EVALUATING THE GROWTH PERFORMANCE OF LOCAL KEI CHICKENS AND THEIR F_1-CROSSES WITH RHODE ISLAND RED AND FAYOUMI BREEDS IN WATERSHED AREAS OF *GURAGHE* ADMINISTRATIVE ZONE, SOUTHERN ETHIOPIA

[EVALUACIÓN DE EL CRECIMIENTO DE POLLOS LOCALES KEI Y SUS CRUZAS F1 CON RAZAS RHODE ISLAND Y FAYOUMI EN LA CUENCA DE LA ZONA ADMINISTRATIVA DEL AREA *GURAGHE* EN EL SURESTE DE ETIOPÍA]

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SUMMARY

This study describes the on-farm performance of local Kei chicken and its F_1 crosses with Fayoumi and Rhode Island Red (RIR) breeds in *Beresa* watershed of *Guraghe* administrative zone, southern Ethiopia. The Kei paternal line was mated with maternal lines of Fayoumi and RIR chickens to produce F_1-crosses. Body weight developments and feed intake were determined on weekly basis. Then body weight gain and feed efficiency ratios (FER, weight gain: feed) were calculated. Hatchability was 59.0% and 73.7%, 54.7% for Kei, Fayoumi-crosses and RIR-crosses, respectively. In male chicks, the mean day-old weight ranged from 28.8 to 40.1 g and in female chicks from 26.2 to 35.8 g. The average body weight of matured male and female RIR-crosses was 1682 and 1227 g, respectively. The corresponding values for Fayoumi-crosses were 1310 and 1054 g and that of local Kei 1273 and 987 g. During the brooding period, the average daily feed intake was 25.9, 27.0 and 24.4 g for Kei, Fayoumi-crosses and RIR-crosses, respectively. The mean FER was 0.197, 0.213 and 0.243 g for Kei, Fayoumi-crosses and RIR-crosses, respectively. The average age at sexual maturity for Kei, Fayoumi-crosses and RIR-crosses was 183, 154 and 162 days, respectively. The results of the present study suggest that both F_1-crosses showed a significant improvement in body weight, weight gain and FER under farmers' management condition of the watershed areas suggesting the suitability of both genetic combinations with local Kei chickens for on-farm chicken productivity.

Key words: Farmers' management; Growth performance; F_1-crosses; Rhode Island Red chicken; Fayoumi chicken; Local Kei chicken

RESUMEN

En este estudio se describe el rendimiento en granja de los pollos locales Kei y sus cruzas F1 con las razas *Fayoumi* y Rhode Island Roja (RIR) en *Beresa* cuenca de la zona administrativa de *Guraghe* en el sureste de Etiopía. La línea paternal de Kei se cruzó con las líneas maternas de Fayoumi y RIR para producir cruzas F1. Se determinó el desarrollo de peso corporal y el consumo de alimento semanalmente. Después se calculó la ganancia de peso y la tasa de eficiencia de consumo (FER, ganancia de peso , alimento). El incubabilidad fue de 59.0% y 73.7% para las cruzas Kei, Fayoumi y 54.7% para las cruzas RIR respectivamente. En pollitos machos, la media de peso por edad tuvo un rango de 28.8 a 40.1 g y en pollitas de 26.2 a 35.8 g . El promedio de peso corporal de los machos maduros y hembras maduras de las cruzas RIR fue de 1628 y 1727 g respectivamente. Los valores correspondientes para cruzas Fayoumi fue de 1310 y 1054 respectivamente y para las locales Kei de 1273 y 987. Durante el periodo de consumo, el promedio de consumo voluntario diario fue de 25.9, 27.0 para las cruzas Fei y Fayoumi y de 24.4 para las cruzas RIR respectivamente. El promedio de edad a la madurez sexual para las cruzas Kei, Fayoumi y RIR fue de 183,154 y 162 días respectivamente. Los resultados del presente estudio sugieren que ambas cruzas F1 mostraron mejoramientos significativos en el peso corporal, ganancia de peso y FER, existe compatibilidad de ambas combinaciones genéticas con los pollos locales Kei sobre la productividad del pollo en granja bajo manejos en condiciones de granja de la áreas de cuencas.

Palabras clave: Manejo de granja; crecimiento, cruzas F1; pollitos Rhode Island rojo; pollo Fayoumi; pollo local Kei.

INTRODUCTION

In Ethiopia, there are about 49.3 million chickens in the country of which 96.6% are local chickens (CSA, 2011), indicating the significance of indigenous chicken ecotypes as principal potential farm animal genetic resources of the country. These chickens have been reported to adapt very well to the traditional small-scale production system of the rural community (Hassen et al. 2007; Moges et al. 2010; Melesse and Negesse, 2011). Comparatively little research and development work has been carried out on village chickens, despite the fact that they are more adapted to various production constraints and numerously available than commercial chickens.

Improving the poultry productivity would improve protein nutrition and could increase the income levels of the rural population. In addition, consumers prefer meat from indigenous chickens, because of its leanness. They also like the multi-colored plumage of these birds, particularly the Kei ecotype due to its reddish feather color. Evaluation of the egg production performance of crossbreeds between local and exotic birds was conducted by different research and development organizations. Most results showed that the overall performance of the crosses was better than either the native or the exotic parents under the existing management condition (Haile-Mariam, 1998; Melesse *et al.,* 2005). However, limited information is available on the comparative growth performance traits of local chickens such as Kei and their F_1 crosses with exotic chicken breeds under farmers' management conditions. Therefore, the study was designed to evaluate the genetic potential of local Kei chicken and their F_1 crosses with RIR and Fayoumi breeds under farmers' management condition of *Guraghe* watershed areas.

MATERIALS AND METHODS

Description of the study area

The present study was conducted in *Beresa* watershed areas of *Guraghe* administrative zone of the southern Regional State of Ethiopia. The watershed comprises two Peasant Associations (PAs), namely *Beresa* and *Dubo-Tuto* and covers an area of 1000 ha. The watershed areas are characterized as food insecure; highly degraded land and poor soil fertility. Agro-ecologically, the watershed is classified under the category of mid-altitude. The average annual rainfall is 1308 mm, while the mean annual temperature is 18.5 ^{o}C (BoARD, 2010).

On-station breeding plan

Acquisition of female and male parental lines.

The project started by purchasing 800 fertile eggs of RIR and Fayoumi breeds. The fertile eggs of RIR breed were obtained from Hawassa's Ministry of Agriculture Poultry Farm while that of Fayoumi from Debre Zeit Agricultural Research Centre (DZARC). At the similar time, 400 fertile eggs of local Kei chicken were purchased from farmers of the study area. Immediately after hatching, chicks were vaccinated against New Castle Disease, Infectious Bursal Disease (IBD) and Marek's disease. During the brooding and rearing periods, all birds were fed *ad libitum* with standard commercial starter and grower rations.

Mating plan to produce experimental birds.

Mating was started at 20 weeks of age using the two exotic breeds (RIR and Fayoumi) as the maternal-lines and local Kei as the paternal-line. Fifty cocks were randomly picked from the local Kei chicken population. The cocks were then divided randomly into two groups of which the first group of 25 cocks was crossed with 100 RIR pullets and the second group of 25 cocks with 100 Fayoumi pullets with the ratio of 1 male to 4 females to ensure better fertilization. The local Kei male and female chickens were mated at similar ratio to produce the Kei chickens as control group. Mating was carried out in separate blocks of houses with a deep-litter housing system, each block had five pens. Each pen was equipped with group laying nests, perches, feeder and drinker. During mating, birds were offered with standard layer ration and water was offered ad libtum.Eggs were collected on daily basis for a period of 10 consecutive days and stored broad-end up-position in a cool dry place to ensure better air exchange until they were set in the incubator. Two-thousand eggs were set from all three genotypes (Local Kei, RIR-crosses and Fayoumi-crosses) in an incubator. Candling was performed on the 10th day of incubation and repeated on the 18th day. Newcastle disease vaccination was given at hatch (ocular administration) and repeated on the 7th and 21st day of age. Chickens were regularly vaccinated every three months thereafter.

On-farm management of chickens

The experiment was conducted on 720 unsexed day-old leg-tagged chicks consisting of 240 chicks from each genotype (Local Kei and its F_1 crosses with RIR and Fayoumi breeds). Seventy-two hay-box brooders fitted with 72 chick-runs of 10 chicks' capacity were constructed adopting the dimensions recommended

by Demeke (1999). The hay-box brooders and chick-runs had dimensions of 30 x 26 x 26 cm and 30 x 56 x 56 cm, respectively. Hay was stuffed very loosely between the sides of the boxes and the top were covered with sacks filled with hay. Twenty-four randomly selected households from watershed area were involved and each received 30 chicks (10 chicks from each genotype). For each household, 3 hay-box brooders fitted with 3 chick-runs were provided to keep the three breeds separate during the brooding period. The hay-box brooders were used during the night whereas chick-runs were used to hold and feed the chicks during the day.

During the brooding period (up to 8 weeks old), chicks were fed on commercial starter ration. A measured quantity of feed was provided to chicks using plastic cups that had been marked and distributed to the participating farmers. Feed refusal from each genotype was collected separately on daily basis using marked plastic bags. Water was provided to chickens at *ad libitum*. After 8 weeks of age, feeding with commercial starter ration was discontinued and chicks were left to scavenge and farmers provided chickens with some whole maize and/or kitchen leftovers occasionally. Female chickens were separated from males by the size of their combs, presence or absence of wattle and tail feathers. Male birds were kept to evaluate body weight development and female birds to evaluate the egg production performance until 52 weeks of age.

Data collection

The fertility and hatchability of eggs were calculated for each genotype. Hatchability was calculated for total eggs set and fertile eggs. Individual body weights were taken immediately after hatch. During the brooding period, individual body weight of chicks was recorded on weekly basis and every two weeks after 8th week until they were 20 weeks old. After 20th week, body weight was recorded bimonthly. Body weight gain was calculated as the difference between weights measured in consecutive measurements. Mortality of chickens was recorded as it occurred during the entire experimental period.

Statistical analysis

Data were subjected to analysis of variance (ANOVA) using the General Linear Models (GLM) Procedure of Statistical Analysis System (SAS, 2002). Single factor ANOVA model was used to assess the effects of genotypes on different response variables. Identification number of each chicken and the households in which groups of chickens were kept has been considered as random effects when there were repeated observations per animal. Moreover, observations on egg fertility, hatchability and mortality of the investigated birds were analyzed using the frequency procedure of Chi-square test. Differences between group means were evaluated by Duncan's Multiple Range Test.

The effects of genotype and sex of chicks on body weight and body weight gain was assessed using two between subject and one within subject (week) repeated measure ANOVA design. Chicks were the subjects and the weeks of body weight measurements repeated measure factors The specific model statement has been described as follows:

$$Y_{ijkl} = \mu + A_i + B_j + + AB_{ij} + e_{ijkl}$$

Where:

Y_{ijkl} output (body weight and body weight gain)
μ overall mean
A_i fixed effect of genotype. i = 3 (Fayoumi-crosses, RIR-crosses and local Kei)
B_j fixed effect of sex. j = 2 (male and female)
AB_{ij} interaction of fixed effects of genotype and sex
e_{ijkl} random error of households

To analyze feed intake and feed efficiency ratio (FER), one between subject factor (genotype) and one within subject factor (experimental week) repeated measure ANOVA design was used. The model statement is expressed as follows:

$$Y_{ijk} = \mu + A_i + B_j + AB_{ij} + e_{ijk}$$

Where:

Y_{ijk} output (Feed intake and FER)
μ overall mean
A_i fixed effect of genotype. i = 3 (Fayoumi-crosses, RIR-crosses and local Kei)
B_j fixed effect of age (experimental weeks). j = 8 (i.e., 1 – 8 weeks of age)
AB_{ij} interaction of fixed effects of genotype and age (experimental weeks)
e_{ijk} random error of households

RESULTS

Fertility and hatchability of eggs

As presented in Table 1, egg fertility on 18th day of candling was 85.8%, 80.5% and 73.4% for Fayoumi-crosses, RIR-crosses and Kei, respectively and did not differ significantly between genotypes ($\chi^2 = 0.153$, $p > 0.05$). The highest fertility was observed in Fayoumi-crosses whereas the lowest in Kei chickens. Hatchability of total eggs set for Fayoumi-crosses, RIR-crosses and Kei was 73.7 %, 54.7 % and 59.0 %, respectively while hatchability of fertile eggs was 85.8 %, 80.4 % and 67.9 % for Fayoumi-crosses, Kei and RIR-crosses, respectively (Table 1). Although

hatchability of total eggs set and that of fertile eggs was higher for Fayoumi-crosses and Kei than for RIR-crosses, the differences were insignificant (χ^2 = 0.102, p > 0.05).

Day old and post-hatch body weights and weight gains

The body weight of day old chicks was significantly (p<0.05) higher for RIR-crosses than Fayoumi-crosses and Kei in both sexes (Table 2).

During brooding period, genotype and sex had a significant (p<0.05) effect on the overall mean body weight (Table 2). Accordingly, the RIR-crosses had the highest body weight (201.8 g) followed by Fayoumi-crosses (186.9 g) and Kei (168.1 g). The overall mean body weight of male chicks (204.0 g) was significantly (p<0.05) higher than female chicks (167.2 g).

Table 1. Hatchability of total eggs set and fertile eggs of local Kei and its crosses with Rhode Island Red and Fayoumi chicken breeds.

	Egg number			Hatchability (%)	
Breed combinations	Set	Fertile	Hatched	of eggs set	of fertile eggs
Fayoumi (♀) x Kei (♂)	600	515	442	73.7	85.8
RIR (♀) x Kei (♂)	600	483	328	54.7	67.9
Local Kei	800	587	472	59.0	80.4

Table 2. Least square means of body weight development of birds from hatch, brooding, post-brooding and maturity phases.

Growth phases	Growth traits	Sex	Kei	Kei x Fayoumi	Kei x RIR	Pooled S.E.M
At hatching	Day old weight (g)	Male	28.8^{c}	29.7^{b}	40.1^{a}	0.22
		Female	26.2^{c}	27.0^{b}	35.8^{a}	0.20
Brooding (Hatch-8 wks)	Body weight (g)	Male	183^{c}	206^{b}	222^{a}	3.89
		Female	153^{c}	167^{b}	179^{a}	3.61
	Weight gain (g)	Male	5.69^{c}	6.33^{b}	6.76^{a}	0.08
		Female	4.73^{c}	5.06^{b}	5.39^{a}	0.08
Post-brooding (9-20 wks)	Body weight (g)	Male	762^{c}	852^{b}	968^{a}	12.0
		Female	641^{c}	704^{b}	778^{a}	9.46
	Weight gain (g)	Male	8.20^{c}	9.12^{b}	10.8^{a}	0.07
		Female	6.75^{c}	7.67^{b}	8.52^{a}	0.06
Matured birds (21-52 wks)	Body weight (g)	Male	1273^{b}	1310^{b}	1682^{a}	13.9
		Female	987^{c}	1054^{b}	1227^{a}	9.60
	Weight gain (g)	Male	2.06^{b}	1.86^{b}	2.76^{a}	0.31
		Female	1.52^{a}	1.42^{a}	1.76^{a}	0.17

[a,b,c] Means within genotypes and sex in the same row with different superscript letters are significantly (p<0.05) different; RIR = Rhode Island Red; S.E.M = Standard error of the mean

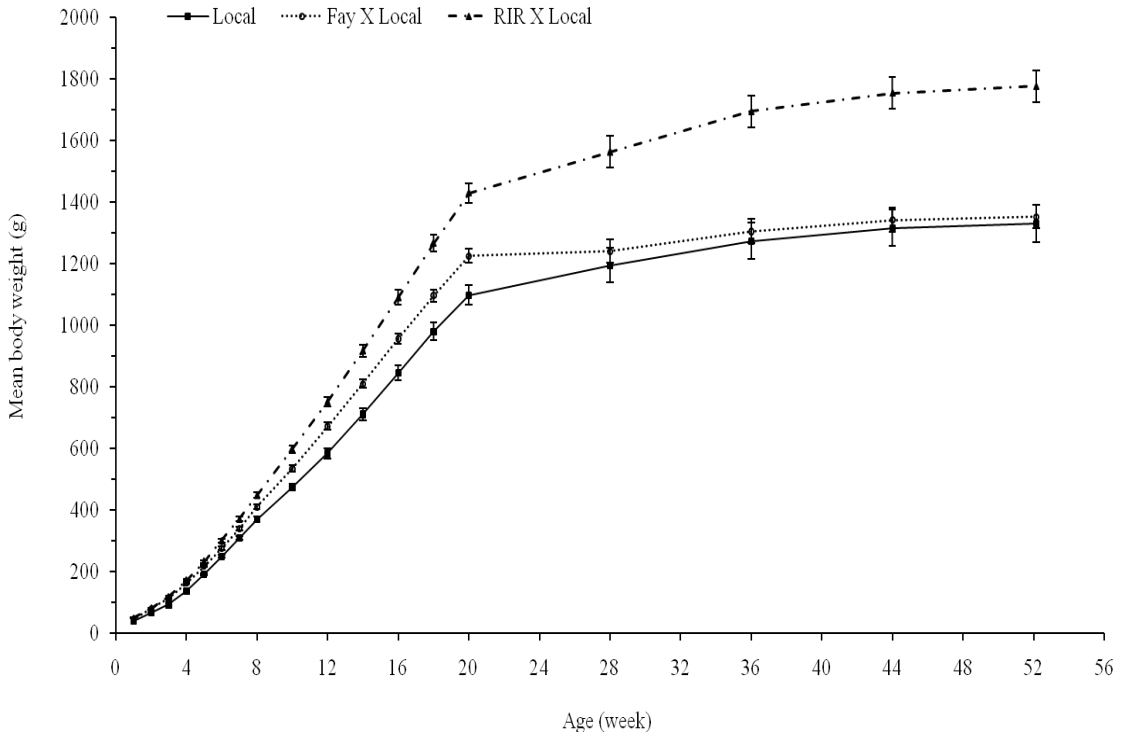

Figure 1. Body weight development of male birds from hatch to 52 weeks of age. Error bars are 95% CI values. Note that non-overlapping error bars indicate significantly different mean values

During post-brooding period, the overall mean body weight of RIR-crosses was significantly ($p<0.05$) higher than those of Fayoumi-crosses and Kei for both sex groups. A significant ($p<0.05$) increase in body weight was observed for both sexes as birds grew older. After 20 weeks of age onwards, the RIR-crosses had still significantly ($p<0.05$) higher body weight than Fayoumi-crosses and local Kei for both sexes. However, no significant ($p>0.05$) difference was observed between Fayoumi-crosses and Kei male genotypes. The mean body weight of male birds was significantly ($p<0.05$) higher than that of females.

As presented in Figures 1 and 2, both male and female birds showed a significant ($p<0.05$) increase in body weight from hatch to 20 weeks of age during which the body weight was increased at a higher rate. However, the body weight development became slower after 20 weeks of age onwards in which the males showed better body weight development as compared to females.

Weight gain

During the brooding period, the Fayoumi-crosses of male and female chicks had significantly ($p<0.05$) higher mean daily weight gain than those of RIR-crosses and Kei (Table 2). However, the difference in daily gain was not significant ($p>0.05$) between F_1 crosses. Male chicks generally gain more weight than female chicks.

During the post-brooding phase, the overall daily weight gain of male and female RIR-crosses was significantly ($p<0.05$) higher than those of Fayoumi-crosses and Kei chickens. The male and female Fayoumi-crosses had significantly ($p<0.05$) higher daily weight gain than local Kei. During this period, the male chickens had significantly ($p<0.05$) higher daily weight gain than females.

During the adult phase, the mean daily weight gain of male RIR-crosses was significantly ($p<0.05$) higher than those of Fayoumi-crosses and local Kei. However, no significance differences were observed amongst the three genotypes in weight gain of female birds. The female birds showed a similar trend in weight gain performance as that of males. During this period, the rate of gain declined consistently.

Figures 3 and 4 show the trend of daily weight gain of male and female birds, respectively during the entire growth period. During the brooding period, a sharp increase in mean daily weight gain was observed among the three genotypes. A low body weight gain was observed during week 8 through10 due to an outbreak of coccidiosis during this period of time.

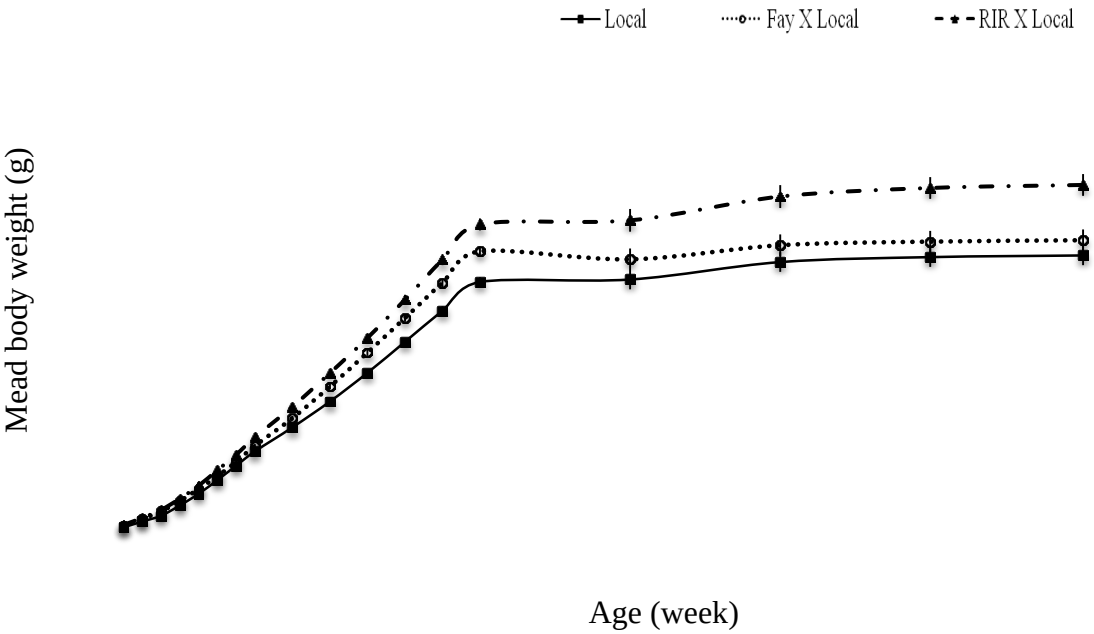

Figure 2. Body weight development of female birds from hatch to 52 weeks of age. Error bars are 95% CI values. Note that non overlapping error bars indicate significantly different mean values

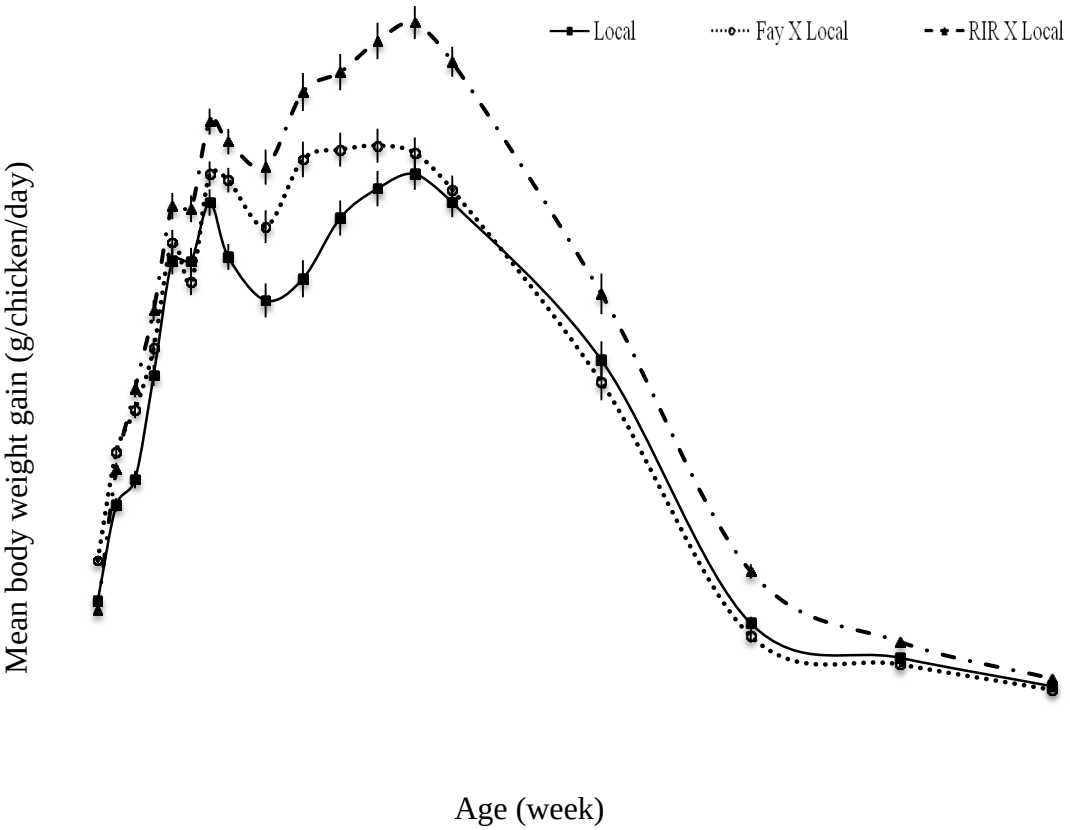

Figure 3. Pattern of body weight gain (g/chicken/day) of male birds from hatch to 52 weeks of age. Error bars are 95% CI values. Note that non-overlapping error bars indicate significantly different mean values

The rate of weight gain in male and female RIR-crosses was comparably higher than both Fayoumi-crosses and Kei chickens. However, the male and female Fayoumi-crosses and Kei chickens showed a comparable daily weight gain performance after 18 weeks of age.

Feed intake

As shown in Table 3, a significant ($p<0.05$) difference in feed intake was observed between the three genotypes at different age points. The Fayoumi-crosses had the highest feed intake followed by Kei and RIR-crosses.

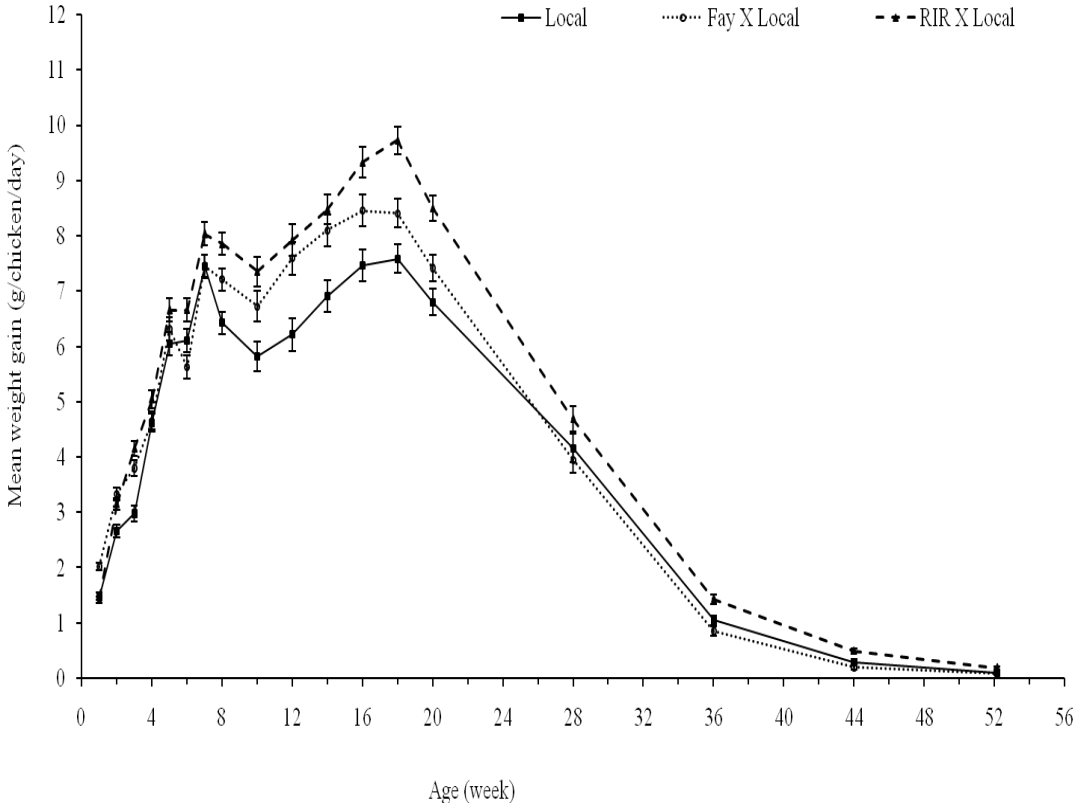

Figure 4. Pattern of body weight gain (g/chicken/day) of female birds from hatch to 52 weeks of age. Error bars are 95% CI values. Note that non-overlapping error bars indicate significantly different mean values

Table 3. Feed intake (g/chicken/day) of the three genotypes at different developmental ages of birds during the brooding period.

Age (wks)	Kei	Kei x Fayoumi	Kei x RIR	Pooled S.E.M
0-1	7.4^{b}	8.2^{a}	6.6^{c}	0.16
1-2	13.3^{b}	14.3^{a}	12.3^{c}	0.21
2-3	21.0^{b}	22.8^{a}	20.8^{b}	0.32
3-4	26.0^{b}	27.4^{a}	24.5^{c}	0.30
4-5	29.0^{a}	30.2^{a}	26.8^{b}	0.32
5-6	32.2^{a}	32.3^{a}	29.6^{b}	0.34
6-7	36.2^{a}	36.8^{a}	34.0^{b}	0.31
7-8	42.3^{a}	43.6^{a}	40.5^{b}	0.42
Overall mean	25.9^{a}	27.0^{a}	24.4^{b}	0.30

^{a,b,c} Means between genotypes in the same row with different superscript letters are significantly ($p<0.05$) different; RIR = Rhode Island Red; S.E.M= Standard error of mean

The Fayoumi-crosses significantly ($p<0.05$) consumed more feed from hatch to 4 weeks of age than both RIR-crosses and local Kei chickens (Table 3). During the same period, the feed intake of Kei was significantly ($p<0.05$) higher than those of RIR-crosses except between weeks 2 and 3. After week 4 to the end of the brooding period, the feed intake of both Fayoumi and Kei chickens was significantly ($p<0.05$) higher than RIR-crosses. However, no significant ($p>0.05$) difference was observed in feed consumption between Kei and Fayoumi-crosses.

Feed efficiency ratio (FER)

A significant ($p<0.05$) difference in FER was observed between genotypes in which the RIR-crosses had the highest value followed by Fayoumi-crosses and local Kei (Table 4). At week 1, the FER value in Fayoumi-crosses was significantly ($p<0.05$) higher than both RIR-crosses and Kei genotypes. At week 2, there was no significant ($p>0.05$) difference in FER between F_1 crosses. However, the FER in both F_1 crosses was significantly ($p<0.05$) higher than that of Kei chickens. After week 2 to the end of brooding, RIR-crosses had the highest FER than other two genotypes.

At week 3, Fayoumi-crosses had significantly ($p<0.05$) higher FER than local Kei. After week 3 through 7 weeks of age, no significant ($p>0.05$) difference was observed between Kei and Fayoumi genotypes. However, at the end of brooding, the FER in Fayoumi-crosses was significantly ($p<0.05$) higer than local Kei.

Mortality

As shown in Table 5, no mortality was recorded during the brooding period due to predation. However, mortality rates of 6.7%, 2.5% and 3.8% were observed for RIR-crosses, Fayoumi-crosses and local Kei chickens respectively during the same growth period. Similarly, a higher mortality rate was recorded from 8 to 20 weeks of age, which was mainly caused by diseases. The mortality rate for RIR-crosses (25.9%) was significantly higher (χ^2 = 9.731, $p < 0.01$) than Fayoumi-crosses (15.8%) and local Kei chickens (17.8%). However, the mortality rate due to predation was very low during this period in the three genotypes (Table 5).

Table 4. Feed efficiency ratio (g weight gain/g feed) of the three genotypes at different developmental ages of birds during the brooding period.

Age (wks)	Local Kei	Kei x Fayoumi	Kei x RIR	S.E.M
0-1	0.213^{b}	0.270^{a}	0.222^{b}	0.031
1-2	0.222^{b}	0.263^{a}	0.282^{a}	0.030
2-3	0.159^{c}	0.189^{b}	0.223^{a}	0.032
3-4	0.192^{b}	0.192^{b}	0.234^{a}	0.024
4-5	0.227^{b}	0.233^{b}	0.275^{a}	0.026
5-6	0.208^{b}	0.196^{b}	0.258^{a}	0.033
6-7	0.217^{b}	0.222^{b}	0.260^{a}	0.023
7-8	0.164^{c}	0.182^{b}	0.212^{a}	0.024
Overall mean	0.201^{b}	0.218^{b}	0.246^{a}	0.023

^{a,b,c} Means between genotypes in the same row with different superscript letters are significantly ($p<0.05$) different; RIR = Rhode Island Red; S.E.M= Standard error of mean

Table 5. The overall mortality (%) of local Kei, Kei x Fayoumi and Kei x Rhode Island Red chickens at different stages of development.

Genotypes	Brooding		Post-brooding		Adult stage	
	Disease	Predator	Disease	Predator	Disease	Predator
Local Kei	3.75^{b}	0	17.8^{b}	2.60	4.17^{a}	8.33^{b}
Kei x Fayoumi	2.50^{b}	0	15.8^{b}	2.14	2.08^{b}	4.17^{c}
Kei x RIR	6.67^{a}	0	25.9^{a}	2.23	4.17^{a}	14.6^{a}
Overall mean	4.30	0	19.8	2.32	3.47	9.03

^{a,b,c} χ^2 <0.05 values differ significantly between genotypes within a column
RIR = Rhode Island Red chicken breed; 0 = Not observed

DISCUSSION

Fertility and hatchability

The hatchability rates of total eggs set and fertile eggs obtained from RIR-crosses were comparable to those reported by Hassen (2007) for RIR chicken breed raised under intensive management. The percentage hatchability from fertile eggs reported by Wondmeneh *et al.* (2011) for Fayoumi breed under intensive management was in good agreement with the current results obtained from Fayoumi-crosses. However, the average percentages fertility and hatchability from the total eggs set reported by the same authors was higher than obtained from Fayoumi-crosses in the current study. On the other hand, values for fertility and hatchability of eggs set and fertile eggs for local Kei chickens in present study were higher than those reported for local chicken ecotypes reared under farmers' management condition (Hassen, 2007). These variations in fertility and hatchability rates of eggs can be explained by the age of the birds, nutrition, disease and environmental factors (North and Bell, 1990).

Body weight and weight gain

The highest body weight observed in F_1-crosses at hatch suggests that crossing of local Kei chickens with RIR and Fayoumi breeds has significantly improved the body weight at hatch. Similarly, an improvement in body weight at hatch of indigenous chickens crossed with RIR and Fayoumi was reported by Bekele *et al.* (2010). The body weight of local chickens at hatch in Northwest Ethiopia reported by Hassen (2007) was 27.2 g for Tilili, 27.9 g for Gelila, 27.1 g for D/Elias and 27.9 g for Mecha under intensive management, which was comparable with the current findings. The same author reported that the body weight of RIR at hatch to be 35.2 g, which was lower than that of RIR-crosses (38.0) in the present study.

The high body weight observed in RIR-crosses compared with Fayoumi-crosses and Kei chickens might be attributed to the genetic superiority of the RIR in body weight that is a highly heritable trait, and known for its non-additive genetic response to crossbreeding. Moreover, RIR is a dual purpose chicken breed recognized for better weight gain compared with egg layer type breeds. Similarly, Zaman *et al.* (2004) reported higher body weight for RIR-crosses than Fayoumi-crosses under semi-scavenging condition in Bangladesh. Furthermore, Forsido (1986), Shanawany (1987) and Bekele *et al.* (2010) reported that heavier eggs produce heavier chicks at hatch.

The body weight of local female chickens reported by Tadesse (2007) between 10 and 20 weeks age was lower than that of the chickens in the current study. Similarly, the pure RIR breed showed relatively lower body weight than the RIR-crosses under the same age category. However, the Fayoumi breed had relatively higher body weight than the Fayoumi-crosses obtained from the current study.

Melesse *et al.* (2005) reported 952 g body weight of Ethiopian female naked-neck chicken under intensive management system, which is comparable to the current results for local female chickens (924 g) of similar age. The same authors reported an average body weight of 1169 g at 20 weeks of age for F_1 crosses of Ethiopian naked-neck and White Lohmann, which is comparable to the body weight of RIR-crosses (1132 g) at similar age.

The average body weight of female local Kei chickens obtained at 52 weeks of age in the present study was 1020 g, which is much lower than reported by Melesse *et al.* (2005) for Ethiopian female naked-neck chickens at similar age. Under scavenging conditions, Melesse and Negesse (2011) reported 1510 and 1204 g of body weight for male and female local Kei chickens, respectively, which is higher than that obtained from the current study. The reported differences in body weight can be explained by the variations in availability of scavenging materials, management and environmental factors. Under the scavenging system, the non-genetic factors in particular poor nutrition and health care have much larger effects on production parameters than the genetic characteristics of the birds (Sazzad *et al*., 1988).

The daily weight gain of Tilili, Gelila, D/Elias, Melo-Hamusit, Gassay/Farta, Guangua and Mecha chickens between day old and 4 weeks of age reported by Hassen (2007) under intensive management was lower than the average of male and female Kei chickens of the current study at similar age. Similarly, the mean daily weight gain observed by Hassen (2007) from the RIR was relatively lower than the average body weight of male and female RIR-crosses of similar age. The same author reported an average daily body weight gain of 9.8 g from 5 to 8 weeks of age for RIR chickens under intensive management which was comparable to the average body weight of RIR-crosses at similar age in the current study. This indicates that under farmers' management conditions, the RIR-crosses can perform better than pure RIR breeds kept under intensive type of production system.

Under intensive management condition, Dessie *et al.* (2003) reported an average daily weight gain of 7.2 g

for local chickens between 6 and 12 weeks of age, which was comparable with that of local chickens in the current study.

Feed intake and utilization

The highest feed intake observed in Fayoumi-crosses could be attributed to their active physical activity, which might have required additional feed consumption to meet the maintenance requirement as reported by Melesse (2008). In agreement with the present result, Akhtar *et al.* (2007) reported higher feed intake for Fayoumi breeds than for Lyallpur Silver Black and RIR breeds. The daily feed intake reported for Tilili, Melo-Hamusit, Guangua and Mecha chickens from day old to 4 weeks age by Hassen (2007) under intensive management were comparable with that of local Kei chickens in the current study at similar age. The daily feed intake of RIR chicks reported by Melesse *et al.* (2011) was comparable with that of RIR-crosses at similar age category. The daily feed intake of Tilili, D/Elias, Melo-Hamusit and Guangua chickens reported by Hassen (2007) under intensive management were comparable with that of local Kei chickens in the present study at similar age. However, the daily feed intake of RIR reported by the same author was lower than that of RIR-crosses at similar age.

The better efficiency in feed utilization (higher FER) of RIR-crosses might be due to their improved body weight gain performance along with low feed intake. Akhtar *et al.* (2007) reported better efficiency in feed utilization of RIR breeds as compared with Lyallpu Silver Black and Fayoumi breeds. The FER reported by Hassen (2007) for Tilili, Melo-Hamusit, Guangua and Mecha local chickens from day old to 4 weeks age under intensive management was lower than that of the current study observed in local Kei chickens at similar age. This could be explained by the fact that chickens kept under intensive management condition might have better chance to express their genetic potential (Sazzad, 1992; Melesse *et al.,* 2005).

Mortality

The low mortality observed during the brooding period might be attributed to the use of brooding box fitted with chicken-run feeding, which could have protected chickens from both aerial and ground predators which have been reported as the main causes of mortality in southern regional state of Ethiopia (Melesse and Negesse, 2011). The higher rate of mortality due to disease observed from 8 to 20 weeks of age was caused by the outbreak of coccidiosis which occurred during this period. The highest mortality rate observed in RIR-crosses due to predation could be explained by the exposure of chickens to the rainy season (June to August) during which time maize and sorghum crops were used as hideout for ground predators such as wild cats and foxes. Moreover, searching for feed resources around the homestead might have exposed birds to be easily spotted and attacked by predators. Beside this, RIR-crosses were relatively less active to escape from both aerial and ground predators compared with Fayoumi-crosses and local chickens.

CONCLUSIONS

The overall results of the present study revealed that both F_1-crosses demonstrated a significant improvement in body weight, weight gain and feed efficiency ratio under farmers' management condition as compared with local Kei chickens. It can be concluded that the exotic blood of Rhode Island Red and Fayoumi chicken breeds had played a significant role in upgrading the productive potentials of the local Kei chicken. Thus, using both exotic chicken breeds as a strategy for upgrading the poor growth performance of indigenous chickens might be an alternative option in *Guraghe* and other watershed areas along with improved feeding, housing and health care schemes. It should be however noted that the Rhode Island Red chicken breeds should be used with cautious as they are highly susceptible to local predators and diseases.

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