552.1^{a} ± 81.2	7.0^{bc} ± 1.6	1748.3^{a} ± 87.7
	Sasso-R	493.8^{e} ± 45.8	15.9^{ab} ± 1.7	939.7^{bcd} ± 75.9	13.9^{b} ± 1.6	1330.3^{b} ± 96.0
Banija	Kuroiler	575.7^{d} ± 43.8	13.3^{ab} ± 1.7	947.6^{bc} ± 44.8	6.4^{bc} ± 1.6	1126.4^{bc} ± 44.8
	Sasso	655.2^{bcd} ± 8.0	4.9^{d} ± 1.7	794.7^{de} ± 46.7	9.2^{b} ± 1.6	1052.7^{c} ± 49.3
	Sasso-R	477.6^{e} ± 43.8	8.7^{cd} ± 1.7	722.1^{e} ± 50.6	11.5^{b} ± 1.6	1042.9^{c} ± 44.8
Fagita	Kuroiler	716.1^{bc} ± 75.9	6.2^{cd} ± 1.7	889.7^{bcde} ± 81.2	2.3^{c} ± 0.6	953.8^{cd} ± 107.4
Lekoma	Sasso	739.0^{b} ± 45.8	12.9^{bc} ± 1.7	1101.1^{b} ± 44.8	2.9^{c} ± 0.6	1184.3^{bc} ± 37.7
	Sasso-R	668.9^{bcd} ± 59.6	6.3^{cd} ± 1.7	846.2^{cde} ± 71.6	2.0^{c} ± 0.6	903.3^{d} ± 75.9
Coefficient of variation		27.01616	26.08696	24.56923	31.42844	21.60513
Source of variation						
Strain		***	***	***	***	***
Location		***	***	***	***	***
Strain *location		***	***	***	***	***

*a,b,c,d Means within a column and breed-location interaction with different superscript significantly different (P<0.05), ***P<0.00*

Table 2. Least square means (Mean±SE) of female body weight (grams) and daily gain (grams) at 12, 16, and 20 weeks

Location	Strain	Body weight (12 week)	Daily gain (12-16 week)	Body weight (16 week)	Daily gain (16-20 week)	Body weight (20 week)
South Achefer	Kuroiler	632.8^{cd} ± 46.9	17.9^{a} ± 1.7	1133.6^{b} ± 81.2	22.6^{a} ± 1.6	1766.3^{a} ± 87.7
	Sasso	1069.3^{a} ± 75.9	17.2^{a} ± 1.7	1552.1^{a} ± 81.2	7.0^{bc} ± 1.6	1748.3^{a} ± 87.7
	Sasso-R	493.8^{e} ± 45.8	15.9^{ab} ± 1.7	939.7^{bcd} ± 75.9	13.9^{b} ± 1.6	1330.3^{b} ± 96.0
Banija	Kuroiler	575.7^{d} ± 43.8	13.3^{ab} ± 1.7	947.6^{bc} ± 44.8	6.4^{bc} ± 1.6	1126.4^{bc} ± 44.8
	Sasso	655.2^{bcd} ± 8.0	4.9^{d} ± 1.7	794.7^{de} ± 46.7	9.2^{b} ± 1.6	1052.7^{c} ± 49.3
	Sasso-R	477.6^{e} ± 43.8	8.7^{cd} ± 1.7	722.1^{e} ± 50.6	11.5^{b} ± 1.6	1042.9^{c} ± 44.8
Fagita Lekoma	Kuroiler	716.1^{bc} ± 75.9	6.2^{cd} ± 1.7	889.7^{bcde} ± 81.2	2.3^{c} ± 0.6	953.8^{cd} ± 107.4
	Sasso	739.0^{b} ± 45.8	12.9^{bc} ± 1.7	1101.1^{b} ± 44.8	2.9^{c} ± 0.6	1184.3^{bc} ± 37.7
	Sasso-R	668.9^{bcd} ± 59.6	6.3^{cd} ± 1.7	846.2^{cde} ± 71.6	2.0^{c} ± 0.6	903.3^{d} ± 75.9
Coefficient of variation		27.01616	26.08696	24.56923	31.42844	21.60513
Source of variation						
Strain		***	***	***	***	***
Location		***	***	***	***	***
Strain *location		***	***	***	***	***

*a,b,c,d Means within a column and breed-location interaction with different superscript significantly different (P<0.05), ***P<0.00*

Table 3. Least square means (Mean ± SE) of male body weight (grams) and daily gain (grams) at 12, 16, and 20 weeks

Location	Strain	Body weight (12 week)	Daily gain (12-16 week)	Body weight (16 week)	Daily gain (16-20 week)	Body weight (20 week)
South Achefer	Kuroiler	714.6^{bc} ± 50.7	22.9^{b} ± 1.7	1355.6^{b} ± 82.3	15.3^{b} ± 1.5	1785.2^{a} ± 94.9
	Sasso	1181.3^{a} ± 82.3	28.7^{a} ± 1.7	1984.0^{a} ± 87.9	4.5^{d} ± 1.5	2111.0^{a} ± 94.9
	Sasso-R	506.3^{d} ± 49.6	19.5^{b} ± 1.7	1052.4^{cd} ± 82.3	20.4^{a} ± 1.5	1624.3^{b} ± 94.9
Banija	Kuroiler	660.5^{c} ± 47.5	13.5^{c} ± 1.7	1039.0^{cd} ± 47.5	6.5^{de} ± 1.5	1219.5^{c} ± 48.5
	Sasso	683.5^{bc} ± 50.8	4.2^{d} ± 1.7	800.4^{e} ± 49.6	3.2^{ef} ± 1.5	889.3^{d} ± 62.2
	Sasso-R	509.4^{d} ± 47.5	11.2^{cd} ± 1.7	823.4^{de} ± 52.0	11.4^{c} ± 1.5	1141.2^{c} ± 48.5
Fagita Lekoma	Kuroiler	738.8^{bc} ± 58.2	5.5^{d} ± 1.7	891.7^{de} ± 87.9	7.8^{d} ± 1.5	1109.4^{cd} ± 116.3
	Sasso	789.9^{b} ± 48.5	12.3^{c} ± 1.7	1133.7^{c} ± 47.5	2.7^{f} ± 1.5	1209.1^{c} ± 54.8
	Sasso-R	660.5^{c} ± 60.1	6.9^{d} ± 1.7	854.8^{de} ± 77.6	2.1^{f} ± 1.5	913.4^{d} ± 82.3
Coefficient of Variation		31.30627	21.66065	24.05181	24.37703	19.84386
Source of variation						
Location		***		***		***
Strain		***		***		***
Strain*location		***		***		***

^{a,b,c,d} *Means within a column and breed-location interaction with different superscript significantly different (P<0.05), ***P<0.001*

Age and Body Weight at First Laying

Age at first laying is an important reproductive trait from an evolutionary and economic point of view (Wright *et al*., 2011). Early age at sexual maturity may result in a large amount and mass of egg production. The current result indicates that the age at first laying was not significant between strains (Table 4). All strains in all locations reached the age at first egg-laying between weeks 25.33 and 26.75. This finding is similar to Alem's (2014) finding that exotic breeds (RIR) reached sexual maturity at 25.2 weeks in central Tigray, but it is higher than Halima's (2007) finding that exotic pullets reached the age of first egg-laying between 20 to 24 weeks. The current study is also higher than the findings of Desalew *et al*. (2013), who found the mean age at the first-lay of Isa brown and Koekoek in east Shewa was 160.5±13.5 and 153.3±6 days, respectively. This indicates that Sasso, Kuroiler, and Sasso-R began laying later than Isa brown and Koekoek. The current finding's first laying age is lower than the local breed's first laying ages of 5.9 to 7.1 months (Fisseha *et al*., 2010), 7.01 months (Mekonnen, 2007), and 7.0 to 7.4 months (Alemayehu *et al*., 2015), which were reported in different parts of Ethiopia. This implies that the currently introduced and evaluated tropically adapted strains began laying earlier than the local breeds. The difference in age at first egg-laying could be genotypic and environmental differences.

However, there were highly significant (P<0.01) effects of strains, locations, and strain by location interaction on body weight at the first laying of chickens. Bodyweight at the first laying of Kuroiler and Sasso in the South Achefer district was higher than other strain by location interactions. The body weight at the first lay of Sasso and Kuroiler in all districts is higher than the report of Desalew *et al*. (2013), where the body weight at the first lay of Isa Brown, Brown, and Koekoek were 1.54, 1.55, and 1.64 kg, respectively in East Shewa. The difference in body weight at first lay could be due to a genetic difference, an environmental difference (altitude difference, temperature), or their interaction. Similarly, management, availability of scavenging areas, and supplementation rate could all be potential environmental factors influencing body weight in the first lay. Bodyweight at the start of egg-laying affects some egg parameters. Egg weight was found to be lower in the low body weight group than in medium and heavy hen groups.

Egg Production

The laying performance of tested chicken strains is presented in Table 5 and 6. The strain by location interaction was significant (P < 0.001) for egg production and egg weight but not age at first laying. Genetic and non-genetic factors affect the productivity of laying birds. Egg production is a dependent variable and is influenced by the breed of chicken, age at point-of-lay, and the environment. Different studies (Yakubu *et al*., 2007) reported that there were significant effects of breeds on egg production in different parts of tropical countries. Sasso (111.9±3.9 eggs) and Kuroiler (112.2±3.5) in South Achefer (midland) and Kuroiler (115.2±4.7) in Banija (highlands) produced significantly higher egg production up to 45 weeks than other strain by location interactions. Singh *et al*. (2009) reported that the interaction between breed and location was significant for egg production and hen-day egg production. The result indicates that phenotypic expression of a particular trait is affected by strain by environment interaction.

Table 4. Least square means (Mean ± SE) of age (weeks) and body weight (gram) at first laying

District	Strain	Age at first laying	Body weight at first laying
South Achefer	Kuroiler	25.71 ± 0.50	1993.70[a] ± 80.35
	Sasso	25.33 ± 0.54	1981.94[a] ± 80.35
	Sass-R	26.66 ± 0.54	1776.57[bc] ± 52.69
Banija	Kuroiler	26.34 ± 0.27	1746.36[bc] ± 46.01
	Sasso	25.68 ± 0.30	1822.85[ab] ± 56.97
	Sass-R	26 ± 0.27	1662.9[c] ± 246.01
Fagita Lekoma	Kuroiler	25.5 ± 0.65	1573.82[cd] ± 72.34
	Sasso	26.4 ± 0.29	1804.33[b] ± 49.34
	Sass-R	26.75 ± 0.46	1423.33[d] ± 78.02
Coefficient of Variation		5.087645	11.26062
Source of variation			
Strain		NS	**
Location		NS	**
Breed*Location		NS	**

[a,b,c,d] *Means within a column and breed with different superscript different significantly (P<0.05)*

The current study's findings were higher than that of Samson *et al*. (2013), who found that the average egg production of Fayoumi chickens managed under backyard management conditions was 150.47±3.15 eggs/hen/year, with hen-day egg production of 41.23±15.97% in Adama, Adami Tullu, Lumie, and Arsi-Negele of Ethiopia's mid-rift valley, and 144±6.97 eggs/hen/year in northern Ethiopia (Abraham and Yayneshet, 2010). Furthermore, Alem (2014) found that in the lowland and highland agro-ecological zones of central Tigray, the average egg production per year per hen of exotic chicken (RIR) was 118.6 and 148.2, respectively. This shows that the tropically adapted dual-purpose breeds of the current study were found better than the previously imported breeds in egg production under the same production system. The current findings imply that the White Leghorn and Red Island Red chickens were genetically prolific breeds, but their egg performance under the village production system was not comparable to tropically adapted strains, which were tested in the current study. The reason may be the adaptable character of Kuroiler and Sasso breeds to the environment, scavenging with supplementation and disease resistance in the current study found to be better than the previously imported breeds from temperate regions.

Egg Weight

The egg weight of Sasso in the Fagita Lekoma district was 60.2±1.4 at week 44, which was higher than the other strain by location interactions (Table 6). The egg weight of all strains in Fagita Lekoma and Banija were significantly higher than in South Achefer. The maximum egg weight of Sasso 60.2±1.4 was a higher egg weight than Rhode Island Red 52.5 grams (Abraham and Yayneshet, 2010).

Table 5. Least square means (Mean ± SE) of strains egg production up to 45 weeks

Location	Strain	Egg production
South	Kuroier	111.9[a] ± 3.9
Achefer	Sasso	112.2[a] ± 3.5
	Sasso-R	100.0[bc] ± 3.9
Banija	Kuroier	115.2[a] ± 4.7
	Sasso	98.6[bc] ± 3.9
	Sasso-R	86.9[cd] ± 3.9
Fagita	Kuroier	98.6[bc] ± 3.9
Lekoma	Sasso	106.9[ab] ± 3.5
	Sasso-R	96.9[bc] ± 3.6
CV		16.45622
Source of variation		
Strain		**
Location		***
Breed*location		**

[a,b,c,d] *Means within a column and breed-location interaction with different superscript significantly different (P<+0.05), ***P<0.001*

Survivability of Chickens

Figure 1 shows the survivability of chickens up to 44 weeks. The survivability of Kurolier in all locations up to 44 weeks was between 71.8 and 76.3%, which is lower than the study of Fassil *et al*. (2009), who found higher survivability in Fayoumi (86%), but higher than the survivability of RIR (71%) at on-farm environmental conditions of southern Ethiopia. The lower survivability of the current result could be related to the season in which the 45-week chicks were distributed to the farmers. The chicks were distributed during the cold season, which let the chickens be less adaptive to the environment and resulted in higher mortality at the start of the on-farm study. As a result, there was higher survivability of chickens in midland areas than in highland areas.

Table 6. Least square means (Mean ± SE) of strains egg weight (gm) at 28, 32, 36, 40 and 44 weeks during the laying period

		Egg weight (gm)				
District	Strain	Week 28	Week 32	Week 36	Week 40	Week 44
Achefer	Kuroiler	43.9^{c} ± 1.4	47.2^{de} ± 1.9	42.0^{c} ± 1.8	44.3^{d} ± 1.6	44.6^{d} ± 1.6
	Sasso	42.5^{c} ± 1.9	43.7^{e} ± 2.0	44.6^{c} ± 1.4	43.7^{d} ± 1.2	43.5^{d} ± 1.6
	Sasso-R	44.9^{c} ± 1.5	44.2^{e} ± 1.6	40.6^{c} ± 1.9	40.8^{d} ± 4.5	43.4^{d} ± 1.4
Banija	Kuroiler	55.8^{b} ± 1.6	49.9^{cd} ± 1.3	51.4^{b} ± 1.2	53.9^{b} ± 1.0	57.3^{ab} ± 1.4
	Sasso	53.0^{b} ± 1.3	NA	52.6^{ab} ± 1.3	53.4^{b} ± 1.0	57.0^{ab} ± 1.2
	Sasso-R	46.7^{c} ± 1.9	47.4^{de} ± 1.3	49.1^{b} ± 1.2	51.2^{bc} ± 0.9	55.7^{bc} ± 1.2
Fagita Lekoma	Kuroiler	59.6^{a} ± 2.5	60.7^{a} ± 1.9	56.4^{a} ± 1.6	50.0^{c} ± 1.5	55.7^{bc} ± 1.2
	Sasso	55.2^{b} ± 1.4	56.2^{ab} ± 1.6	55.7^{a} ± 1.1	58.9^{a} ± 1.0	60.4^{a} ± 1.4
	Sasso-R	58.0^{a} ± 1.9	52.3^{bc} ± 1.3	51.0^{b} ± 1.2	51.1^{b} ± 1.1	53.2^{c} ± 1.6
Coefficient of variation		11.13779	11.34251	10.33798	8.646479	9.673025
Source of variation						
Strain		**	**	**	**	**
Location		**	**	**	**	**
Week		**	**	**	**	**
Strain *location		**	**	**	**	**
Strain *location*week		**	**	**	**	**

a,b,c,d Means within a column and breed with different superscript different significantly (P<0.05)

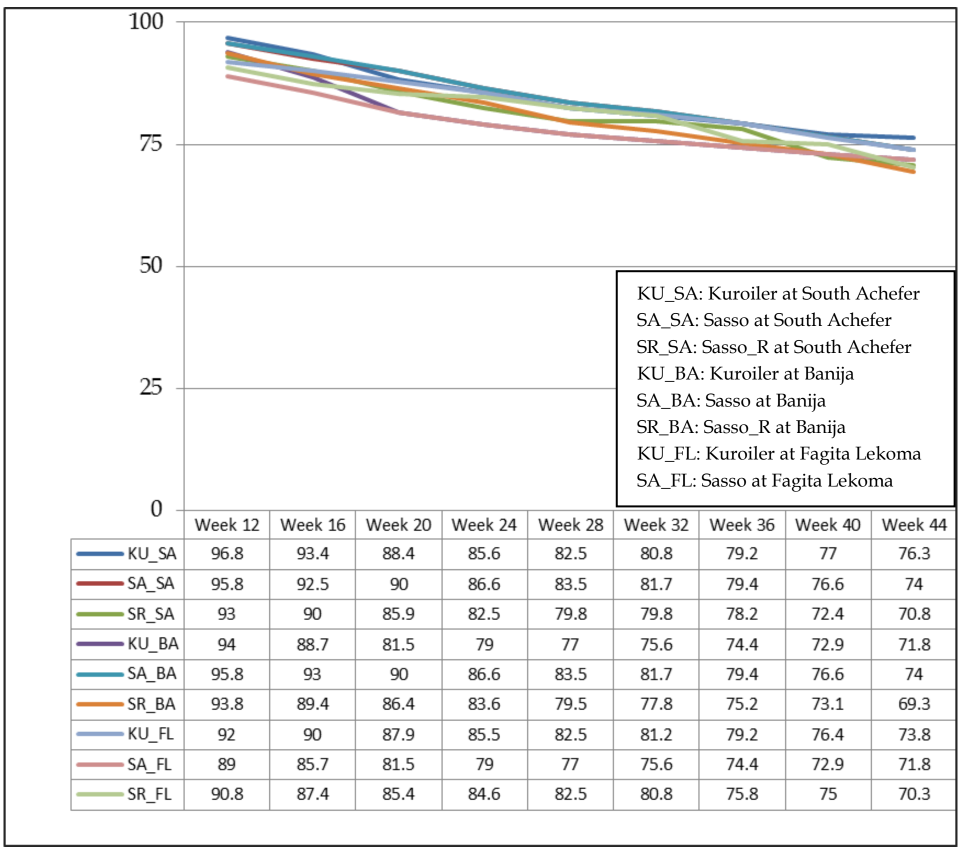

Figure 1. Survivability of the tested strains in different locations across weeks

CONCLUSION

According to this finding, Kuroiler and Sasso were the early mature strains in the midlands, while Kuroiler performed well in the highlands. Sasso and Kuroiler in South Achefer, as well as Kuroiler in Banija, produced the highest eggs. Kuroiler produced 187% more eggs than local chickens in the highlands, while Sasso and Sasso-R produced 180 and 150% more eggs in the midlands, respectively. In general, Kuroiler and Sasso performed better in all of the testing sites in terms of growth and egg production, which, in turn, would increase the income of chicken producers. As a result, Kuroiler and Sasso are recommended to be produced in the testing areas and similar environments. Further testing of these strains' different traits, and their crosses with local chickens under various management systems, should be conducted.

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